PROCEEDINGS OF THE CONSTRUCTION BUSINESS & PROJECT MANAGEMENT CONFERENCE

THEME: Conceptualising challenges and opportunities in the construction industry

24 - 25 JUNE 2021

UCT GRADUATE SCHOOL OF BUSINESS, ACADEMIC CONFERENCE CENTRE
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DECLARATION

Eighty-one submissions were received for the Conference from 30 Universities, Polytechnics and Organisations located in Australia, Ghana, India, Malaysia, New Zealand, Nigeria, South Africa, the United Kingdom and Zambia, out of which 41 full papers were accepted. All full papers in this publication went through a double-blind peer-review process which involves abstracts assessment by the scientific committee, feedback to authors on abstracts submitted, submission of full papers for the accepted abstracts, review of full papers by the scientific committee and panel of reviewers, feedback to authors on full papers submitted which included a decision on acceptance and evaluation of the revised papers by the scientific committee and reviewers to ensure the quality of content.

CBPM 2021 Conference Stats

Abstract/Full Paper	Full Paper

Institutional Affilliation	Count of Affiliation	Affiliation (%)
Durban University of Technology	4	7.02%
Ahmadu Bello University, Zaria	4	7.02%
University of Cape Town	4	7.02%
Nelson Mandela University	3	5.26%
University of South Africa	3	5.26%
Federal University of Technology, Minna	3	5.26%
Moshood Abiola Polytechnic, Abeokuta	3	5.26%
Obafemi Awolowo University, Ile-Ife	3	5.26%
Univerisity of Ilorin	3	5.26%
Univerisity of Kwa-Zulu Natal	3	5.26%
University of Johannesburg	2	3.51%
University of The Free State	2	3.51%
Kingston University, London	2	3.51%
Walter Sisulu University	2	3.51%
Niger State Polytechnic, Zungeru	1	1.75%
Curtin University	1	1.75%
Kwame Nkrumah University of Science and Technology	1	1.75%
Denel	1	1.75%
Akwa Ibom State Polytechnic, Akwa Ibom	1	1.75%
Olabisi Onabanjo University, Ago-Iwoye	1	1.75%
Department of Science and Innovation, South Africa	1	1.75%
Stellenbosch University	1	1.75%
Modibbo Adama University, Yola	1	1.75%
University of the Witwatersrand	1	1.75%
University of Manchester	1	1.75%
Waziri Umaru Federal Polytechnic, Birnin Kebbi	1	1.75%
Darik Homes Limited, Abuja	1	1.75%
The Federal Polytechnic Ilaro	1	1.75%
Bayero University, Kano	1	1.75%
The Oke-Ogun Polytechnic Saki	1	1.75%
Grand Total	**57**	**100.00%**

PREFACE

Dear Conference Participants,

It is a pleasure to welcome you to the Construction Business and Project Management (CBPM) Conference, 24-25 June 2021. The conference is organised under the auspices of the University of Cape Town and Durban University of Technology.

The construction industry plays a vital role in the economy of any nation, and it is a significant contributor to economic growth. It creates employment, especially for unskilled workers, which can be used in the development and transfer of technology, creating many opportunities for enterprises and contributing directly to improving the quality of life of its users. The construction industry is more than a single industry comprising a complex cluster of sectors, including banking, materials and equipment manufacturers, contracting organisations, consultancies and suppliers of goods and services.

In 2013, the construction sector in South Africa contributed 13% of the GDP with expectations for an increase to 15% by 2020. However, a dismal contribution of the construction industry to the GDP has been observed in South Africa and globally. The current COVID-19 pandemic has now worsened this dismal performance. Furthermore, society faces numerous problems concerning infrastructure delivery and management and the failure of construction companies. In the ten years leading up to the Covid pandemic in 2020, many small and medium-sized construction companies underwent business rescue. However, the challenges also extend to large companies whose failure has also led to the collapse of many smaller companies – their appointed sub-contractors.

This conference aims at conceptualising the various challenges and opportunities in the construction industry by providing a platform that brings all stakeholders involved in the construction industry, both academia and practitioners, to collaborate and brainstorm on the challenges of, opportunities and the future directions for construction business and project management. It is believed that through its collaborative motive, this forum will bring about changes in the delivery of sustainable construction businesses, professional practices and projects. Furthermore, sharing experiences and ideas in infrastructure delivery, management and procedures should be an ongoing priority as infrastructure is required for economic growth and development.

To stimulate interaction between the conference participants, the organising committee has designed a programme that enables networking, learning, and discussion opportunities. In addition to four keynote addresses and the presentation of 41 papers, the conference takes place immediately after a public lecture on "Leading inclusive change in Affordable Housing and Development in African cities," and a workshop on "The use of Local Building Materials/Alternative Technologies in housing construction."

Based on examination of the abstracts and full papers submitted by the Keynote speakers and authors from 30 institutions and 13 countries, I am convinced that this will be an inspiring event. Furthermore, the event will generate new insights and solutions to the myriad challenges facing the construction industry, identifying opportunities for growth and research collaborations.

Finally, I wish to thank all our Local Organising Committee and Scientific Committee members who gave their time selflessly to the organisation and realisation of the CBPM conference. I also want to thank all other individuals who played an important role in the logistical support of the conference. I wish you all a stimulating conference, and to those who made it to Cape Town, I wish you a pleasant stay.

Prof. Abimbola Windapo
Chair, Scientific Committee CBPM 2021 Conference

ORGANISING COMMITTEE

Abdulrauf Adediran	University of Johannesburg, South Africa
Amanda Mtya	University of Cape Town, South Africa
Ayodeji Olatunji Aiyetan	Durban University of Technology, South Africa
Bhekisipho Twala	Durban University of Technology, South Africa
Cecilia Mewomo	Durban University of Technology, South Africa
Chioma Okoro	University of Johannesburg, South Africa
Kehinde Alade	University of Cape Town, South Africa
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Nicholas Chileshe	University of South Australia, Australia
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Yewande Adewunmi	University of the Witwatersrand, South Africa
Zakari Mustapha	Cape Coast Technical University, Ghana
Zakheeya Armoed	Durban University of Technology, South Africa

THE PEER REVIEW PROCESS

All the full papers in this publication went through a rigorous two-stage blind peer review process by no less than two acknowledged experts in the subject area. Experts, including industry professionals and academics, were assigned to ensure that high-quality scientific papers were produced and included in the proceedings.

The first stage of review

Submitted abstracts were double-blind peer-reviewed. Each abstract was reviewed in terms of relevance to the conference theme and objectives, academic rigour, contribution to knowledge, originality of material and research methodology. Authors whose abstracts were accepted were provided with anonymous reviewers' comments and requested to address the review comments when developing their full papers.

The second stage of review

The submitted full papers were first of all checked originality and inappropriate copying using Turnitin/Ithenticate software. After that, the papers were assigned to experts in the field based on their areas of expertise for review. The full papers were reviewed in terms of relevance to the originality of the material; technical writing; academic rigour; contribution to knowledge; pertinent literature review; research methodology and robustness of analysis of data; empirical research findings; and overall quality and suitability of the paper for inclusion in the conference proceedings.

The third stage review

Authors whose papers were accepted after the second review were provided with additional anonymous reviewers' comments on evaluation forms, and requested to submit their revised full papers. Evidence was required relative to specific actions taken by the authors regarding the referees' suggestions. Final papers were only accepted and included in the proceedings after satisfactory evidence was provided. To be eligible for inclusion in the conference proceedings, these papers were required to receive a unanimous endorsement by the Scientific Committee and Review Panel that the paper had met all the conditions for publication. Out of 81 submissions, 41 papers were finally accepted and included in the CBPM-2021 conference proceedings.

At no stage was any member of the Scientific Committee, Review Panel or the Organising Committee, or the Editors of the proceedings involved in the review process related to their own authored or co-authored papers. The role of the editors and the scientific committee was to ensure that the final papers incorporated the reviewers' comments and to arrange the papers into the final sequence as captured on the USB memory stick and Table of Contents.

Prof. Abimbola Windapo
Chair, Scientific Committee CBPM 2021 Conference

ENDORSEMENTS

The Construction Business and Project Management Conference is accredited by the South African Council for the Project and Construction Management Professionals (SACPCMP) for 8 CPD points. The conference is also supported by the Journal of Construction Business and Management.

https://journals.uct.ac.za/index.php/jcbm/login

KEYNOTE SPEAKERS

The Conference Organising Committee would like to thank our keynote speakers for accepting our invitation to come and share their presence and thoughts with us. Thank you very much.

Dr Kgosientsho Ramokgopa

Dr Kgosientsho Ramokgopa is currently the **Head of the Investment and Infrastructure office** in the office of the President of South Africa. Before this, Dr Ramokgopa was Gauteng MEC (Member of Executive Committee) for Economic Development, Agriculture and Environment. Previously, he has held the position of Executive Mayor of the City of Tshwane between 2010 and 2016, at the time he was one of the youngest Mayors of a Metropolitan in the country. Dr Ramokgopa's previous positions include holding the position of CEO for both the Metropolitan Trading Company and the Johannesburg Market and he has previously been the Deputy Chairperson of the board of Trade and Investment in Limpopo.

Dr Ramokgopa holds a PhD and a Masters of Public Administration from the University of Pretoria, and a Masters of Business Leadership from the University of South Africa. He completed his BS in Civil Engineering at the University of Durban Westville in 1998. MEC Ramokgopa's political participation dates back to the '80s when he was 14 and participating in the Atteridgeville-Saulsville Residents Organisation (ASRO). Dr Ramokgopa offers lessons in leadership and public management at various tertiary institutions as a guest lecturer, something he does pro-bono. Dr Ramokgopa lives by the motto; "If you live truthfully, you shall prevail against all adversity."

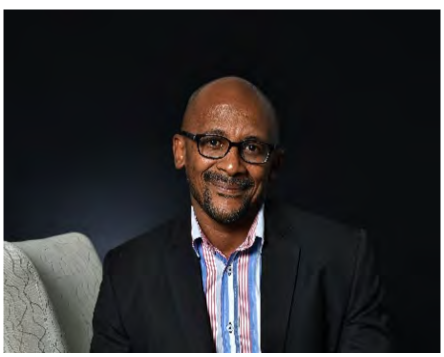
Prof Chimay Anumba

Professor Chimay Anumba is Dean of the College of Design, Construction and Planning at The University of Florida. He is a Fellow of the Royal Academy of Engineering, FREng (the United Kingdom's National Academy of Engineering). He holds a Ph.D. in Civil Engineering from the University of Leeds, UK; a higher doctorate – D.Sc. (Doctor of Science) - from Loughborough University, UK; and an Honorary Doctorate (Dr.h.c.) from Delft University of Technology in The Netherlands. He has over 500 scientific publications and his work has received support worth over $150m from a variety of sources. He has also supervised 52 doctoral candidates to completion and mentored over 26 postdoctoral researchers. He is the recipient of the 2018 American Society of Civil Engineers' Computing in Civil Engineering Award and a member of the US National Academy of Construction (NAC).

Prof John Smallwood

Prof John Smallwood is the Professor of Construction Management in the Department of Construction Management, Nelson Mandela University, and the Principal, Construction Research Education and Training Enterprises (CREATE). Both his MSc and PhD (Construction Management) addressed construction health and safety (H&S). He has conducted extensive research and published in the areas of construction H&S, ergonomics, and occupational health (OH), but also in the areas of the environment, health and well-being, primary health promotion, quality management, and risk management.

Prof Bhekisipho Twala



Bhekisipho Twala is the Executive Dean of Engineering and Built Environment and Professor in Artificial Intelligence and Data Science at the Durban University of Technology, South Africa. Before then, he was the Director of the School of Engineering at the University of South Africa and the Institute for Intelligent Systems at the University of Johannesburg. Prof Twala's current work involves promoting and conducting research in Artificial Intelligence within the Big Data Analytics field and developing novel and innovative solutions to key research problems in this area. He earned his Bachelor's degree in Economics and Statistics from the University of Swaziland in 1993; followed by an MSc in Computational Statistics from Southampton University (UK) in 1995; and then a PhD in Machine Learning and Statistical Science from the Open University (UK) in 2005. Prof. Twala was a post-doctoral researcher at Brunel University in the UK, mainly focussing on empirical software engineering research and looking at data quality issues in software engineering. His broad research interests include multivariate statistics, classification methods, knowledge discovery and reasoning with uncertainty, sensor data fusion and inference, and the interface between computing and statistics. He has particular interests in applications in finance, medicine, psychology, software engineering and most recently in robotics and has published over 180 scientific papers. Prof Twala is currently an associate editor of the Information Sciences Journal, Intelligent Data Analysis Journal, Journal of Computers, International Journal of Advanced Information Science and Technology, International Journal of Big Data Intelligence, Journal of Image and Data Fusion, Journal of Information Processing Systems, and a fellow of the Royal Statistical Society. Other professional memberships include the Association of Computing Machinery (ACM); the Chartered Institute of Logistics and Transport (CIT), South Africa and a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE). Twala is the recipient of the TW Kambule research and its outputs award, the highest honour bestowed by the South African government on outstanding scientist for up to fifteen years after the award of a PhD or equivalent.

PROGRAMME

Construction Business and Project Management Conference, 24-25 June 2021
Venue: UCT Graduate School of Business, Cape Town/Online
Theme: Conceptualising Challenges and Opportunities in the Construction Industry

Day 1 - Thursday, June 24th			
2021-06-24	8:30-09:00	**Registration and Welcome (Prof Bheki Twala)**	
2021-06-24	09:00-09:30	**Keynote Address 1**	
	09:00-09:30	S1	**Dr Kgosientso Ramokgopa. Contextualizing Infrastructure Delivery and Management in South Africa**
2021-06-24	09:30-11:10	Session 1: Day 1: Session A. Session Chair - Prof. Abimbola Windapo	
	09:30-09:48	2	Kehinde Alade and Abimbola Windapo. A leadership and strategic decision framework for construction company survival.
	09:48-10:06	36	Luyanda Ngomane and Nthatisi Khatleli. Rethinking Resilience: A review of the infrastructure management capability maturity levels in South African category B4 municipalities: The Case of Nyandeni Local Municipality
	10:06-10:24	58	Oluwole Olatunji and Ephraim Osaghae. Dynamic Capabilities in Multicultural Project Teams: Conceptual Review, Framework Analysis, and Practical Implications
	10:24-10:42	61	Tselane Chicks and Makgopa Tshehla. Procurement Innovation and Transformation in Commercial State-Owned Enterprises (SOES) – Infrastructure Projects
	10:42-11:10	81	Amit Rambaruth, Jamila Khatoon Adam and Suresh Babu Naidu Krishna. Strategic Management in construction firms with focus on small and medium enterprises: A case study of eThekwini, South Africa
2021-06-24	11:10-11:30	Session: Tea Break	
2021-06-24	11:30-13:00	Session 2: Day 1: Session B. Session Chair - Dr Ayodeji Aiyetan	
	11:30-11:48	18	Chinedu Adindu, Chioma Okoro, Ikechukwu Diugwu and Saheed Yusuf. Prospects of Multi-skilling as Strategic Construction labour response to Covid-19 Pandemic: A Study of selected Projects in the Federal Capital Territory area councils, Nigeria.

	11:48-12:06	22	Afia Attrams and Professor Makgopa Tshehla. Determinants of small and medium enterprises financing sources: evidence from Ghana
	12:06-12:24	32	Sihle Mbekushe and Christopher Amoah. Impact of unskilled labourers on the construction productivity
	12:24-12:42	55	Athenkosi Sogaxa and Stoffel Fourie. Sustainable Construction Project delivery: A Skills Availability Assessment in the Eastern Cape Province of South Africa
	12:42-13:00	75	Justin van Wyk, St John Wilson and Mochelo Lefoka. Management Tools and Techniques Impacting On-site Labour Productivity
2021-06-24	13:00-14:00	Session: Lunch Break	
2021-06-24	14:00-14:30	**Keynote Address 2**	
	14:00-14:30	S2	**Prof. Chimay Anumba. Towards Smart and Resilient Built Environments**
2021-06-24	14:30-16:10	Session 3: Day 1: Session C. Session Chair - Dr Emmanuel Nkeleme	
	14:30-14:48	8	Bello Mahmud Zailani, Mu'Awiya Abubakar, Yahaya Ibrahim Makarfi, Kabir Bala and Muhammad Sadiq Abdallah. Integrating Building Information Modelling (BIM) Tools and Techniques in Construction Organizations: Effect on Culture and Structure
	14:48-15:06	26	Dillip Das and Ayodeji Olatunji Aiyetan. Exploring the use of Drones for sustainable construction in developing countries
	15:06-15:24	41	Lily Dixon and Nnedinma Umeokafor. Determinants of Smart Technology adoption in the Construction Phase of Projects: A Scoping Study of the United Kingdom
	15:24-15:42	62	Micayla Prozesky, Shweeta Bagoandas, Amanda Mtya and Abimbola Windapo. Benefits of the adoption of digital technologies on South African construction projects
	15:42-16:00	63	Tinotenda Chirenda, Ellis Chitakatira, Reyaboka Mpeke, Amanda Mtya and Abimbola Windapo. Capability factors influencing the adoption of Building Information Modelling (BIM) by South African AEC organizations
2021-06-24	16:10-16:30	Session: Tea Break	
2021-06-24	16:30-18:00	Session 4: Day 1: Session D. Session Chair – Mr Kenny Alade	

	16:30-16:48	3	Babatunde Dosumu, Obuks Ejohwomu and Akilu Yunusa-Kaltungo. Development of a project risk/cost estimation framework: a case study of Nigeria.
	16:48-17:06	19	Jan Wium and Chris Jurgens. Benefits of the application of data sciences in construction
	17:06-17:24	38	Ikechukwu A. Diugwu, Haruna Musa, Nnedinma Umeokafor and Yekeen Sanusi. A scoping study of barriers and drivers of sustainable design and construction in Nigeria
	17:24-17:42	74	Momoh Ohiomah Oboirien. Artificial neural network models: conceptualized and improved method of contingency assessment for Construction Projects in Nigeria
	17:42-18:00	78	Emmanuel Ifeanyichukwu Nkeleme, Ikem Mbammali and Winston Shakantu. Effects of combustion generated pollutants on the indoor air quality of university laboratories.
End of Day 1			
Day 2 - Friday, June 25th			
2021-06-25	09:00-09:30	**Keynote Address 3**	
	09:00-09:30	s3	**Prof John Smallwood. Adaptation, Resilience and Mental Health Post-Covid**
2021-06-25	09:30-11:10	Session 5: Day 2: Session A. Session Chair - Amanda Mtya	
	09:30-09:48	17	Hassan Ahmadu, Kabiru Nasiru, Mustapha Abdulrazaq and Muhammad Aliyu Yamusa. Assessing Barriers and Facilitators to Adoption of Design for Safety by Construction Organisations in Nigeria
	09:48-10:06	37	Muziwandile Mabaso and John Smallwood. Fatal Trench Collapses on Sewer Reticulation Projects in the Construction Industry
	10:06-10:24	48	Ayodeji Olatunji Aiyetan and Opeyemi Ayobami David. Causes of fatality relative to construction site accidents in the KwaZulu-Natal construction industry
	10:24-10:42	53	Mwewa Mambwe, Erastus Mwanaumo, Wellington Thwala and Clinton Aigbavboa. Employee Wellbeing Factors for Improving Occupational Health and Safety Performance by Small-Scale Electrical Contractors in Zambia
	10:42-11:00	60	Takalani Sigama, Mabila Mathebula and John Smallwood. The impact of Business Forums on Construction Health and Safety (H&S) in South Africa

2021-06-25	11:10-11:30	Session: Tea Break	
2021-06-25	11:30-13:00	Session 6: Day 2: Session B. Session Chair - Dr Ayodeji Aiyetan	
	11:30-11:48	5	Abdullateef Adewale Shittu, Yakubu Danasabe Mohammed, Rasheed Temitope Ayodele, Ibrahim Inyass Adamu, Sani Ibrahim and Shakirat Remilekun Abdulazeez. Effect of Total Quality Management on The Safety Performance of Construction Firms in Abuja, Nigeria
	11:48-12:06	14	Ranti Taibat Adebiyi, Ganiyu Amuda-Yusuf, Abdulkadir Shehu Rasheed and Scholastica Fidelis Ekanem. Women Career Advancement for Sustainable Development in Construction Industry in Nigeria
	12:06-12:24	45	Tshepang Mosiea, Precious Lukhele, Sijekula Mbanga and Dr Sithembiso Myeni. Assessing the role of institutionalised self-help housing in achieving United Nations Sustainable Development Goals in Post-Apartheid South Africa
	12:24-12:42	54	Athenkosi Sogaxa, Ruben Ndihokubwayo and Eric Kwame Simpeh. Effective material Management practices adopted by SMEs to achieve project success: a perspective of construction industry in the Eastern Cape Province
	12:42-13:00	80	Samuel Olatunbosun, Sunday Odediran and Azeez Akinborode. Factors Influencing Construction of Sustainable Buildings in Lagos Metropolis, Nigeria
2021-06-25	13:00-14:00	Session: Lunch Break	
2021-06-25	14:00-14:30	**Keynote Address 4**	
	14:00-14:30	S4	**Prof Bhekisipho Twala. Big analytics in the construction industry**
2021-06-25	14:30-16:10	Session 7: Day 2: Session C. Session Chair - Prof John Smallwood	
	14:30-14:48	10	Christopher Amoah and Janine du Plessis. Factors influencing student's accommodation selection.
	14:48-15:06	13	Lukman Olarewaju Olorunoje, Sunday Julius Odediran and Ganiyu Amuda-Yusuf. Entry modes used by multinational firms in crossing borders into the Nigerian construction market
	15:06-15:24	34	Solomon Ojo and Sodiya Abiodun. Frameworks for Renumeration of Construction Consultants during unwarranted Project Time Overrun in Nigeria

	15:24-15:42	65	Modupe Mewomo and Ayodeji Aiyetan. Unethical Behaviour in Construction Industry – The South African Construction Professionals Views.
	15:42-16:00	76	Makgopa F Tshehla and Tsholofelo M Mokoma. The effect of Incubation Programme Small, Micro and Medium Enterprises Development: A cross-sectional survey
2021-06-25	16:10-16:30	Session: Tea Break	
2021-06-25	16:30-18:00	Session 8: Day 2: Session D. Session Chair - Dr John Babafemi	
	16:30-16:48	7	Babatunde Kazeem Adeleke, Muhammed Magaji Garba and Mohammed Mustapha Saad. An Investigation on the Determination of Compressive Strength of Poured-earth/Earth-cobs (PEEC) Masonry Wall
	16:48-17:06	25	Dillip Das. Impact of construction for the expansion of National Highways on the local environment in India.
	17:06-17:24	43	Umar Obafemi Salisu, Nathaniel Oluwaseun Ogunseye, Ayobami Ademola Akanmu, Simeon Oluwagbenga Fasina, Wakeel Iyanda Solabi and Abeeb Olawale Olanipekun. Environmental Implications of Construction Activities in A Fast-Growing Nigerian City: A Study of Ota, Nigeria
	17:24-17:42	51	Fatimo Osho and Adeshina Dauda Adebayo. Effect of Moisture on Durability of Concrete Components in Residential Buildings
	17:42-18:00	73	Samuel Olatunbosun and Sunday Odediran. Impact of Energy Access on the Delivery of Construction Projects in Lagos Metropolis, Nigeria
	18:00-18:18	79	Dele S. Kadiri, Obiora K. Uroko, Babajide O. Onabanjo and Elijah O. Oyewole. An Evaluation of Planning Techniques Impacting Construction Project Performance in Nigeria
	18:20		**Closing and Presentation of Certificates**
2021-06-26	**10:00**		**Sightseeing - Tour of Robben Island**

SECTION 1: KEYNOTE ADDRESSES

Contextualising Infrastructure Delivery and Management in South Africa

Dr Kosientsho Ramokgopa

Investment and Infrastructure Office, Office of the President of South Africa

Globally, there is an adjustment of strategies by Governments and a recovery plan, Post-COVID. While the United States proposes a 2 Trillion Dollars stimulus plan, a 200 Billion Dollars infrastructure plan has been promised by the G7 at its meeting on 15 June 2021 to help Africa develop its infrastructure. In South Africa, the Finance Minister has made a bold declaration that *“Infrastructure will be the catalyst and flywheel for the country’s economy to grow POST-COVID.”* Fifty-two projects that are ready for construction have been Gazetted. These projects aim at providing economic stimulus necessary for providing traction to the economy. However, it is not yet known how the South African Government’s promises on delivering infrastructure will translate into realities for skills training and value-added jobs in the construction sector. This talk presents an overview of the South African Government’s R360 Billion construction industry recovery plan towards providing an understanding of the 52 projects that are ready for construction and projects that have been prioritised to achieve construction industry recovery and economic growth in South Africa. The talk will also highlight how these projects unlock opportunities for skills training, value-added jobs for students, manufacturers, construction companies and consultancies; whether there is a match between proposed project delivery methods and the construction industry capacity to deliver; and the challenges to the realization of speedy and economic benefits from the identified projects.

Towards Smart and Resilient Built Environments

Professor Chimay J. Anumba

University of Florida, United States of America

There is growing interest in ensuring the resilience of the built environment given the increasing severity and frequency of adverse weather events and rising sea levels. These have been attributed to climate change, and it is imperative that built environment researchers and practitioners formulate strategies for addressing this. In parallel, developments in information and communications technologies are enabling the integration of smart components in various aspects of buildings and civil infrastructure. This has led to several initiatives that are intended to deliver smart cities and built environments that leverage these emerging technologies to improve the quality of life for the public. This lecture will explore the concept of resilience, and its importance in the development of built and natural environments that are less vulnerable to adverse weather impacts. It will argue that built environment resilience is best achieved within the context of a 'system of systems' approach to sustainable development, which recognizes the interdependencies of the built and natural environments, as well as the interconnectedness of various building and civil infrastructure systems. The role of emerging technologies in the delivery of smart and resilient built environments will be discussed with particular attention paid to those technologies considered critical to Industry 4.0. Examples will be drawn, where appropriate, from the approach being adopted in research projects at the University of Florida and elsewhere.

Adaptation, Resilience and Mental Health Post-Covid

Professor John Smallwood
Nelson Mandela University, Port Elizabeth, South Africa

Historically, the South African construction industry has focused on the 'safety' component of health and safety (H&S) as opposed to the 'health' component, despite the 'health' issues being more pronounced and more serious in nature, depending on the occupational disease (OD). The advent of the COVID-19 pandemic has highlighted the need for a differing approach to manage H&S, especially occupational health (OH) and primary health (PH) in both the business of construction, and on projects. Furthermore, COVID-19 has impacted substantially on the business of construction in terms of reduced business volumes, and downsizing. However, the overall impact has had far reaching effects in terms of mental health. Recent 'people in construction' (PiC) and H&S research indicates that mental health and well-being have become the predominating PiC and H&S issues in construction. The keynote address presents a review of the 'literature' conducted to determine the impact of COVID-19 on the business of construction, and reports on two empirical studies. The first study, qualitative in nature, was conducted among staff in the employ of a large national general contractor (GC) in four regions of South Africa to determine the impact of COVID-19 on the construction process and its activities. The second study reports on an exploratory quantitative PiC study conducted among delegates attending the International Council for Research and Innovation in Building and Construction (CIB) W099 (Safety, Health and Well-being in Construction) and TG59 Conference in Salvador, Brazil.

The salient findings include: COVID-19 has resulted in a major reduction in construction business volumes, led to business closures, and liquidations; screening and sanitising (entry), sanitising stations, and social distancing predominate among changes made on site to accommodate the COVID-19 pandemic; 'change becomes a new habit / becomes the norm' predominates in terms of how management on site is adopting to the changes; 'sticking to rules = adoption' predominates in terms of how supervisors on site are adopting to the changes; workers have generally complied with COVID-19 protocols; maintaining social distancing is the predominating social challenge, and the top five PiC issues are mental health, workforce well-being, workforce engagement, H&S, and productivity. Conclusions include: COVID-19 has had a major impact on the business of construction; COVID-19-related changes have had, among other, construction process, procedure, protocol, logistics, productivity, and financial implications; management, supervisors, and workers on site are generally adopting to these changes, and mental health and well-being have become the predominating PiC and H&S issues. Recommendations include: construction businesses should include possible pandemics in their general risk managment processes and strategic planning; awareness with respect to COVID-19 and the implications of infections must be maintained; COVID-19 protocols must be enforced; employers should establish mental health programmes, and tertiary built environment education, built environment statutory councils, professional and employer associations, and employers should focus on 'PiC' issues, especially mental health, and wellbeing issues.

Big Analytics in the Construction Industry

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The technologies driving Industry 4.0 are already leaving a mark on the construction industry. Over the past decade, digital progress has transformed whole industries, ushering in a new technological era now known as the 4th industrial revolution (4IR) or Industry 4.0. Platforms and streaming services such as DSTV, ESPN+, Netflix, Prime Video, Peacock, Spotify and YouTubeTV have transformed media and entertainment. E-commerce giants including Amazon and Alibaba have disrupted bricks-and-mortar retailers. Digital mobility companies are challenging automotive manufacturers. These new technologies are not only satisfying consumer demand for better entertainment, shopping and transport. Innovation has improved companies' productivity and sustainability and redefined the skills and competencies needed to thrive. While most other industries have undergone tremendous changes recently, the construction industry has been reluctant about plenarily embracing the newly emerging technological adoption. Varying sophistication of construction, this talk empirically evaluates large construction firms' point of view on challenges of the construction industry in the era of IR4. The findings reveal that construction companies need to deal with the manifold PESTEL (political, economic, social, technological, environmental, and legal) challenges. Adopting the IR4 hindered by lack of policies, financial problem, limited demand for innovation among large economic players, lack of trust towards foreign partners, and limited adaptability of foreign software. This talk will help scholars and industry players to redefine the development of the construction industry into detailed strategic plans or policies in the future. In a nutshell, transforming the construction industry into digitization and digitalization might confront few challenges but the long-term benefits obtained throughout application should not be forgotten.

SECTION 2: CONFERENCE PAPERS

Table of Contents

Women Career Advancement for Sustainable Development in Construction Industry in Nigeria

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Abstract:
Women in the construction industry found it difficult to break through in career advancement even with their knowledge, skills and experience, thereby constitute a small percentage at the top management positions. This study, therefore, analysed factors impeding women from attaining the top in their career. Data for the study were collected from contracting and consulting firms in Lagos State, Nigeria, through the administration of questionnaire to conveniently selected Architects, Quantity Surveyors, Engineers and Contractors. Analyses of data were carried out using Mean Score and Standard Deviation. Findings revealed that family/work-life balance, high degree of stress on the job and lack of flexible work hours and schedules are the most important factors that constitute a barrier to women carrier advancement. Better work/life balance and equality in career development opportunities for both males and females were the most important factors facilitating women's career advancement. The correlation coefficient indicated a strong positive relationship between factors constituting a barrier to women career advancement and factors that facilitate career advancement in the construction industry. The degree of agreement among the respondents in their judgments concerning their ranking of the factors was determined. The results indicated a significant degree of agreement among the respondents. Findings revealed that employers should establish flexible working practices and provide equality in career development opportunity for both men and women to be at par with men at the top managerial positions.

Keywords:
Career advancement, Construction industry, Lagos, Managerial positions, Women

1 Introduction

It is a known fact that there is significant progress in the pursuit of gender equality in the labour market over recent years (Obamiro & Obasan, 2013; Munn, 2014; Akomolafe & Muhammed, 2015). The increased engagement of women in the labour market is discovered to be closely linked with achieving the unique goals of the United Nations on the 2030 global agenda for sustainable development (El Arnaout *et al.,* 2019). The economic factors and continuous improvement in women's access to education and training have also facilitated their participation (Akomolafe & Muhammed, 2015; Masidah *et al.,* 2015). Women tend to be economically independent (Sazali *et al.,* 2014). Despite this development, professional women in Nigeria make up a small percentage at the highest cadre of authority in many industrial sectors like building, financial, telecommunication, transportation, oil and gas, manufacturing and mining (Obamiro & Obasan, 2013; Rajkumar *et al.,* 2016). Akpinar (2012) found out that despite the penetration of women in non-traditional professions, they are woefully underrepresented at the top management levels and, in most cases, stuck at lower levels. Even in a woman, traditional jobs such as teaching, a higher percentage of teachers are female while most top management staff are male. A similar situation is reported in the medical sector; doctors and top hospital management staff are mostly men, while most nurses and support staff are women. Positions of authority in Nigeria are not left out. Currently, 36 states Governors are 100% male. Also, Deputy Governors are 91.7% male while females are only 8.3%. Even though the estimated population in Nigeria is 50.7% male and 49.3% female. Several female parliamentarians have also revealed the underrepresentation of women at the top management level in Nigeria. Women are far lower than men; only about 6% of members of the Nigerian Senate and House of Representatives are female.

According to Durasaro (2016), women can perform all tasks that men perform, but there has always been a role stereotype because of conventional, cultural, physiological, and religious perceptions of women. Women were perceived to be weak and therefore cannot and should not be seen performing some leading roles even if they can perform such roles. Women sometimes start their careers at the same level as men but gradually lose ground with time. This study, therefore, investigates factors impeding women career progression to enable them to reach the highest levels in their career.

Several women's organisations have emphasised how to overcome the discrimination that hinders women career progression (Salma *et al.,* 2014). The immediate past government of Nigeria advocated for up to 40% of women involvement in key positions. Still, the majority of the outcomes were far below what was expected (Akpinar 2012). Though some employers are beginning to promote women more systematically and are introducing family-friendly policies to attract and retain women in the various workplace, despite that, women in the construction industry found it difficult to breakthrough in career progression (Claudi, 2010; Mordi *et al.,* 2011).

Although several studies carried out on career progression have focused on the ordeal of women at the highest cadre of their career in the organisations (Akunyili, 2006; Mordi *et al.,* 2011; Masidah *et al.,* 2015), little or no major studies had been done on women career progression in the Nigerian construction industry. Despite the important roles women play in all economic activities, they are still under-represented at the top management levels in the construction industry. For this reason, this study is being undertaken to address women career advancement in the construction industry. This study is useful to women and employers in the construction industry to understand how women career progression is influenced by some barriers and how to facilitate women to attain the top.

2 Literature Review

2.1 Career Advancement

Career can be explained as the particular occupation a person has been prepared for. In other words, this study defined career as the sequence of actions and roles that an individual performs during all his or her life. Mordi *et al.* (2011) conceptualised career as a sequence of professional experience and organisational objectives which an individual goes through all his life. Therefore, Babatunde *et al.* (2012) described career progression as the long-term growth and development of individuals professionally in the organisation. The growth and self-esteem of employees are achieved by the availability of effective career development practices. This practice will enable them to update their skills and knowledge. Such motivated employees are encouraged to put in the best in their work. Availability of career development opportunities sometimes serves to keep the employees in the organisation. The decision made by the employees to remain in the organisations might depend on available career development opportunities (Claudi, 2010). The employers are therefore required to provide opportunities for continued self-development. This will be beneficial for both the individual employees and the organisations. Therefore, it was established that career development enhances individual work performance and satisfaction (Mordi *et al.,* 2011).

2.2 The Process of Women Career Advancement

Career is a life–long, uninterrupted experience of work that can be split into several stages of development, beginning with initial ideas about working and ending with retirement. According to Babatunde *et al.* (2012), career development practices are efforts made by organisations to enable the employees to progress in their careers and to assist the organisations to achieve their mission. Career development practices include strategies, policies and programs which may be formal or informal, structured, or unstructured.

Unlike men, a system of women's career progression is mostly affected by family and workplace responsibilities and commitment (Mordi *et al.,* 2011). According to Baker and French (2018), the underrepresentation of women in Australian construction and property development industries results from work practices, presenteeism and the filtering of personnel in recruitment and promotion practices. Therefore, it was proposed that career development programs should describe women's career separately from men's careers (Munn, 2014). Munn (2014) concluded that women career development practices must take account of the following factors: career preparation: this describes how women are brought up in a way to pursue a career; available career opportunities for women; effects of marriage on the career of women; effects of pregnancy and childbirth on the career of women; timing and age: women's careers do not follow the same chronological patterns as those of men regarding family responsibilities and commitment.

2.3 Women Career Advancement in Construction Industry

From a historical perspective, Nigerian women built their family homes with clay and thatched roofs, cultivated land for farming and made money to raise their children (Masidah *et al.,* 2015). However, quite different in today's construction industry, the industry is cautious in recruiting women. The construction labour market is now segregated into masculine and feminine jobs due to the prevalent social conditions. Most women employed in the industry undertake administrative responsibilities. Adeyemi *et al.* (2006) confirmed that women constitute about 16.3% of the total workforce in the Nigerian construction industry, of which 50% held administrative positions, 10% as professional and management staff, while only 2.5% as craftswomen. Construction industry Training Board (CITB, 2005) revealed a similar situation in the UK construction sector, women constitute only 9% of the total workforce, of which 84% are employed as Secretaries, about 11% held professional posts while the remaining are craftswomen. The above findings revealed that modern-day women do not often take jobs that require much physical strength, operating machine, requiring precision, but rather associate with jobs in a clean and tidy work environment. This perception usually hinders efforts to attract women to take up manual work in the construction industry. Recruitment of women into the construction labour force is one side of the coin; career progression issues are the other.

2.4 Barriers to Women Career Advancement in Construction Industry

The barrier to entry of women into the construction industry starts from the low enrolment of female students into courses related to construction in higher institutions. Babatunde *et al.* (2012) asserted that professional women are confronted by difficulties joining the construction industry then followed by attaining the top management positions. Various studies were carried out to assess the barriers to women involved in the construction industry. According to Navarro-Astor *et al.* (2017), women in the construction industry are confronted by numerous barriers different from countries to countries. However, the more frequent are balancing work and family, gender discrimination and lack of professionalism in human resource management. Griffin (2013) identified that women in the construction industry are with poor career counselling because of the unavailability of role model. Most organisations' recruitment exercises are gender-biased to reduce women's participation in the industry, affecting career progression. Durosaro & Ogungbemi (2014) identified a high level of illiteracy among women, low self-esteem, feeling of inferiority complex and poor career aspiration. According to Akomolafe & Mohammed (2015), women are faced by several difficulties in joining the construction industry due to the image of the industry, career knowledge, family commitment, male-dominated culture and work environment, which made it difficult for women to capture the most senior position in the organisation's hierarchy.

Shanmugam *et al.* (2006) identified women's lack of confidence, lack of competitiveness, failure to have their contribution recognised, not being taken seriously, and fear of failure as barriers to women entry into a leadership position. Salman *et al.* (2014) found that the most prevalent problem is sexual harassment, long working hours, isolation on the Jobsite, negative perceptions of women capabilities, expectations to mimic male's aggressive behaviours, lack of mentors/role models, small representation on the Jobsite, family/work-life balance, slow career progression, high degree of stress on the job, lack of encouragement from supervisors, limited training opportunities, unfair perception of women performance and pay gap compared to male counterparts. Radhlinah & Jingmond (2011) identified lack of training and hiring programs, working environment, lack of flexible work hours, and schedule issues confronting women carrier progression in the construction industry. Durosaro (2016) found out that cultural practices, norms, unwritten family codes are the most prevalent difficulties facing women entering the labour force.

3 Research Methodology

The preliminary data was gathered by performing extensive literature searches from published journals and conference proceedings in line with studies carried out by Amuday-yusuf *et al.* (2015) and El Arnaout *et al.* (2019). The questionnaire was used as a research instrument for this study and was designed to generate data in a simple, clear, and unambiguous manner to assist a continuous flow of thoughts required by the respondents. The questionnaire has two main sections; the first section dealt with the particulars of the respondents such as gender, age, specialisations, academic qualification attained and years of experience in the industry; the second section focused on the study's objectives. Factors constituting barriers to women career advancement and facilitating women's career progression were extracted from the literature that formed the rudiments for the questionnaire. The questions were asked on a 5-point Likert scale rating, with 5 being the highest. Many researchers have replicated and confirmed the validity of the Likert scale, e.g., Babatunde *et al.* (2012), Obamiro and Obasan (2013), Amuday-yusuf *et al.* (2015) and Adebiyi, *et al.* (2017). A digital copy of the questionnaire was administered to registered consultants and contractors in Lagos, Nigeria, via their e-mail's addresses with their professional bodies. The consultants include Architects, Quantity Surveyors and Engineers. A convenience sampling method was adopted to choose the appropriate sample size in the study area. The choice of Lagos as the study area is because it houses up to 60 per cent of head offices of both consulting and contracting firms in Nigeria (Babatunde *et al.,* 2012).

Furthermore, Lagos is very busy in terms of construction activities (Obamiro & Obasan, 2013). Data collected were analysed through Statistical Package for Social Sciences (SPSS) using mean score, standard deviation and Kendall coefficient of concordance. Mean score and standard deviation were used for ranking, while the Kendal coefficient of concordance determines the degree of agreement among the respondents in their ranking. A hypothesis was developed to establish a relationship between factors constituting barriers to women career advancement and factors facilitating carrier advancement in the construction industry. The strength of the correlation coefficient indicates a positive or negative relationship between the two factors. Alternative hypothesis (H_1) is accepted for a strong positive relationship while null hypothesis (H_0) is rejected vice versa.

4 Findings and Discussion

One hundred and fifty copies of the questionnaire were administered to consultants and contractors in the study area. A total of 95 copies representing 63% were retrieved and found suitable for the analysis. It was found that 70% of the firms surveyed are male-dominated and that about 82% of the respondents are above 40 years old. All the respondents are educated; about 86% are graduates. The findings from respondents' work experience indicate that majority of the respondents (60%) had been with the firm for more than ten years while 28% had been with the firm for between 6-10 years, only 12 per cent of the respondents had between 0-5 years of experience. The educational qualification and experience of the respondents provide reliability and credibility to the data collected.

4.1 Factors Constituting Barrier to Women Carrier Progression in Construction Industry

Twenty-eight major barriers that women mostly face in career progression in the construction sector were included in the questionnaire for the respondents to indicate their opinions on a five-point Likert scale, from 5 (strongly agree) to 1 (strongly disagree). In evaluating the results, Mean Score (MS) and Standard Deviation (SD) were used to rank the factors that constitute a barrier to women carrier progression in the construction industry. Table 1 provides the summary of the statistical mean and standard deviation.

Table 1. Factors Constituting Barrier to Women Carrier Advancement in Construction Industry

Factor Constitute Barrier to Women Carrier Development	Mean Score	Standard Deviation	Rank
Family/work-life balance	4.11	0.900	1
High degree of stress on the job	4.06	0.873	2
Lack of flexible work hours and schedule	4.03	0.822	3
Unfair perceptions of women performance capabilities	3.91	0.853	4
Gender biased recruitment	3.89	0.963	5
Lack of mentor/role model	3.83*	0.857	6
Male-dominated nature of the industry	3.83*	0.954	7
Harshness of job conditions	3.80	0.901	8
Poor career guidance	3.77	0.910	9
Unfair performance evaluations by male supervisors	3.74	0.950	10
Sexual harassment	3.71	0.860	11
Lack of support from the spouse	3.57	1.119	12
Failure to have women's contribution recognised	3.51	0.919	13
Lack of encouragement from supervisors	3.49	0.818	14
Career limited to clerical/administration duties	3.17	0.785	15
Traditional/Religious restriction of women to certain work types	2.94	1.027	16
Lack of confidence and timidity	2.91	0.781	17
Fear of failure	2.86	1.061	18
Feeling of inferiority complex	2.66*	0.816	19
Low self-esteem	2.66*	0.838	20
Macho behaviour of male colleagues	2.37	1.215	21
Lack of networking opportunities	2.34	0.968	22
Loss of sense of femininity and social rejection	2.14*	0.912	23
Slow career progression	2.14*	0.944	24
Poor career aspiration or focus	2.09	0.907	25
Limited training opportunities	2.03	0.954	26
High level of illiteracy among women	1.97	1.043	27
Lower salaries than male counterparts (pay gap)	1.91	0.781	28

* Same mean score, the standard deviation was used to rank

The table shows that family/work-life balance is the most significant factor contributing to women career development in the construction industry. It was ranked first with an MS of 4.11 and an SD of 0.900. The high degree of stress on the job was ranked second with an MS of 4.06and SD of 0.873. Lack of flexible work hours and the schedule was ranked third, obtaining an MS of 4.03 with an SD of 0.822. Unfair perceptions of women performance capabilities and gender-biased in recruitments are other important factors constituting a barrier to women carrier progression, and they were categorised as fourth and fifth factors with MS of 3.91 and 3.89, SD of 0.853 and 0.963, respectively. These were considered the most significant in this research study. According to Adeyemi *et al.* (2006), employers on construction sites mostly do not consider women for hazardous, tedious, and dirty jobs with long working hours.

Nevertheless, it can also be seen from the table that traditional/religious restriction of women to certain work types, lack of confidence and timidity, fear of failure, low self-esteem and macho behaviour of male colleagues were also factors that constitute a barrier to women carrier development in built environment albeit not significant. According to the findings, the least significant factors include lower salaries than male counterparts, a high level of illiteracy among women, and limited training opportunities for women.

4.2 Factors Facilitating Women Carrier Progression in Construction Industry

Mean scores and standard deviation of respondents' opinion concerning advancement on women's career revealed that better work/life balance was ranked the highest with an MS of 3.89 and SD of 0.896. This was followed by equal opportunity in career advancement for men and women (MS of 3.69 and SD of 0.834). The finding is consistent with the study carried out by Lingard and Lin (2004); the study revealed that access to career development opportunities is a major factor for women to improve their organisational commitment. Masidah *et al.* (2015) posited that most women were not considered for promotion to top positions due to low level of commitment, competence, experience and education. Flexible working hour, improved perception of the value of women's work and women participation in construction management were ranked third, fourth and fifth with MS of 3.53, 3.40, 3.35 and SD of 0.838, 0.706 and 0.861, respectively. Flexible working hour, improved perception of the value of women's work and women participation in construction management were ranked third, fourth and fifth with MS of 3.53, 3.40, 3.35 and SD of 0.838, 0.706 and 0.861, respectively.

4.3 Degree of Agreement among the Four Groups of Respondents with respect to their Rankings of the Factors

Kendal Coefficient of Concordance was used to quantitatively determine the degree of agreement in ranking among the respondents, i.e. Architects, Quantity Surveyors, Engineers and Contractors. Kendal Coefficient of Concordance is a measure of association among many variables. Table 2 revealed a degree of agreement among the four groups of respondents with respect to their rankings for factors constituting barriers to women career advancement and factors facilitating the advancement in women career advancement and computed value x^2 and x^2 critical table.

Table 2. Computed Value X^2 and X^2 Critical Table

Factors	Kendal Coefficient of Concordance (W)	Chi-square statistic as x^2 = k(N-1)W	Computed Value x^2	Critical table x^2 at 0.05	Inference
Barriers	0.6671	4(28) 0.6671	75	41.33	Significant
Facilitators	0.7330	4(21) 0.7330	62	41.33	Significant

The Kendal coefficient of concordance (W) for factors constituting barriers to women career advancement and factors facilitating advancement are 0.6671 and 0.7330, respectively. The high value of Kendal's Coefficient of concordance indicates strong agreement among the respondents on the ranking of all the factors. A similar test by Gearhart *et al.* (2013) reveals Kendall Coefficient of Concordance ranges of 0.00 to 0.9208, which suggested high validity of the instrument. Therefore it was concluded that the degree of agreement among the respondents with respect to how the factors were ranked is reported to be significant.

4.4 Relationship between Factors that Constitute Barrier to Women Career Advancement and Factors that Facilitate the Carrier Advancement in Construction Industry

A hypothesis was developed to establish a relationship between factors that constitute barriers to women career advancement and factors that facilitate career advancement in the construction industry.

Hypothesis:

$\boldsymbol{H_o}$**:** There is no relationship between factors that constitute a barrier to women career advancement and factors that facilitate career advancement in the construction industry.

Vs

$\boldsymbol{H_1}$**:** There is a relationship between factors that constitute a barrier to women career advancement and factors that facilitate career advancement in the construction industry.

The correlation coefficient indicates a strong positive relationship between factors that constitute a barrier to women career advancement and factors that facilitate women carrier advancement in the construction industry, with a 51.9% correlation. Gasparyan *et al.* (2019) emphasised the importance of a hypothesis as an essential research tool to determine the relationship between factors.

The p-value was revealed to be statistically significant at a 1% level of significance with the p-value <0.05. The null hypothesis (H_0) is hereby rejected, and the alternative hypothesis is accepted (H_1). This implies a strong relationship between factors that constitute a barrier to women career advancement and factors that facilitate women carrier advancement in the construction industry. So, therefore, to eliminate barriers to women career progression, factors facilitating career progression can be applied.

5 Conclusion and Further Research

This study reviewed various literature on women's career and leadership to examine the representation of women at the top management level in the construction industry. Findings from literature revealed that women found it difficult to break through in career progression, especially in the construction industry, thereby constitute a small percentage at the top management positions. This was found to be a result of conventional, cultural, physiological and religious perceptions of women. The challenges that women face in career advancement were discussed in the literature. The mean score ranking revealed that family/work-life balance, high degree of stress on the job and lack of flexible work hours and schedule were the major factors responsible for the low representation of women at the top management positions in the organisations. Considering these challenging factors, it is felt that reducing or eliminating them is an important step that led to analysing factors that can facilitate the career development of women. The mean score ranking also revealed that better family/work-life balance, equal opportunity in career development for men and women, flexible working practices, and improved perception of the value of women's work could increase the rate of women career advancement.

Moreover, Kendall's coefficient of concordance indicates strong agreement among the respondents on the ranking of all the factors. To develop a high-quality workforce at the top management level that is motivated and skilled, employers in the construction industry need to facilitate women's career advancement. This study recommends a further study on the challenges facing the effective performance of women at the top management level in the organisations.

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An Investigation on the Determination of Compressive Strength of Poured-earth/Earth-cobs (PEEC) Masonry Wall

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Abstract:
Excessive shrinkage as the cause of low compressive strength associated with the monolithic poured earth method of earth construction is always a discouraging factor for professionals in the built environment. Poured earth is becoming more widely used to construct buildings worldwide and has gained popularity as an aesthetically pleasing, low cost and sustainable building technique. Poured earth structures could be monolithic if cast completely from the same earth slurry or masonry if produced from two heterogeneous materials. Therefore, this research adopted spherical earth-cobs as plums in poured-earth for the construction of earth-based masonry wall. Three different types of earth-cobs and four different types of poured-earth were produced at different percentages of cement in the mixes. Prisms with a height-to-thickness ratio of 2.1 were used to determine the compressive strength of the Poured-Earth/Earth-Cob (PEEC) masonry wall. Twelve different types of cast prisms were produced from different combinations of poured-earth and earth-cobs. Additional four types of prisms were also produced by using poured-earth slurries alone for compressive strength compared with the types that have earth cobs. The result of IRA shows that the suction effect of the spherical earth-cobs through capillary action increases with an increase in cement added to the mixes and increases with time. The results of the compressive strength of the masonry wall samples show improved strength and approximately total elimination of shrinkage compared with the monolithic poured earth wall. The research, therefore, recommends the use of poured-earth with earth cobs as plums for the construction of earth masonry wall.

Keywords: Compressive strength, Earth-cobs, Initial rate of absorption, Masonry wall, Poured-earth

1 Introduction

Masonry structures are typically a non-elastic, heterogeneous and anisotropic element composed of two materials of different properties (Kaushik, Rai & Jain, 2007). It consists of two phases, namely, the unit phase and the mortar phase. Under lateral loads, masonry does not completely behave elastically, even in the range of small deformations. It is very weak in tension because it comprises two different materials distributed at intervals, and the bond between them is weak. Therefore, masonry structures are expected to resist mostly compressive stresses (Kaushik et al., 2007; Thaickavil &Thomas, 2018). Masonry walls are used in almost all types of building construction in many parts of the world because of their low cost, good sound and heat insulation properties, easy availability of materials and skilled labour (Kaushik et al., 2007). It is one of the oldest structural elements known to man, which is believed to have been in use for over 6000 years, and its construction remains relatively popular in many parts of the world and is practised widely even today (Thaickavil & Thomas, 2018). As a well-proven building structure, Masonry possesses excellent properties in terms of appearance, durability, and cost. The quality of masonry in a building depends on the materials used, which must conform to certain minimum standards (Hendry, Sinha & Davies, 2004).

Peec masonry is a type of masonry comprising poured-earth slurry as the binding component and solid spherical earth-cobs as the unit component of the masonry (Adeleke, 2020). The two masonry components are used to form a masonry wall with properties similar to other types of masonry wall system. Examples of other types of masonry include bricks/mortar masonry, blocks/mortar masonry and stone/mortar masonry. The spherical earth-cobs are combined with the poured-earth slurry-like plum concrete construction. The word 'plum' in concrete means boulders of sizes between 150mm – 300mm. Plum concrete construction is a way of introducing these boulders into concrete construction to reduce the volume of concrete needed for a required structural element or probably to improve the strength of such an element (Adeleke, 2020). Plum concrete can be used below footing as a base so that water from the footing will not be absorbed by the earth below. Plum concrete is used in areas that need massive concrete placement, such as dams and bridge piers.

The problem of excessive shrinkage is associated with most of the earth methods of building construction. Some of the methods of earth construction that suffer excessive shrinkage include adobe rammed earth, cob and poured earth (Wolfskill et al., 2017). In the poured-earth method of earth construction, shrinkage and shrinkage cracks are developed because of the high moisture content in the slurries used to make the monolithic wall (Adeleke, 2015; Sackey, 2015; Williamson, 2012; Wolfskill et al., 2017). Therefore, reducing or eliminating shrinkage and shrinkage cracks in earth construction is of great importance.

Poured earth is a fluid mix that consists of a mixture of gravel, sand and silt, which is agglomerated by clay (Carlos, Edgardo & Yolanda, 2016). Poured earth is also considered soil in liquid mud form, but containing sandy aggregates can perform the same function as lean concrete (Houben & Guillaud, 1994). Poured earth walls have been known for the problem of low compressive strength. This has been attributed to the peculiarity of excessive shrinkage and shrinkage cracks in poured earth walling system (Adeleke, 2015; Sackey, 2015; Williamson, 2012; Wolfskill et al., 2017). If poured-earth samples shrink, shrinkage cracks will occur, and if the shrinkage stress is more than the ultimate tensile strength of the samples, it leads to a reduction in compressive strength of the poured-earth samples.

Earth-cob is an earth building technique that involves forming a lump of balls in a plastic state and stacking them wet/dry to build a load-bearing wall with/without mortar (Hamard et al., 2016). Cob construction is carried out with highly wetted soil material (water must be added above the plastic limit of the soil), kneaded by foot and piled on the wall in a plastic state. The primary advantage of this method of earth construction is the simplicity in technique and construction equipment (Wolfskill et al., 2018). Earth-cob, due to its flexibility, could be combined with other building techniques, such as poured earth, earth-bag technique, wood frame, concrete, straw bale, adobe, wattle-and-daub, to reduce costs, time, or to improve its performance according to the surroundings (Estrada, 2013; Smith, 2000). If technologically combined with poured earth, the Cob method of earth construction will be an earth-based building technique that may be an alternative for constructing new homes in developing and developed countries. Earth-based constructions commonly used in the past, like adobe and wattle-and-daub, have increasingly been replaced by building using more processed methods.

Therefore, the study's outcomes could have structural, economic, ecological/environmental, and social benefits. The structural significance is the improved strength and durability properties that the study investigated. The combination of earth-cobs and poured-earth improved the compressive property of poured-earth/earth-cobs masonry walls. The economic importance of the use of local building materials will be of great benefits. The ecological and environmental benefits arising from using local building materials (especially those based on earth) are plentiful. It helps to reduce the amount of cement used in global building processes and, consequently, the amount of CO_2 emitted to the atmosphere, thereby reduces the effect of global warming. Socially, the poured-earth/earth-cob (peec) method of construction will meet the requirements of local production situations, such as using local existing or easily transferable skills, avoiding costly training of the workforce, and reducing societal or cultural disruption.

2 Material and Methods

2.1 Prism Samples for Peec Masonry Wall

Before producing the prisms used for the main experiments, many trials were carried out to ascertain the quality of the cast prisms. According to ASTM E447, tests on the prisms were carried out at 21 days (T1), 28 days (T2), 56 days (T3) and 90 days (T4). A total of 288 prisms were prepared from 3 types of earth cobs and four types of poured-earth with six samples for each type at a particular age. One sample was always used as a trial during crushing in order to have an idea of the probable failure load for each type of sample at a particular age. The other five were used for the main crushing and recorded.

Table 1. Different Combinations of Poured-earth and Earth-cobs of the Prisms

S/N	Poured earth	Earth-cobs		
		0% cem. addition (B1)	5% cem. addition (B2)	10% cem. addition (B3)
1	0% cement addition (S1)	S1B1	S1 B2	S1B3
2	5% cement addition (S2)	S2B1	S2B2	S2B3
3	10%cement addition (S3)	S3B1	S3B2	S3B3
4	15%cement addition (S4)	S4B1	S4B2	S4B3

Based on the experimental trials, the ratio of the volume of earth-cobs to that of poured-earth in all the prisms used for the main experiment was 0.25. There was a need to spray water on the dried earth cobs for proper bonding between the earth-cobs and poured-earth. The sizes of the 288 prisms produced for the experiment were 230mm length by 190mm thickness by 400mm high except for prisms produced without the use of earth-cobs, i.e., poured-earth alone (S_1B_0, S_2B_0, S_3B_0 and S_4B_0) that suffered both vertical and horizontal shrinkage as established in similar research by Adeleke (2020) as shown in Plate I. Before producing the prisms, non-absorptive metal moulds were coupled and placed on the metal plate of similar materials. The moulds were lubricated for easy demoulding after the samples have set.

Plate I: Excessive Shrinkage   Plate II: Placing the E.C on the Face of P.E   Plate III: Test on IRA of Earth-Cobs

After pouring the first layer of earth slurry to about one-quarter (¼) of the mould height and compacted by hitting the sides of the moulds, two pieces of dried spherical earth-cobs were placed on the face of the first layer, after which the second layer of earth slurry was poured to about half (1/2) of the moulds' height and compacted for another two pieces of the earth-cobs to be placed on its face. The third layer of earth slurry was also poured to about three-quarter (3/4) of the mould height and compacted for the last two pieces of the earth cobs to be placed on its face, as shown in Plate II.

The fourth layer of the earth slurry was then used to fill up the mould and compacted. The final face of the prisms was now dressed in hand-trowel and designated with appropriate code for easy identification. Therefore, a total of 6 earth-cobs (with an approximate weight of 1kg each) were used with the four layers of the poured-earth to produce the respective prisms. The cast prisms were now demoulded the next day after they had set and covered with polythene material to avoid rapid moisture loss in the samples.

3 Laboratory Test

3.1 Initial Rate of Absorption (IRA) of the Earth-cobs

This is a test on durability measure which give information about the quality of the earth-cobs. The suction of water from the poured-earth by earth-cobs due to capillary action was measured by the initial rate of absorption test. The test was carried out on samples of earth-cobs at 21, 28, 56 and 90 days according to BS EN 772-11:2011. It was measured in terms of the mass of water absorbed per minute by the earth-cobs per unit area of the earth-cobs immersed in about 5mm deep water, which was kept constant by adding water during the test as shown in Plate III. The IRA was calculated using equation 1. The IRA was measured before the usage of the earth-cobs in the production of the masonry prisms. This was to assist in the poured-earth selection and material handling in the production processes following similar researches.

IRA (kg/m^2/min) = $\frac{\text{Mass of water absorbed by spherical earth−cobs (kg)}}{\text{Area of the spherical earth−cobs (m2)}}$

IRA (kg/m^2/min) = $\frac{\text{M2−M1 (kg)}}{\text{A (m2)}}$ .... (1)

Where M2 = final mass of earth-cobs after immersion
M1= initial mass of earth-cobs before immersion
A = πR^2
R = radius of the spherical earth-cobs = 50cm

3.2 Compressive Strength of Masonry Wall Samples (prisms)

Out of the 288 prisms cast and cured for compressive strength, 211 prisms were used to carry out compressive strength, as shown in Plate IV. There was no proper bonding between the masonry wall components for the remaining 69 prisms leading to major constructional cracks as shown in plate V. These prisms (S_1B_1, S_1B_2, and S_1B_3) were the type produced from the unstabilized poured-earth (S_1) when combined with the different types of earth-cobs (B_1, B_2, B_3).

The 211 prisms were tested for compressive strength at 28, 56 and 90 days according to BS EN 1996-2: 2006. The test could not be carried out at 21 days due to the wetness of the sample. The load was applied in four stages to allow for deformation measurement on a dial gauge attached to a universal testing machine, as shown in Plates VI. The ultimate load was recorded, and the strength of the masonry wall was calculated with Equation 2.

$f_p = \frac{F_{max}}{A}$ .... (2)

Where f_p is the compressive strength masonry wall (prism) (N/mm^2)
F_{max} is failure load (N)
A is the cross-sectional area of the face of the prism (mm^2)

Plate IV: Some of the Cast Prisms

Plate V: Prisms that Suffered Bonding

Plate VI: Test on Compressive Strength of Prisms

3.3 Stress-Strain Behaviour and Elastic Modulus

The stress-strain curves of the prisms were determined by the double averaging method in line with similar researches (Costigan et al., 2015; Kaushik et al., 2007; Thaickavil & Thomas, 2018). According to the researchers, the method is how averaged strain values are plotted on the abscissa against the predetermined stress values on the ordinate, which are also averaged across different specimens. The modulus of elasticity was then calculated using equation 3, which was derived from stress-strain curves by measuring the slope of secant between ordinates corresponding to 33% (1/3) of the ultimate strength of the specimen samples according to BS EN 1996-2: 2006 and MSJC 2002.

To determine the strain values for all the samples used for the experiments, deformation was measured using a long-plunger dial gauge connected to the testing machine, as shown in Plate IX.

$$E_c = \frac{F\ (N)}{3\epsilon A\ (mm^2)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

Where E_c is the modulus of elasticity, ϵ is the compressive strain at any point on the stress-strain curve, F is the applied force at a particular stage, A is the loaded cross-sectional area of the face of the sample.

The dial gauge with serial number 213211 and 0.0001mm division was made in England by John Bull British Indicator limited. The deformations were measured at their corresponding loadings of the samples. The loadings on the samples of the prisms were in the range; 5-10KN, 10-20KN, 20-40KN and failure load, which varied depending on the samples. The process was carried out at 28, 56 and 90 days. To avoid errors, it was ensured that the displacement meter on the dial gauge was zeroed when the loading on each sample was also at zero and the head of the long plunger of the dial gauge was made to touch the face of the moving plate of the testing machine. This was ensured when the plates were already in contacts with the sample. After multiplying the readings on the dial gauge by its division (0.0001mm), the strain values were now calculated by dividing the distance travelled by the original height of the samples.

4 Results and Discussion

4.1 Initial Rate of Absorption of Earth-Cobs (IRA)

The absorption of moisture by capillary action in the earth cobs produces a suction effect that draws water from the poured earth, and the result is shown in Table 2. It shows the result of the IRA test on the earth cobs before their usage for masonry wall construction. The result varies from 0.63 to 2.95kg/m^3/min according to the types of earth-cobs and age.

Table 2. Initial Rate of Absorption (IRA) of the Earth-cobs

S/N	Designation	Initial Rate of Absorption (kg/m^2/min)			
		21 Days	28 Days	56 Days	90 Days
1	B_1	1.05	0.92	0.88	0.63
2	B_2	2.74	1.52	1.22	1.21
3	B_3	2.95	1.72	1.31	1.27

A higher value of IRA was found with earth-cobs of 5% and 10% cement stabilization (B_2 and B_3). This could be because of more hydration reactions in the stabilized earth cobs. It is also seen that IRA values decrease with an increase in age for all earth-cobs used for the research. This could also be because of a reduction in the hydration processes as age increases. Therefore, the suction effect of the earth-cobs through capillary action increases with the percentage addition of cement and generally reduces as the age increases.

4.2 Compressive Strength of Masonry Walls

4.2.1 Compressive Strength of Masonry Walls with 0% Cement in Poured-earth Combined with Different Earth-cobs

In this set of prisms, the results show that only samples of S_1B_0 have the visible result, as shown in Table 3. The research is not visible for S_1B_1, S_1B_2 and S_1B_3 because there is no bond between the earth-cobs and poured-earth for S_1B_2 and S_1B_3, thereby causing major cracks in the samples. However, for S_1B_1, there was a little bond that is not enough to hold the two components together, thereby causing lesser cracks in the samples. The results of S_1B_2 and S_1B_3 could be because of the high water-absorptivity (suction value) of B_2 and B_3 earth-cobs combined with poured-earth with very low water retentivity (S_1). The little bond formed for S_1B_1 could be because of the low suction effect of B_1 combined with very low water-retentivity of the poured- earth, S_1. There was rapid sucking of water from the poured-earth by the earth-cobs leading to insufficient water for binding processes, thereby creating major cracks in the samples. The result of S_1B_0 increases with an increase in age, as shown in the table.

4.2.2 Compressive Strength of Masonry Walls with 5% Cement in Poured-earth Combined with the Different Earth-cobs

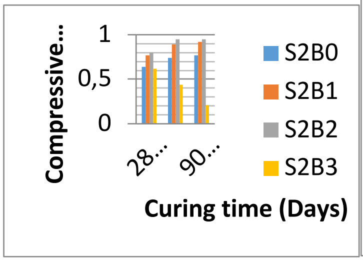
The results of compressive strengths of a masonry wall with 5% poured earth is shown in Figure 1. It shows that the research is visible for all the samples of the walls. Compressive strength of the walls increases with the increase in age and percentage increase in cement addition for the earth-cobs for all the samples except S_2B_3. The two materials were seen to be properly bonded with very few light cracks in the samples except for S_2B_3, whose cracks become obvious as the materials dry with age. The visibility of the bond could be because of the ability of poured-earth to withstand the suction effect of the earth-cobs in the combinations (S_2B_1 and S_2B_2) thus, making water available for hydration of cement in the poured earth. In the case of S_2B_3, the result could be attributed to the very-high absorptivity of earth-cobs combined with the low water-retentivity of poured-earth (S_2). The increase in the strength as the age increases for S_2B_0, S_2B_1 and S_2B_2 could result from a continuous increase in the hydration reactions in the poured earth, thereby making their bonds stronger. Nevertheless, in the case of S_2B_3, the decrease in strength as the age increases could be because of continuous water absorption from the poured-earth through capillary action by earth-cobs, B_3 leading to insufficient water for hydration of cement in the poured-earth.

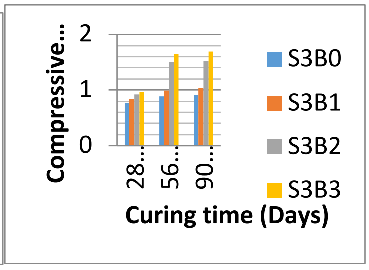
4.2.3 Compressive Strength of Masonry Walls with 10% Cement in Poured-earth combined with Different Earth-cobs

The results of compressive strengths of a masonry wall with 10% poured earth is shown in Figure 2. It shows that the research is visible for all the samples of the walls. Compressive strengths are observed to increase with the increase in age and percentage increase in cement addition for earth-cobs for all the samples. The two materials were observed to be properly bonded with no crack in the samples. This could be attributed to the high water-retentivity of poured-earth (S_3). It means that the poured earth can retain water against the suction effect of the earth-cobs, thereby making enough water available for hydration of cement in the mix. The strength increase with age could be attributed to a continuous process of hydration of cement in the poured-earth mix.

4.2.4 Compressive Strength of Masonry Walls with 15% Cement in Poured-Earth combined with Different Earth-cobs

The results of compressive strengths of masonry wall samples with 15% poured earth is shown in Figure 3. It shows that the research is also visible for all the samples of the walls. The compressive strength of the masonry wall is observed to increase with the increase in percentage cement addition of the earth-cobs for all the samples. The two materials were seen to be properly bonded with no crack in the samples. The improved strengths in this case, when compared with when poured-earth with 10% cement addition was used, could be attributed to two reasons: availability of more binding material (cement) and very high water-retentivity of the poured-earth (S4) against the suction effect of the different earth-cobs making more water available for the hydration of cement. The strength increase with age could be attributed to a continuous process of hydration of cement in the poured-earth mix.





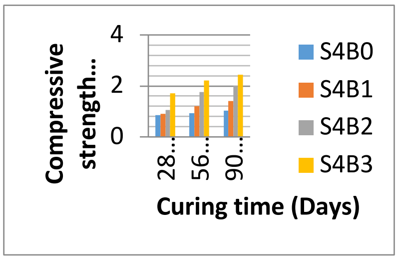


Fig 1: Compr str of 5% cement P.E masonry Fig 2: Compr str of 10% cement P.E masonry Fig. 3: Compr str of 15% cement P.E masonry

4.2 Stress-strain Curves and Elastic Modulus of the Masonry Wall

For the poured-earth/earth-cobs (peec) masonry wall, the stress-strain curves for the wall samples when the four types of poured-earth were combined differently with the three types of earth-cobs are shown in figures 4-12. The curves generally show that the curves consist of rising and falling parts, and the following were deduced as control points. According to Kaushik et al. (2007), these control points can be effectively used to define the performance limits states of the peec masonry wall.

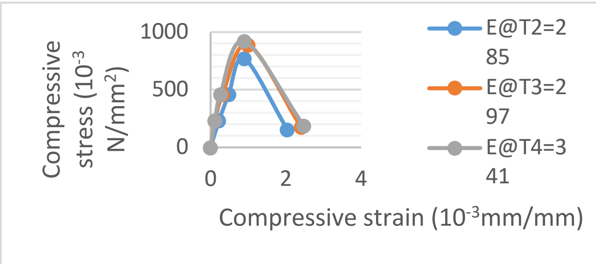
(i) One-third of maximum compressive strength represents the point up to which the stress-strain curve remains linear. Thereafter, several cracks start to develop in the peec masonry wall samples introducing non-linearity

(ii) At the ultimate stress level, the maximum compressive strength is achieved. Then, the peec masonry wall samples drop the load and exhibit a sudden increase in strain value.

(iii) 0.2 of maximum compressive strength is the maximum residual compressive stress and corresponding failure strain observed in the peec masonry wall sample

The results of the stress-strain curves in the figures show that clauses (i), (ii) and (iii) agree with the clauses already established by Kaushik et al. (2007) on brick masonry. Therefore, the elastic region of the masonry wall is between compressive stresses of zero to 0.33 of the maximum compressive stress (point of elastic limit), then the plastic region begins up to a point 0.2 for the masonry wall. The materials are seen to be fully plastic from the point of maximum compressive strength.

The result of elastic modulus from the stress-strain curves shows that it generally increases with an increase in age. The increase in elastic modulus as the age increases is due to an increase in the elastic region of the material with age, thereby making it more elastic. Therefore, the resistance of the material to failure by fracture or excessive deformation when loaded (stiffness) increases with the age of the samples.



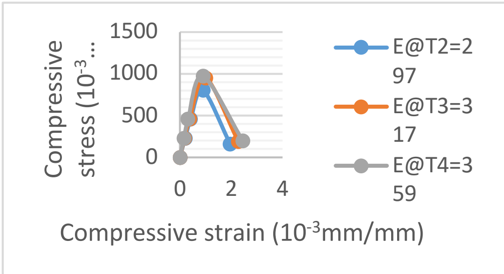
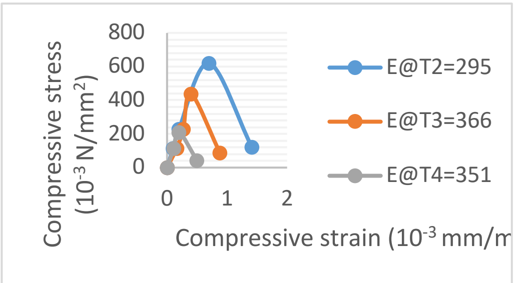


Fig. 4: Stress-Strain Curves for S_2B_1 at 28, 56 & 90 days

Fig. 5: Stress-strain Curves for S_2B_2 at 28, 56 & 90 days



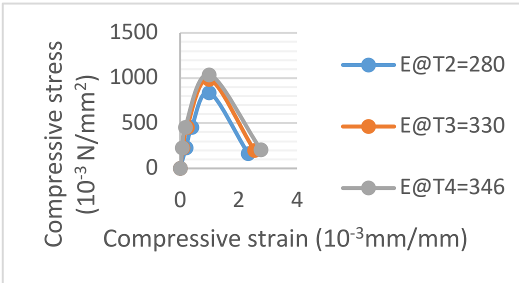
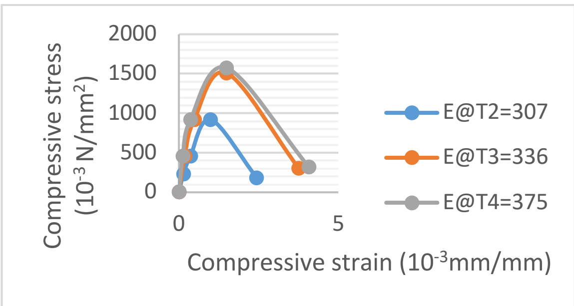


Fig. 6: Stress-strain Curves for S_2B_3 at 28, 56 & 90 days

Fig. 7: Stress-strain Curves for S_3B_1 at 28, 56 & 90 dayS



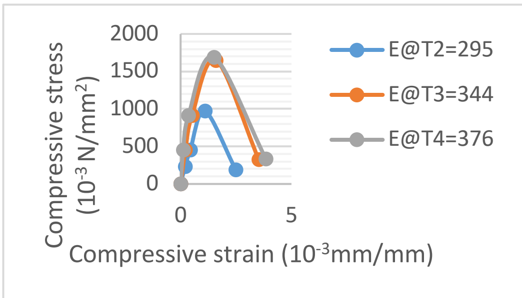
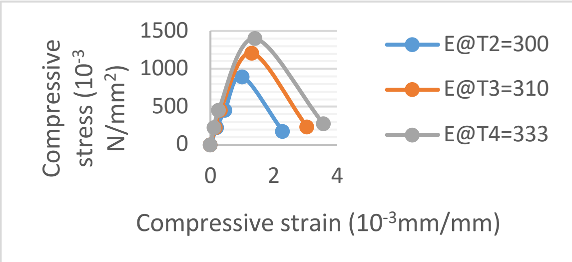


Fig. 8: Stress-strain Curves for S_3B_2 at 28, 56 & 90 days

Fig. 9: Stress-strain Curves for S_3B_3 at 28, 56 & 90 days



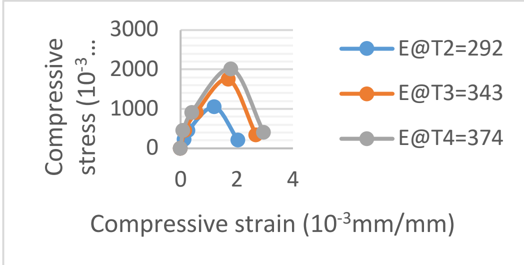


Fig. 10: Stress-strain Curves for S_4B_1 at 28, 56 & 90 days Fig. 11: Stress-strain Curves for S_4B_2 at 28, 56 & 90 days

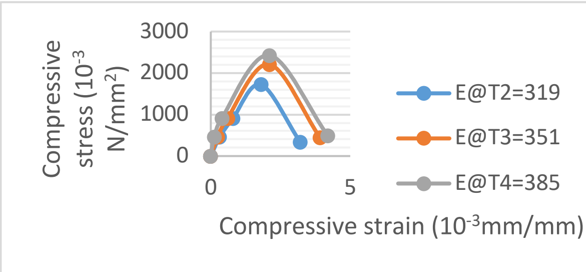


Fig. 12; Stress-strain Curves for S_4B_3 at 28, 56 & 90 days

5 Conclusion

1. From the experiments, the following factors were highlighted as factors responsible for major cracks and improper bonding between the spherical earth-cobs and poured-earth in the prisms.
   a. unsuitable diameter of earth-cobs in the samples of prisms
   b. the unsuitable ratio of the volume of earth-cobs to the volume of poured-earth in the prisms production
   c. the high suction effect of earth-cobs in the cast prisms
   d. ow water retentivity of the poured-earth against the suction effect of the earth-cobs
   e. non-availability of gravel size in the laterite
   f. dryness of surroundings in terms of weather condition

2. The compressive strength for all the peec masonry wall samples shows that only the samples with S_4B_2 and S_4B_3 designations accurately meet the 2.0N/mm^{2}load-bearing compressive strength for stabilized rammed earth walls in line with International Building Code (ICC), 2006. S_3B_1, S_3B_2 and S_3B_3 have values ranging from 1.04N/mm2 to 1.69N/mm2, which fall within the range of non-load bearing wall.

3. The performance limits states established for the peec masonry wall are elastic region, elastic limit, elastoplastic region and plastic region. The performance limits can be used in structural and numerical analyses of peec masonry structures. Therefore, their stress-strain curves conform with the stress-strain curve already established by BS EN 1996-2: 2006 for brick masonries.

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Prospects of Multiskilling as a Construction Labour Deployment Strategy during Covid-19 Pandemic Post-lockdown Era in Nigeria: A Study of Selected Projects in Abuja Municipal Council

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Abstract:
Construction labour constitute critical resource in nation's infrastructure delivery. Management of some construction organizations during the post-lockdown era in Nigeria's federal capital territory (FCT), adopted multiskilling as a strategic response to the ravaging effects of COVID-19 on site labour-force, by minimizing their number of tradesmen without loss of planned productivity, continuity and quality targets. This study examined the extent to which multiskilling of construction tradesmen led to achievement of planned productivity levels, continuity of operations, and extent to which output quality of multiskilled tradesmen compared with traditional single trades. Descriptive survey research methodology was adopted with structured questionnaire as research instrument administered to a sample of 210 respondents selectively chosen from a study population of 380 project site administrators in six towns of Abuja municipal council. Study's results showed that adoption of multiskilling at the project sites achieved high productivity (0.76), ensured high continuity (0.77), and produced comparably high-quality standards (0.74). From the findings, a legislation of construction trade multiskilling would serve as a strategic response to site-level human capacity planning and scheduling of tradesmen, towards maintenance of planned productivity, continuity, quality performance, and workmen safety during post-lockdown era of COVID-19 pandemic in Nigeria.

Keywords:
Construction tradesmen, COVID-19 pandemic, multi-skilling, post-lockdown, Nigeria

1 Introduction

Wuhan, China, sometime in December 2019, experienced an outbreak of the novel Coronavirus. This disease was said to have killed over 1,800 and infected 70,000 individuals within the first 50 days of the epidemic (Sheeran, et al., 2020). The disease was spread mostly through person-to-person contact, and the virus responsible was named Covid-19, by Chinese researchers. The World Health Organization (WHO) declared the Covid-19 outbreak a pandemic on March 11, 2020 as the virus continued to spread across countries and continents. By late November, 2020, the WHO recorded over 61.8 million confirmed cases globally with over 1.4 million reported deaths since the start of the pandemic (WHO, 2020). The pandemic led to consequential adverse impact on social-economic activities globally, as such, Nigeria was not spared. Gamol & Alhager, (2020) identified the most significant consequences of COVID-19 pandemic on the construction industry as suspension of projects, labour impact and job loss, time overrun, cost overrun, and financial implications.

Unlike many other sectors, the construction industry requires nearly all categories of workers to perform or monitor work activities to ensure effective project delivery (Gamol & Alhager, 2020). Hence, during the pandemic, construction firms faced more challenges and had to seek for flexible ways to maintain workflow, site productivity and output quality without exposing the workforce to the dangers of COVID-19 virus, by adopting a physical distancing, non-pharmaceutical labour deployment strategy known as multiskilling. The opportunity for flexible working is a distinguishing feature of modern construction industry work culture. It is considered beneficial to both employers and employees. For the employee, it gives room for leveraging on skills, hence, the ability to go undertake tasks beyond immediate roles. Multiskilling is part of an organization's deliberate change strategy, with the objective of improving efficiency, competitiveness, reducing costs, improving quality, and increasing production (Horbury & Wright, 2001). Chapman, (2020) states that multiskilling is particularly ideal during unpredictable business climate, where need for downsizing of labourforce arise, and in situations that necessitate a freeze in recruitment. The theory of labourforce down-sizing in the wake of unpredictable business climate occasioned by COVID-19 pandemic, necessitating physical distancing, a non-pharmaceutical prevention measure, constitutes the fundamental premise in which this study on 'multiskilling' is underpinned.

1.1 Problem Statement and Justification of the Study

The construction industry is labour-intensive and its activities made-up of several crafts (Lill, 2009) with labour costs constituting a critical component of the overall development cost, despite improved level of mechanization of activities in recent years (Gunduz & Abu-Hijleh, 2020; El-Gohary & Aziz, 2014). The industry requires nearly all categories of workers to perform or monitor work activities to ensure effective project delivery. This, under the new normal is not feasible due to the Covid-19 pandemic. Also, the growing demand for environmentally sustainable construction imply that traditional practices must change. These are issues that require new ways of thinking, necessitating new approaches to established conventions to maintain tempo of activities without loss of productivity, while meeting contractual obligations of time, cost, and functionality (Kalirajan & Babu, 2019).

Multiskilling is an innovative labour planning and scheduling strategy by which few workmen each with multi-skills are deployed on activities and processes to maintain required workflow and productivity. Unfortunately, COVID-19 pandemic does not occur regularly in the course of human existence, as such, pioneering researches are scarce and to a large extent non-existent especially as it relates to construction labour management. Construction firms can exploit this innovation to boost productivity level, quality, safety, and improve project management (Maskuriy et al., 2019), as well as competitive advantage (Aghimien, 2019).

1.2 Aim of Study

This study explores multiskilling, a flexible labour planning and scheduling strategy, that deploys tradesmen with capability to perform two or more roles, without compromise to site productivity targets and as a non-pharmaceutical strategic response that promotes physical distancing with the aim of substantially minimizing the numerical strength of traditional workforce, to guard against the spread of COVID-19 during the post-lockdown era.

1.3 Objectives of the Study

1. to examine the extent to which multiskilling of construction tradesmen achieved planned productivity levels during COVID-19 post-lockdown era

2. to assess the extent to which multiskilling ensured continuity of operations during COVID-19 post-lockdown era

3. to evaluate the extent to which output quality of multiskilled tradesmen compared with traditional single trades during COVID-19 post-lockdown era

2 Literature Review

2.1 Global Overview of the Construction Industry and Multiskilling Technique

The construction industry plays a strategic role in infrastructure provisioning (Soe & Cho, 2014) and in general economic development of a nation (Gunduz & Abu-Hijleh, 2020). Majority of industrial sectors including the construction sector are now considering new ways of increasing productivity, optimizing resources, raising profits and reducing costs (Bojarska & Wińska, 2019; Livotov et al., 2019; and Craveiro et al., 2019). Wright, (1996) case studies on 'Business re-engineering and health and safety management' revealed that multiskilling was used by eight out of the ten companies studied. The study observed that the multiskilled companies were from various economic sectors, namely: railways, aircraft industry, chemical manufacturing, and power generation.

The core elements of multiskilling flexible production system include- training of multiskilled workers and job rotation, characteristic of many Japanese steel plants in the late 1950s and early 1960s. Various researches corroborate the growing adoption of this flexible production systems in many Japanese corporations, involving broad skills and decentralization of specialization (Aoki, 1988; Lincoln & Kalleberg, 1990, Kagono, et al., 1985).

Andersen & Ankerstjerne, (2010) views multiskilling as a system of job design that enables an individual to perform two or more traditionally separate job functions. In doing this, some degree of training is required to help a multiskilled worker function effectively. On the contrary, multitasking though similar, do not necessarily involve training of any kind. Andersen & Ankerstjerne, (2010), identifies three dimensions of multiskilling, namely:

1. Vertical multiskilling – The employee is given a managerial function, involving supervision, an administrative task, leading or coordinating a self-managed team. By so doing, the employee develops his managerial skills and trust.

2. Horizontal multiskilling – The employee embarks on additional task(s) that are at the same level with his or her normal task.

3. Depth multiskilling – The employee acquires a set of complex skills within the main job function to enable him offer a more comprehensive, qualitative and value-added service to the client.

The practice of multiskilling eventually found its way into other industrial sectors including construction in the post-war period. Ejohwomu et al., (2006) citing Burleson et al., (1998) empirical study, revealed multiskilling as having the following benefits, in US construction sector - 5-20% savings in labour cost, 35% reduction in labour requirement, a 47% elongation of workers' average employment period, and an increase in workers' earning potential. Horbury & Wright, (2001), state that multiskilling impacts organizations' performance in several ways, including- task continuity, task supervision and coordination, resource flexibility, team deployment, staff morale, and job satisfaction. Chapman (2020), declared that to the service providers, 'multiskilling resulted in better project deliverables and also enhanced productivity'.

3 Research Methodology

This empirical study involved descriptive survey research design in which structured questionnaire was administered to a sample size comprising 210 project site administrators purposively selected from a study population of 380, working on ongoing public and private building projects in six towns of Abuja Municipal Council (AMC) area, namely- Asokoro, Garki, Wuse, Maitama, Wuye, and Utako. The projects were undertaken by medium to large sized building construction firms, each with operational experience spanning over 10 years, and pre-COVID-19 labourforce ranging between 150-250 workers, with large stock of construction plant/ equipment holding, and a capital base each, in excess of N5Billion. 210 out of the 380 active project sites in the municipality practice multiskilling as a deliberate construction labour strategy of physical distancing, a non-pharmaceutical measure, aimed at minimizing the numerical strength of construction personnel in the ardent effort to guard against the contact and spread of COVID-19 amongst the workforce during the post-lockdown era.

A total of 176 responses were received out of the 210 questionnaires issued to different project site administrators whose nomenclatures varied depending on the site of works, namely-project managers, site agents, contract managers, site managers, other site administrators amongst the above six stated towns of Abuja municipality, thus, representing 83.31% response rate. Study revealed that 86.53% of the project site administrators were involved in site-level human resource management, especially in the areas of construction labour recruitment, selection, placement, scheduling, deployment, training and development, health and safety, discipline, promotion, demotion, and withdrawal/termination of services.

The trades that practiced several combinations of multiskilling, majorly 2-4 skills per tradesman, included block/bricklaying, masonry, carpentry, joinery, fitters, tilers, painters, plumbers, electricians, roofers, concreting, and helpers. The study adopted factor analysis (FA) approach in the analysis of Table 3 (Objective-1), Table 4 (Objective-2), Table 5 (Objective-3), and Table 6 (Objective-4). Likert 5-point scale was adopted as response metric for items of survey, in descending order of scale, viz; TGE-to a great extent (5); TCE- to a considerable extent (4); TME-to a moderate extent (3); TLE- to a low extent (2); and TNE- to a no extent (1), thus, following the path established by several scholars and researchers in the social sciences. This research was conducted for a period of 22 weeks, specifically between mid-September, 2020 and end of February, 2021.

4 Findings and Discussion

Table 1 shows that a majority of the respondents were male site administrators (89.21%) while a few were females (10.79%). The distribution of educational qualification of the respondents are as follows: PhD (1.14%); MSc/MTech (18.75%), BSc/BTech (28.98%), HND/OND (44.32%), and others (6.81%); hence, a majority of the project site administrators possessed between HND/OND - BSc/BTech (73.30%). The job experience of respondents was as follows; below 10 years (7.95%), 11-15years (38.07%), 16-20 years (40.43%), over 20 years (13.55%); hence a majority of the project site administrators had a minimum job experience of 11years (78.50%). Adjudging from the results of the studies, it can be deduced that majority of the respondents (project site administrators) attained reasonable education level, and also possessed considerable wealth of industry experience. As such, their responses would be considered a fair sense of judgment on issues raised by the survey.

Table 1. Descriptive Statistics of Respondents (Project site administrators)

Demographics	Categories	Frequency	Percent (%)
Gender	Male	157	89.21
	Female	19	10.79
	Total	176	100.00
Education Level	PhD	2	1.14
	MSc. /MTech.	33	18.75
	BSc. /BTech	51	28.98
	HND/OND	78	44.32
	Others	12	6.81
	Total	176	100.00
Job experience in years	Below 10years	14	7.95
	11 – 15 years	67	38.07
	16 – 20 years	71	40.43
	Over 20 years	24	13.55
	Total	176	100.00
Designation/Job position	Project Manager	29	16.48
	Site Agent	47	26.71
	Contract Managers	38	21.59
	Site Manager	33	18.74
	Othersite Administrators	29	16.48
	Total	176	100.00

Source: Authors' Field Survey, 2020-2021

Table 2 shows that a total of 210 questionnaires were issued as follows: Asokoro-32, Garki-33, Wuse-38, Maitama-34, Wuye-37, and Utako-36. A total of 176 valid responses were received from different designations of project site administrators across the six selected towns in Abuja Municipal Council, namely: Project managers (16.48%), Site agents (26.71%), Contract managers (21.59%), Site managers (18.74%), and other site administrators (16.48%). The distribution of the return rates according to the selected towns are as follows: Asokoro (81%), Garki (76%), Wuse (95%), Maitama (82%), Wuye (92%), and Utako (75%). Results show that each of the towns had a relatively high response rate when compared with the number issued.

Table 2. Descriptive Statistics of Questionnaires distributed and responses received from different site administrators in selected towns of Abuja Municipal Council (AMC) during COVID-19 post-lockdown era.

Selected towns in AMC	Project Managers (16.48%)			Site Agents (26.71%)			Contract Managers (21.59%)			Site Manager (18.74%)			Other Site Administrators (16.48%)			Total Nr Issued/ Returned		
	NI	NR	%	NI	NR	%	NI	NR	%	NI	NR	%	NI	NR	%	NI	NR	%
Asokoro	3	2	67	9	8	89	3	2	67	10	9	90	7	5	71	32	26	81
Garki	5	3	60	7	6	86	7	6	86	10	8	80	4	2	50	33	25	76
Wuse	9	9	100	12	11	92	5	5	100	2	2	100	10	9	90	38	36	95
Maitama	4	3	75	7	5	71	8	7	88	6	6	100	9	7	77	34	28	82
Wuye	8	8	100	8	7	88	13	12	92	5	5	100	3	2	67	37	34	92
Utako	6	4	67	13	10	77	7	6	86	4	3	75	6	4	67	36	27	75
TOTAL	35	29	85	56	47	84	43	38	88	37	33	89	39	29	74	210	176	83.81

NI = Number of Questionnaires issued; NR = Number of Questionnaires returned; % = Percentage of Questionnaires Returned

Source: Authors' Field Survey, 2020-2021

Objective 1: To examine the extent to which multiskilling of construction tradesmen achieved the planned productivity levels during COVID-19 post-lockdown era

Table 3, measures the extent to which multiskilling achieved planned productivity levels in construction trades during COVID-19 post lock-down era. The results show a weighted agreement factor of 0.75 for Asokoro, 0.72 (Garki), 0.74 (Wuse), 0.81 (Maitama), 0.79 (Wuye), and 0.77 (Utako). The weighted agreement factors for achievement of planned productivity (APP) construct in the six towns was relatively high. The average agreement factor (AAF) for APP construct is 0.76, and well above 0.70. This high result aligns with the study of Kalirajan & Babu, (2019), which stated that new approaches to conventional construction practices were necessary without loss of productivity. Study results also averred with the researches of Bojarska & Wińska, (2019); Livotov et al., (2019); and Craveiro et al., (2019), which stated that majority of industrial sectors including the construction sector are now considering new ways of increasing productivity, optimizing resources, raising profits and reducing costs.

Table 3. Extent to which multiskilling of construction tradesmen achieved the planned productivity levels during COVID-19 post-lockdown era

S/No	Town in Abuja Municipal Council (AMC)	No of Multiskilling sites studied in the Town	No of Multiskilling sites that responded	% response	Responses TGE……………………TNE					Weighted Agreement Total (WAT)	Weighted Agreement Factor (WAF)
					5	4	3	2	1		
1	Asokoro	32	26	81	8	10	3	3	2	97	0.75
2	Garki	33	25	76	9	9	4	2	1	90	0.72
3	Wuse	38	36	95	11	15	6	4	2	133	0.74
4	Maitama	34	28	82	13	8	4	2	1	114	0.81
5	Wuye	37	34	92	10	16	5	3	-	135	0.79
6	Utako	36	27	75	7	14	3	1	2	104	0.77
	TOTAL	210	176	83.81	58	67	30	15	8	673	4.58/6 AAF=0.76

Weighted Agreement Total (WAT); Weighted Agreement Factor (WAF); Average Agreement Factor (AAF)

Source: Authors' Field Survey, 2020-2021

4.2 Objective 2: To assess the extent to which multiskilling ensured continuity of operations during COVID-19 post-lockdown era

Table 4. Extent to which multiskilling ensured continuity of operations during COVID-19 post lock-down era

S/No	Town in Abuja Municipal Council (AMC)	No of Multiskilling sites studied	No of Multiskilling sites that responded	% response	Responses TGE……………..……..TNE					Weighted Agreement Total (WAT)	Weighted Agreement Factor (WAF)
					5	4	3	2	1		
1	Asokoro	32	26	81	11	8	5	2	-	106	0.82
2	Garki	33	25	76	7	10	4	3	1	94	0.75
3	Wuse	38	36	95	12	9	7	5	3	130	0.72
4	Maitama	34	28	82	9	10	6	2	1	108	0.77
5	Wuye	37	34	92	10	13	8	3	-	132	0.78
6	Utako	36	27	75	8	11	4	2	2	102	0.76
	TOTAL	210	176	83.31	57	61	34	17	7	672	4.60/6 AAF=0.77

Weighted Agreement Total (WAT); Weighted Agreement Factor (WAF); Average Agreement Factor (AAF)
Source: Authors' Field Survey 2020-2021

Table 4, measures the extent to which multiskilling ensured continuity of operations in construction trades during COVID-19 post lock-down era. The results show a weighted agreement factor of 0.82 for Asokoro, 0.75 (Garki), 0.72 (Wuse), 0.77 (Maitama), 0.78 (Wuye), and 0.76 (Utako). Similarly, the weighted agreement factors for achievement of continuity in operations (ACO) construct in the six towns was relatively high. The average agreement factor (AAF) for ACO construct is 0.77, and well above 0.70. This result aligns with Horbury & Wright, (2001), which stated that multiskilling impacts organizations' performance in several ways, including- task continuity amongst others.

4.3 Objective 3: To evaluate the extent to which output quality of multiskilled tradesmen compared with traditional single trades during COVID-19 post-lockdown era

Table 5: Extent to which output quality of multiskilled tradesmen compared with traditional single trades during COVID-19 post-lockdown era

S/No	Town in Abuja Municipal Council (AMC)	No of Multiskilling sites studied	No of Multiskilling sites that responded	% Response	Responses TGE…………………..TNE					Weighted Agreement Total (WAT)	Weighted Agreement Factor (WAF)
					5	4	3	2	1		
1	Asokoro	32	26	81	10	7	4	3	2	98	0.75
2	Garki	33	25	76	8	9	5	2	1	96	0.77
3	Wuse	38	36	95	12	11	8	3	2	136	0.76
4	Maitama	34	28	82	7	13	4	2	2	105	0.75
5	Wuye	37	34	92	9	12	7	4	2	124	0.73
6	Utako	36	27	75	8	9	7	2	1	94	0.70
	TOTAL	210	176	83.31	54	61	35	16	10	653	4.46/6 AAF=0.74

Weighted Agreement Total (WAT); Weighted Agreement Factor (WAF); Average Agreement Factor (AAF)
Source: Authors' Field Survey, 2021-2021

Table 5, measures the extent to which output quality of multiskilled tradesmen compared with traditional single trades during COVID-19 post lock-down era. The results show a weighted agreement factor of 0.75 for Asokoro, 0.77 (Garki), 0.76 (Wuse), 0.75 (Maitama), 0.73 (Wuye), and 0.70 (Utako). Similarly, the weighted agreement factors for achievement of single trades output quality (SOQ) construct in the six towns was relatively high. The average agreement factor (AAF) for SOQ construct is 0.74, and well above 0.70. The result of the study aligns with that of Chapman (2020), which stated that to the service providers 'multiskilling resulted in better project deliverables (quality output) and also enhanced productivity'.

5 Conclusions and Further Research

The most significant impacts of COVID-19 pandemic on the Nigerian construction industry included suspension of projects, labour downsizing and job losses, construction time and cost overruns, and several others. In view of these challenges, construction firms had to seek for flexible ways to maintain workflow, site productivity and output quality without exposing the workforce to the dangers of COVID-19 virus, by adopting a physical distancing, non-pharmaceutical labour deployment strategy known as multiskilling.

This study examined the extent to which multiskilling of construction tradesmen during COVID-19 post-lockdown era, led to achievement of planned productivity levels; ensured continuity of operations; and the extent to which output quality of multiskilled tradesmen compared with traditional single trades. Descriptive study research methodology was employed and the research instrument involved structured questionnaire administered to 210 project site administrators working in Asokoro, Garki, Wuse, Maitama, Wuye, and Utako towns of Abuja Municipal Council, representing 83.81 response rate. Data obtained from study's results was analysed using factor analysis statistical technique. The studies showed that multiskilling of tradesmen achieved high productivity (0.76), ensured high workflow continuity (0.77), and attained comparably high-quality standards (0.74). From the findings, government legislation of construction trade multiskilling would serve as a strategic response to site-level human capacity planning and scheduling, in ensuring productivity, continuity, quality performance, and workmen safety at construction sites during COVID-19 pandemic post-lockdown era. The study recommends a further research on 'the level of awareness and degree of adoption of multiskilling' in construction firms in Nigeria's North-central geo-political zone.

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Assessing Barriers and Facilitators to Adoption of Design for Safety by Construction Organisations in Nigeria

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Abstract:
Reactive construction safety measures are becoming increasingly criticised for their poor bearings on construction accident hazards. Conversely, Design for Safety (DfS) is a proactive measure, proven to have improved on the state of construction Health and Safety performances. Studies, however, show that the adoption of DfS in developing countries to be poor. This study thus assessed the barriers and facilitators to the successful adoption of DfS by construction organizations in Nigeria. A quantitative research approach was used, collecting data via structured questionnaires administered to construction organisations. The data was analysed using descriptive statistics (mean and standard deviation). The study found ‘Client interest in the use of DfS in their projects’, ‘Top Management support and commitment’ and ‘Government policy via legislation’ to be the most important facilitators for adopting Design for Safety in the Nigerian construction industry. While ‘More satisfied clients', 'Shorter construction periods' and, 'Better construction and maintenance safety' were the most important benefits of adopting Design for Safety in the Nigerian construction industry. With regards to barriers, the study found 'Other project objectives given higher priority by project stakeholders', 'The predominant use of the traditional project delivery method' and 'Absence of collaboration between designers and contractors' to be the essential contractual related barriers to the adoption of Design for Safety in the Nigerian construction industry. The study concludes that barriers that hamper the successful adoption of the DfS practice pose as risks that will continue to prevent successful adoption of DfS through the effective use of the facilitators for the adoption of Design for Safety in the Nigerian construction industry. The study recommends that government should also provide a more enabling environment by enacting policies and legislation that will guide and ease the implementation of Design for Safety and focus attention on client interest, top management commitment and support, and government policy via legislation.

Keywords: Construction, design for Safety, Health and Safety performance, Nigeria

1 Introduction

Inadequate Health and Safety (H&S) activities have resulted in accidents and injuries that sometimes result in death or permanent deformity to victims in the construction industry. This, therefore, hampers the success on the delivery of projects by being responsible for projects overrunning their budgeted costs and time, disputes within and outside organisations, organisations losing their reputation, and bad image for the construction business (Kheni, Gibb and dainty, 2010; and Project Management Institute, PMI, 2017).

To ensure apt H&S and thus facilitate successful delivery of projects, strategies have been recommended by various studies, which include the use of personal protective equipment (PPE), consistent training on safety, adequate supervision of works, regulatory laws, creating behavioural health awareness, and building safety environment at construction sites. (Lingard and Turner, 2016; Diugwu, and Occupational Safety and Health Administration, OSHA, 2016). However, although these strategies resulted in considerable improvement of H&S performance, they have been termed reactive as findings have revealed a gap in safety performance (Bureau of Labor Statistics, 2009).

These findings from researchers coined the roots for consideration of safety at the design stage (Hinze and Wiegand, 1992), which has been a proactive approach referred to as Design for Safety (DfS). Since its adoption, the approach yielded benefits that include reducing construction accidents, improving efficiency in cost, time and productivity, because it takes into account the project lifecycle completely (Gambates, Hinze and Haas, 1997; and Institute for Safety through Design, 2003). These benefits have long-term effects due to reduced construction costs and enhanced safety at the operation and maintenance phase. However, even with the identified benefits of this proactive approach, its adoption is still being troubled by numerous factors, consisting of the absence of adequate regulatory requirements, heightened designers' cost, designers resisting in fear of lawsuits by accident victims (Toole and Erger, 2019).

Manu et al. (2018a) acknowledged studies on DfS focusing on developed countries, including Australia, the United Kingdom, and the United States of America with limited attention to the developing countries. In a step towards bridging that wide gap, Manu et al. (2018a) and Manu et al. (2018b) studied the awareness and practice of DfS among architects in the Nigerian construction industry and that of Ghana. They found them to be aware of the concept of DfS. However, even with the efforts above, the adoption is still low. This study assessed the barriers and facilitators to the successful adoption of DfS in the Nigerian construction industry to bridge this gap. Developing countries have been found to experience poorer H&S performance (Umeokafor, 2015), requiring the adoption of proven measures like DfS (Manu et al., 2018b). Furthermore, to improve the practice of novel measures, the establishment of essential requirements is needed (Combe, 2014), and the absence of such would hamper the effective adoption of these measures. The study will benefit designers, clients, and contractors in the successful execution of projects by bringing about improved health and safety performance and, hence, improved success on the delivery of projects.

The aim of this study, which is to assess the barriers and facilitators of DfS adoption by Nigerian construction organisations, was achieved by identifying the barriers and facilitators for DfS adoption. The identified factors were then assessed. The scope of the study considered clients, contractors and consultants in the construction mainstream. This is because they are deemed to hold the fundamental key for DfS practice (Manu et al., 2018a).

2 Literature Review

2.1 Design for Safety (DfS)

This has to do with approaching construction safety right from the design stage. Many terms have been used over the years to refer to the approach which include "Design for Construction Safety (DfCS)", "Construction Hazard Prevention through Design (CHPtD)", "Prevention through Design (PtD)" and "Safety in Design (SiD)". Several authors have given various definitions for DfS. Behm (2005) referred to DfS as considering the safety of the construction site during a project's design. Toole (1997) gave its definition as safety constructability, while Schulte et al. (2008) defined it as the approach of expecting and designing out probable occupational safety and health hazards and risks related to new procedures, structure, equipment, tools and the organisation of works in a way which puts into account the construction, maintenance, decomposition disposal/recycling of waste materials while identifying the economic and social benefits of doing so.

2.2 Benefits of DfS Implementation

Implementing DfS has the primary goal of the construction worker's safety on site (Toole and Gambatese, 2008). DfS, a proactive method of identifying and eliminating construction hazards, has been safer and has better cost-effectiveness than reactive hazard management (Toole and Gambatese, 2008). Another issue which the DfS tackles is the high rate of injuries and casualties resulting from accidents (Gambatese 1998; Hagan et al., 2009). Manuele (1997) also stressed that through the application of DfS notions, more output could be realised and a decrease in the cost of operation and retrofitting.

Some benefits also found from the implementation of DfS by Gambatese et al. (1997) include improved collaboration among the various distinct project participants, healthier client approval, construction projects executed in shorter times, improved construction and maintenance safety, greater end-user safety, better design, greater health and safety performance for the industry, higher certainty, and augmented status of organisation.

2.3 Barriers to DfS Implementation

Implementing the DfS concept did not come without some barriers hindering its successful implementation. These barriers serve as a bottleneck to the success of DfS implementation. The barriers have been identified and generally grouped into four (Toole, 2005; Gambatese et al., 2017b; Tymvios, 2013; and Toole and Erger, 2019): regulatory and legal which include lack of regulatory requirements, potential resistance from professional bodies to implement the measure, increased number of lawsuits against designers, increased number of lawsuits against owners, potential designer resistance to implement the measure, and risk of liability for post construction activities; contractual barriers which encompass other project objectives given higher priority by project stakeholders, the predominant use of the traditional project delivery method, absence of collaboration between designers and contractors, poor understanding of contract terms and scopes of work, increased design duration, long implementation period, poor client trust on designers competence to practice DfS; economic barriers which consist of high short term project costs to the owner, higher fee demands from designers, increases direct and overhead costs for designers, and lack of incentives and motivation; and educational barriers to include inadequate exposure to requirements for DfS implementation, designer lacking requisite knowledge and skills, DfS construction means and methods not generally known during design, lack of DfS awareness and education programmes, misconceptions about DfS practice, and DfS seen as too complex and alien.

2.4 Facilitators for DfS implementation

Even though barriers have been identified to hamper the successful implementation of DfS, those barriers can be overcome. This can be achieved via some factors which facilitate DfS implementation. These facilitators refer to some key modifications can be done at the industry level. Tymvios and Gambatese (2016) found some factors as facilitators to the successful implementation of DfS. Some these factors have also been stressed by Gambatese et al. (2017a), Toole et al. (2017), and Atkinson and Westall (2010). They found DfS to be facilitated through factors that include client interest in the use of DfS on their project, government policy via legislation, commitment and cooperation of professional bodies, top management support and commitment, education and skills development, availability of trained professionals and attitudinal change.

3 Research Methodology

A survey strategy was adopted to accomplish the set goal of the study (Collis and Hussey, 2013). After careful literature review, the factors identified based on the context were used to draft a close-ended questionnaire to collect data for the study. The study was conducted in Kaduna, Abuja, and Lagos states of Nigeria. This was done to collect data from different country's geo-political zones to do away with bias and because these locations are the centers of construction activities in the country.

For a fair representation and coverage as this study requires, a stratified sampling technique was adopted. Ogunbameru and Ogunbameru (2010) identified stratified sampling as a sampling method used when the population is made up of sub populations with different features known as strata. Therefore, a stratified sampling technique was adopted since the population cuts across distinct strata.

The client organisations considered were experienced public client organisations (Federal ministries) and private client organisations (Property developers). The respective sample frames used were a list of federal ministries in the country and a list of property developers registered with the Real Estate Developers Association of Nigeria (REDAN). The population of these organisations were 26 and 967, respectively. The consultant organisations considered were Architectural consultancy firms, Civil Engineering consultancy firms, Project Management consultancy firms, Quantity Surveying consultancy firms, Mechanical and Electrical (M&E) consultancy firms and Building consultancy firms. The sample frames used were registers of these firms from their respective professional bodies viz; Architects Registration Council of Nigeria (ARCON), Council for the Regulation of Engineering in Nigeria (COREN), Quantity Surveyors Registration Board of Nigeria (QSRBN) and Council of Registered Builders of Nigeria (CORBON). However, there is no sampling frame identified for project management firms in Nigeria as at the time of this study. The population of these organisations were 1095, 1236, 340, 42, and 763 for the Architectural consultancy firms, Civil Engineering consultancy firms, Quantity Surveying consultancy firms, Building consultancy firms and Mechanical and Electrical (M&E) consultancy firms, respectively. The Contractor organisations considered were building contractors and heavy engineering contractors. The sample frames used were registers of these firms from their respective professional bodies viz; Council of Registered Builders of Nigeria (CORON) and Council for the Regulation of Engineering in Nigeria (COREN). The population of these organisations were respectively 61 and 411. The individual populations were summed up to get the population size for this study which was 4941.

Since all the population size cannot be studied, a sample of the population was focused on. Making use of the formula for calculating sample size proposed by Yamane (1986),

$$n = \frac{N}{1 + N(e)^2}$$

Where; n = required sample size; N = the population size (4941);e = level of precision (0.050)

The sample size for this study was calculated to be approximately 382.

The study targeted a total of 382 respondents, where the researchers recovered 188 (49%) of the questionnaires. The amount of feedback was deemed fitting as Moser and Kalton (1979) regarded the survey's response rate to be categorised as important when it has a return percentage of 30-40%.

The data collection instrument was divided into two parts: with the first part covering the respondents' area of expertise, and the other part capturing questions on the facilitators, benefits, and barriers of DfS adoption on a Likert of 1-5. On the scale 1 = Strongly disagree, 2 = Disagree, 3 = Somewhat agree, 4 = Agree and 5 = Strongly agree. The responses were evaluated using mean and standard deviation descriptive statistics. For analysis, version 25 of the Statistical Package for Social Science (SPSS) was adopted. Where 0-1.49 represent very low, 1.50-2.49 represent low, 2.50-3.49 represent moderate, 3.50-4.49 represent high and 4.50-5.00 represent very high in the table after analysis.

4 Results and Discussion

4.1 Introduction

The results of the study show that 34 of the respondents, which make 18.1% of the total respondents, were organisations engaged in architectural consultancy, property developers with 31 respondents, representing 16.5% of the total respondents, and 27 civil engineers with 14.4% of the total make up the top three respondents.

4.2 Facilitators and Potential Benefits for Adopting Design for Safety

Table 1 shows the extent of agreement of the respondents with factors that could be termed facilitators for adopting Design for Safety in the Nigerian construction industry. As shown in the table, the respondents ranked Client interest in the use of DfS in their project, Top Management support and commitment and Government Policy via legislation as the three most important facilitators for adopting Design for Safety in the Nigeria construction industry, while Commitment and cooperation of Professional bodies, Availability of trained professionals and Education and skills development were the least ranked factors. However, all the factors were significant because the mean score of the factors ranged between 4.69 to 4.33.

Table 1. Facilitators for Adopting Design for Safety

Facilitators	**Respondents' assessment**					**Mean**	**SD**	**Rank**
	1	**2**	**3**	**4**	**5**			
Client interest in the use of DfS in their project.	0	0	6	47	135	4.69	0.53	**1**
Top Management support and commitment	0	0	5	52	131	4.67	0.53	**2**
Government Policy via legislation	0	0	22	43	123	4.54	0.70	**3**
Attitudinal change	0	1	9	68	110	4.53	0.62	**4**
Commitment and cooperation of Professional bodies	0	0	15	67	106	4.48	0.64	**5**
Availability of trained professionals	0	1	15	86	86	4.37	0.65	**6**
Education and skills development	0	2	12	94	80	4.33	0.69	**7**

Source: Field Survey, 2020

4.3 Benefits of Adopting Design for Safety in the Nigerian Construction Industry

Similarly, Table 2 shows the respondents' extent of agreement with factors that could be termed as Potential Benefits for adopting Design for Safety. As shown in the table, the respondents ranked, More satisfied clients, Shorter construction periods and Better construction and maintenance safety as the three most essential benefits for adopting Design for Safety in the Nigeria construction industry. At the same time, Productivity gains, Greater predictability and Increased organisation's reputation were the least ranked factors. This is in line with the work of Toole and Erger (2019) where they identified reduced injuries and fatalities, reduced total design and construction costs for clients and faster construction durations to be among the crucial benefits of adopting DfS. However, all the factors were significant because the mean score of the factors ranged between 4.75 for the top-ranked and 3.69 for the least ranked factors.

Table 2. Potential Benefits for adopting Design for Safety

Benefits	**Respondents' assessment**					**Mean**	**SD**	**Rank**
	1	**2**	**3**	**4**	**5**			
More satisfied clients	0	0	2	43	143	4.75	0.46	**1**
Shorter construction periods	0	0	2	46	140	4.73	0.47	**2**
Better construction and maintenance safety	0	0	5	66	117	4.60	0.54	**3**
Better end-user safety	0	0	4	81	103	4.53	0.54	**4**
Improved design	0	0	13	73	102	4.47	0.62	**5**
Reduced costs	0	1	29	104	54	4.12	0.67	**6**
Less waste	0	0	48	90	50	4.01	0.72	**7**
Improved safety and health for the industry	0	1	58	107	22	3.80	0.64	**8**
Improved quality	0	5	50	112	21	3.79	0.67	**10**
Productivity gains	0	1	61	103	23	3.79	0.65	**10**
Greater predictability	0	0	70	90	28	3.78	0.69	**11**
Increased firm/organisation’s reputation	0	0	80	86	22	3.69	0.67	**12**

Source: Field Survey, 2020

4.4 Barriers to Adopting Design for Safety in the Nigerian Construction Industry

Table 3 shows the extent of agreement of the respondents with factors that could be termed as barriers militating against the adoption of Design for Safety in the Nigerian construction industry. As the table depicts, the respondents ranked, 'Other project objectives given higher priority by project stakeholders', 'Predominant use of the traditional project delivery method' and 'Absence of collaboration between designers and contractors' as the three most significant barriers against the adoption of Design for Safety in the Nigeria construction industry, while 'Increased number of lawsuits against owners', 'Potential designer resistance to implement the measure' and 'Risk of liability for post-construction activities' were the least ranked factors. This differs from what Toole and Erger (2019) found, as they found major barriers to DfS adoption to be enhanced risks of inappropriate lawsuits, owner’s resistance to increased design fees, and lack of support for the DfS process. However, all the factors were significant because the mean score of the factors ranged between 4.75 and 3.69.

Table 3. Barriers to adopting Design for Safety

Barriers	Respondents' assessment					Mean	SD	Rank
	1	2	3	4	5			
Other project objectives given higher priority by project stakeholders	0	0	2	33	153	4.80	0.42	**1**
The predominant use of the traditional project delivery method	0	0	3	39	146	4.76	0.46	**2**
Absence of collaboration between designers and contractors	0	0	5	41	142	4.73	0.50	**3**
Lack of regulatory requirements	0	1	12	35	140	4.67	0.62	**4**
High short term project costs to the owner	0	6	14	67	101	4.40	0.76	**5**
Inadequate exposure to requirements for DfS implementation	0	0	40	67	81	4.22	0.77	**6**
Higher fee demands from designers	0	4	26	93	65	4.16	0.74	**7**
Designer lacking requisite knowledge and skills	0	1	37	90	60	4.11	0.73	**8**
DfS construction means and methods not generally known during design	0	0	31	110	47	4.09	0.64	**9**
Poor understanding of contract terms and scopes of work	0	4	45	85	54	4.01	0.78	**10**
Increases direct and overhead costs for designers	0	5	38	99	46	3.99	0.75	**11**
Potential resistance from professional bodies to implement the measure	0	7	25	124	32	3.96	0.67	**12**
Increased design duration	0	6	41	99	42	3.94	0.75	**13**
Lack of DfS awareness and education programmes	0	0	56	93	39	3.91	0.71	**14**
Long implementation period	0	2	62	78	46	3.89	0.78	**15**
Poor Client trust on Designers competence to practice DfS	0	12	53	92	31	3.76	0.80	**16**
Misconceptions about DfS practice	0	7	76	62	43	3.75	0.85	**17**
Lack of incentives and motivation	0	11	83	41	53	3.72	0.94	**18**
Increased number of lawsuits against designers	0	25	56	62	645	3.68	0.98	**19**
Seen as too complex and alien	0	6	91	55	36	3.64	0.82	**20**
Increased number of lawsuits against owners	0	12	76	80	20	3.57	0.77	**21**
Potential designer resistance to implement the measure	1	0	68	89	17	3.55	0.81	**22**
Risk of liability for post-construction activities	1	23	63	75	26	3.54	0.90	**23**

Source: Field Survey, 2020

5 Conclusion

After analysing the results, the study found that 'Client interest in the use of DfS in their projects', 'Top Management support and commitment' and 'Government policy via legislation' are the most important facilitators for adopting Design for Safety in the Nigerian construction industry. While 'More satisfied clients', 'Shorter construction periods' and, 'Better construction and maintenance safety' were the most important benefits of adopting Design for Safety in the Nigerian construction industry. With regards to barriers, the study found 'Other project objectives given higher priority by project stakeholders', 'The predominant use of the traditional project delivery method' and 'Absence of collaboration between designers and contractors' to be the most important contractual related barriers to the adoption of Design for Safety in the Nigerian construction industry.

Based on the findings from this research, benefits for the adoption of DfS exists which will yield positive outcomes in the health and safety practice of the Nigerian construction industry. Barriers that hamper the successful adoption of the DfS practice pose risks that will continue to prevent successful adoption of DfS. The threats the barriers pose can be addressed through effective use of the facilitators for adoption of Design for Safety in the Nigerian construction industry. The study has revealed the key benefits, barriers, and facilitators to the successful adoption of DfS.

The study recommends that government should also provide a more enabling environment by enacting policies and legislation that will guide and ease the implementation of Design for Safety and focus attention on client interest, top management commitment and support, and government policy via legislation.

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Causes of fatality relative to construction site accidents in the KwaZulu-Natal construction industry

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Abstract:
Construction site is a high-risk threatening environment with respect to safety, due to harsh work conditions attracting different kinds of mishaps. KwaZulu-Natal Province has recorded quite a number of accidents attributed to use of machines during construction activities. Based on this the study was initiated and aims to identify causes of machine accidents in the KZN construction industry. A questionnaire survey was conducted. The data for the study were analysed using correlation analysis. Fifty (50) sites were randomly selected and surveyed. The research is limited to construction firms in the KwaZulu-Natal province in South Africa. The application of the result is limited to firms in the KwaZulu-Natal province in South Africa. Findings indicate that fatalities from machine accidents in construction sites can be avoided through observing safety protocols as expected of site workers and machine operators. Further findings indicate that one of the most significant factors of safety is the ability to have skilled, licensed and experienced plant operators. Based on data analysis, the following recommendations were reach: wearing of protective personal equipment whether a staff or allowed visitor, safety evaluation before commencement of construction activities, constant reminder that safety and health is everyone's responsibility.

Keywords: Accidents, Construction, fatality, sites, project delivery

1 Introduction

Construction site is a highly volatile and life threatening environment with regard to safety, due to harsh working conditions, attracting different kinds of mishaps. Behaviour of on-site workers, unfavourable working conditions, arguments and disagreements, carelessness and negligence, people and objects falling from heights, and many more are some of the possible reasons. There have been work principles, safety measures and researches developed toward achieving zero fatalities in site environments. The Province KwaZulu-Natal (KZN) has recorded quite a number of accidents attributed to use of machines during construction activities. Fatality is one of the results of accidents, if accidents can be minimized, then fatalities can equally be minimized.

The aim of this research work is to investigate machine related accidents in the construction industry of KZN through statistical analysis of data on construction site accidents. The causes and the rate of fatality is being assess closely to establish their relationship. This paper also compares and reviews fatalities recorded in construction environment at selected locations. Obtained findings were extensively analysed, while the outcomes of the investigation into the causes of fatal accidents in construction sites are presented. Implementation of these research outcomes is capable to mitigate fatalities caused by machines in the construction industry. This work also addresses techniques to improved work environment by using safety techniques when working under dangerous conditions.

2 Literature Review

Machinery related accidents occur on construction sites. The frequency of occurrence, cause of accidents, organizational status of victims, factors and effects, are key contributors to fatality in question. These contributors need to be assess to be able to demonstrate potent/viable approach to mitigate or prevent. Some of the causes identified are as follows: insufficient procedure of operation, inadequate machine and tools training, and failure of moving machines. In order to prescribe workable and sustainable solutions to rampant fatal accidents in construction industry, adequate research, investigation and analysis is ultimately necessary. Vasconcelos and Junior, (2015) list major basic safety and health requirements for accident free activities in construction sites:

i. Efficient health and safety procedures;
ii. Machine, equipment and spares design;
iii. Technological advancement and management style;
iv. Working conditions.

Accidents in construction sites are majorly products of complicated and interconnected causes, such as; mechanical failures, perceptions, faulty technical designs, mode of operations, teamwork and related factors are responsible for fatal accidents in construction environments (Zwetsloot et al., 2013). It is worth noting that one accident cause may not be enough to cause so much damage, as accidents are cause majorly because of complex and connected causes (Smallwood and Emuze, 2016).

2.1. Effects

Fatalities in construction industry account for some losses that threaten project productivity. The effect of the impact may be technically achieve by measuring through available data and scientific procedures. This step is important because this period in South Africa and specifically in KwaZulu-Natal region, a lot of intensive construction projects are ongoing and some concluded. A lot fatal accidents occur every year because of machine used in construction business, making it one of the highly risky industry. (Teo et al., 2005) and (Åsgård and Jørgensen, 2019). Fatalities in construction industry in Korea is on the increase, especially among older workers 45 years and above (Rhee et al., 2013).

2.1.1. Age and Experience effect

As a way of investigating risk groups among construction work environments, it is important to consider workers age and work experience period. (Mučenski et al., 2015) conduct a research that studied the impact of age and years of experience on construction accidents occurrence, the result reveal that jobs that do require training record lesser accidents. Construction workers with short period of experience tend to be more involved in site injury. According to (Levitt and Samelson, 1993), about one-quarter of construction fatalities involve workers with less than 2 months in the work. Out of 143 companies investigated in the US for construction accidents, the result indicates that fatality is about 52% higher among those who were not train, when compared with the trained (Mučenski et al., 2015). Also, age group of 18-34 have the highest construction fatal injury risk; age group 20-24 is about 27% above average, while age group 25-34 is 24% above average fatality rate (Reese and Eidson, 2006). In the contrary, fatalities occurrence in building construction work is minimal in younger age group than older age group. Age group 50-54 with experience up to 20 years have injury rate close to 70% more than average (Mučenski et al., 2015).

2.1.2. Overview of fatalities in Construction

Reports reveal that up to 52.5% of South African construction sites were not health and safety (H&S) complaint, which is attributed to insignificant influence on site health and safety by construction patrons (CIDB, 2009, Smallwood and Emuze, 2016). The country's DIIR, (Disabling injury incidence rate) is computed to be around 0.98, this means 98 injuries that could lead to disability out of 10,000 workers, while the rate of fatality was determined to be about 0.255 per 1000 construction workers (CIDB, 2009, Smallwood and Emuze, 2016).

The construction industry hires up to 10% work population in advanced nations, but contributes almost 40% work related fatality, while the International Labour Organisation (ILO) puts global figure of annual fatality at 60,000 at the rate of 1 accident every 10 minute (van Heerden et al., 2018). Of about 4,693 occupational fatalities in the US in 2016, construction sector were attributed 21%, ranging from falls from height, caught in-between, electric shock, and struck by moving objects (van Heerden et al., 2018). According to Construction Health & Safety Group report of 2020, construction sector in the United Kingdom has more cases of fatal work related accidents among all sectors as reflected in Figure1. These reviews stressed the need to investigate construction sector data in KZN to know the extent of effects and be able for determine sustainable preventive measures.

Incidents of fatal accidents because of machinery in construction is on the increase (Lee et al., 2016), calling for review of health and safety improvement measures. (Hoła et al., 2017), investigate and analyze 485 construction accidents in Poland, 37% happened to be fatal. Construction accidents are becoming frequent because of flaws and inadequate employee preparations for the work. Employee behaviour contributes to construction accident cases (Drozd, 2016). (Vasconcelos and Junior, 2015) conducted a thorough investigation into the causes and effects of fatal accidents in construction environment. A study of fatality in Portugal reveal that over 709 construction accidents were recorded in a span of three years to proffer and recommend sustainably safe construction work environment (Soeiro and Reis, 2008).

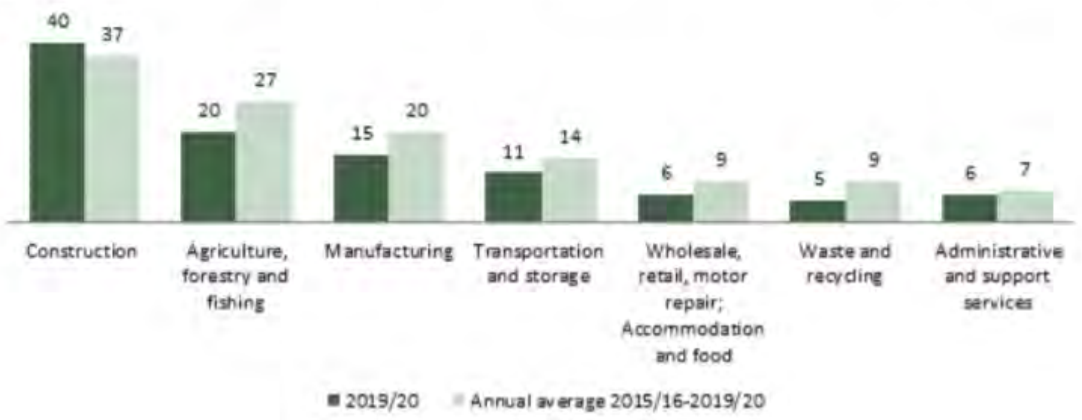

Figure 1. Number of fatal injuries by industry in the UK (HSE, 2020).

Causes because of accident type and cause because of behaviour elements were also analyze among 296 fatal excavation accidents in the US between the year 1997 and 2001 (Arboleda and Abraham, 2004). Scaffold accident accounts for considerably high number of fatal accidents in construction sites (Ismail and Ghani, 2012). Scaffolds account for 21% of non-fatal construction accidents (Cattledge et al., 1996b). 18.6% of fatalities in construction and occupational injuries between the years 1980 to 1989 were attributed scaffolds (Cattledge et al., 1996a). In Malaysia, scaffolds accident has become a serious issue to be assuaged (Ismail and Ghani, 2012). Error due to crane operation, faulty construction sites design, choice and location of equipment, are some of the causes of accidents (Lee et al., 2016).

2.2 Prevention

Because accidents affect flow of work and cause delays and losses, it should be considered as a component of the construction business, to pay a keen attention to it (Vasconcelos and Junior, 2015). Three interconnected stages were recommended to assuage the effects of construction fatalities, which are technical, human error and socio-technical stages (Swuste et al., 2012). Safety is considered one of the measurements of successful construction activities (Demirkesen and Ozorhon, 2017, Smith et al., 2014), and once jeopardized, it will affect other component of life cycle because of the overlapping effect (Åsgård and Jørgensen, 2019).
There are efforts to make construction site fatality almost zero that is; achieving accident free, injury free construction site (Smallwood and Emuze, 2016Corrective and mitigating measures should be designed based on the type of equipment used at a particular potential construction accident site (Vasconcelos and Junior, 2015).

3 Research Methodology

The paper thoroughly investigated available data obtained from trusted sources. It was base on the data obtained through questionnaire survey and the statistics of Federated Employer's Mutual Assurance Company (FEM) historical data in the province between the year 2000 and 2020. A survey was conducted by administering survey questionnaires to many construction industry professionals, identified in several construction companies around KwaZulu-Natal province of South Africa. The sample frame was 110 professionals; the sample size was 110 and were administered detailed questionnaire about site safety when using machines on site. A total number of 50 respondents gave feedbacks, which were collated from 22 February to 21 October 2020 from selected construction companies in Durban and analyzed for the purpose of this work. Ninety-five percent (95%) of respondents work in the private sector, while the remaining 5% are with the public sector. The selection of the target construction companies were based on number of employees, year of establishment, number of equipment working in construction sites and the number of accidents recorded. The sample size was drawn from big, medium and small companies.

Analysis of data was performed using Analysis of Variance with F-Test statistics. The question to test is the relationship between the average numbers of machine related fatal accidents in construction industry and their associated causes of accident. The null hypothesis was "the average number of fatality is the same across all causes", with an alternative hypothesis being "the average number of fatally is different between causes at least one pair of causes. Two approaches were applied at this stage, identified as method 1 and method 2. Out of the 27 identified machine related construction accidents in the province, 12 recorded at least one fatality during the 21 years study period. The first step was to test the significance of the causes of fatal accidents. The method tagged "method one" analyses causes with at least one fatality. The second step analyses all causes of accident based on total causes of accident even without indicating fatality within the study period. All causes without any fatality record were represented with zero. This will give a better overall statistical interaction of all causes. The interpretation of the hypothesis of interest is “whether the cause of fatalities depends on the number of accidents”. Univariate tests of within-subject effect was perform as “Tests of Within-Subjects Contrasts” and “Tests of between-Subjects Contrasts”. The outcome of the analysis on these are presented in section 4.2.

4 Findings and Discussion

The three approaches to investigating and analyzing machine related accidents in the construction industry of KwaZulu-Natal Province revealed different outcomes whose interpretations are very significant in mitigating fatalities or ensuring zero fatalities. The results from administered survey and interviews reveal that accidents can be avoided if all safety, health, training and behavioural factors are genuinely observed. The three results are presented below.

4.1. Analysis of causes of machine-related accidents with at least one fatality

Table 1 presents the outcomes of the tests. The second column shows their equivalent approximate F-values, with degrees of freedom shown in column two. For one-way within-subjects ANOVA, all multivariate tests yield the same results. For this analysis, the multivariate tests indicate a significant effect since P <0.0000001.

Table 1. ANOVA result of causes with at least one fatality

Variables	Degree of freedom	Sum of square	Mean square	F-statistics	P-value
Cause	12	17.0	1.55	1.88	0.0666
Residuals	48	39.6	0.824		

From Table 1, a P-value of 0.0666 was computed. Because of this value being greater than the significance level 0.05, it means that the null hypothesis is accepted and one can conclude that there are no significant differences between the number of fatalities and the selected causes. This means there is no association between causes and fatality.

From the result displayed in Figure 2, each year recorded fatality because of construction machines. Of all the years between 2000 and 2020, 2019 recorded the highest incidents of fatality 8. The sharp spike may be attributed to a commensurate rise in construction projects or due to mass emigration of skilled workers resulting in a huge vacuum to be fill. From Figure 2, a pattern in the number of annual fatalities within the study time. It could also be as a result of being random it happened because it was not meant to happen and was unexpected. The years 2007, 2013 and 2018 recorded six fatalities each. Prior 2007, there were considerably low machine use fatalities in KZN construction industries, which rose from two in 2002, to three in 2003 and 2004. One could say that after a couple of years of careful occupational practice, negligence creeps in and causing reduced safety and health observations causing a hike in related accident in the subsequent years. This pattern is observed in 2007, 2013, and 2019. It is shocking to see that the highest number of machinery accidents of 519 was recorded in 2002, but fatality of two.

The cause of accident with the highest number of fatal accidents is motorized equipment-(trucks, lorries and dumpers) (ME_TLD) of 34, as indicated in Figure 3. Scaffolds & stagings, recorded 13, but only one fatality was recorded from each of the mixer and hoisting - power shovels, bulldozer, excavator (H_POWSH).

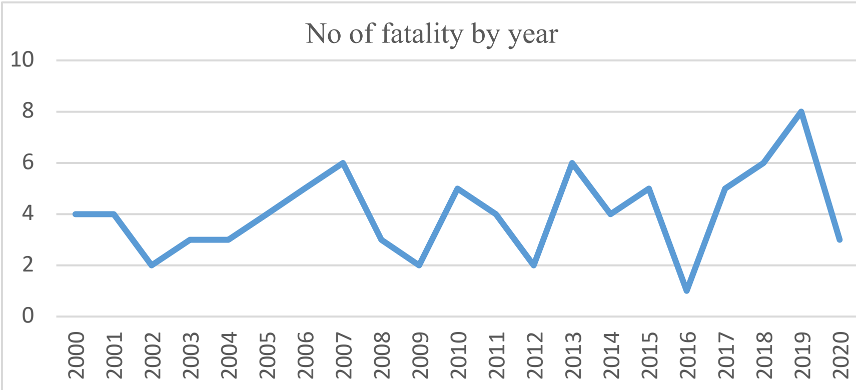

Figure 2. Presents the number of machine-related fatalities in the study period and area.

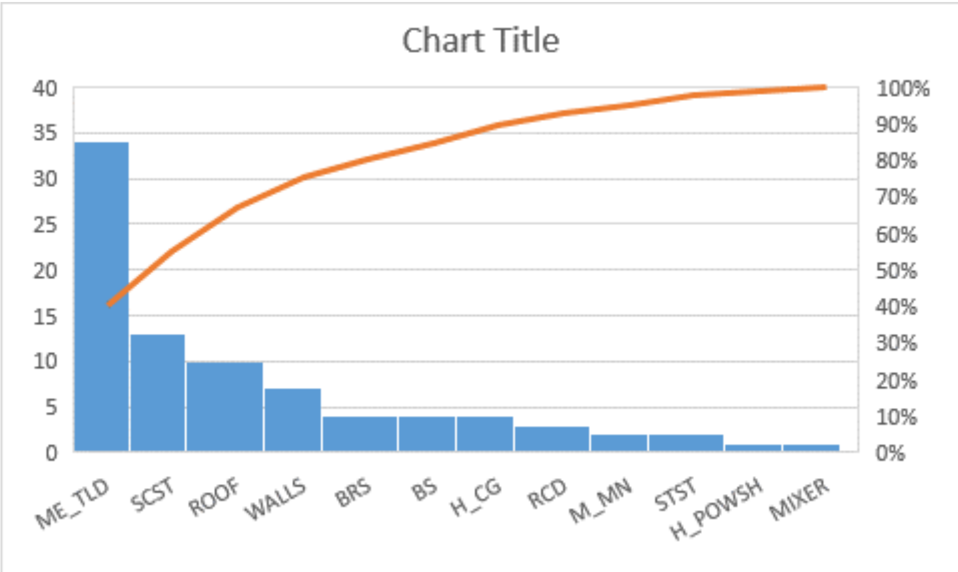

Figure 3. Reflects the frequency of machine-related fatalities, according to causes.

Where: ME_TLD=Motorised Equipment - Trucks, Lorries, Dumpers, SCST=Scaffolds & Stagings, ROOF=Roof, BRS=Brick, Rock and Stone, BS=Building Structure, H_CG=Hoisting Apparatus - Cranes and Gantries, RCD=Hoisting Apparatus - Cranes and Gantries, M_MN=Misc. - Machines, N.E.C., STST=Steps and Stairs, H_POWSH=Hoisting Apparatus Cranes and Gantries, and MIXER=Mixer

A comparison was made of the number of machine related fatalities in construction sites to the total accident recorded within the study period. The outcomes is reflected on Figure 4, indicating the number of fatalities plotted against the number of accidents to check the correlation of both factors. The equation guiding the correlation graph is presented on the graph as y, while the correlation factor is -0.16879. The line graph shows that fatality did not increase or decrease with an increase in the number of accidents. This shows that the number of accidents does not determine the number of fatalities. The degree of correlation between number of accident and fatality is 0.16879, which is about 17% correlated; the negative value also means accident does not result in an increase in fatality.

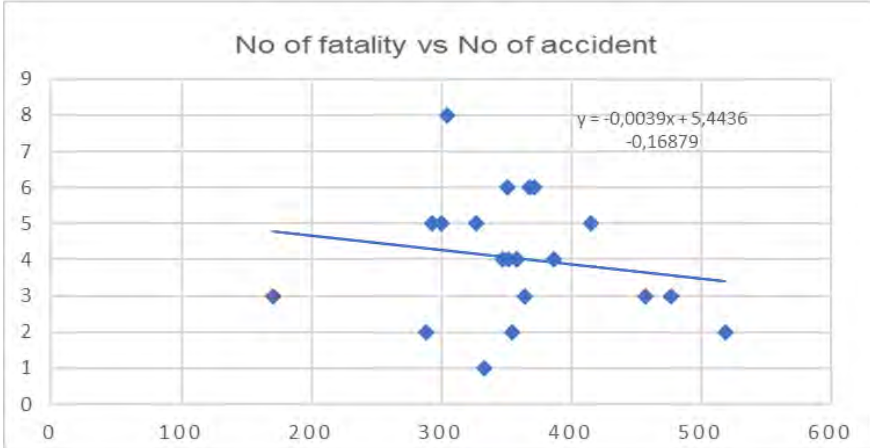

Figure 4. Correlation between number of accidents and number of fatalities.

4.2. Analysis of all causes of machine-related accidents

Two statistical tools R and SPSS were use in data analysing under this class of investigation. Both tools gave similar outcome, which proves there is an association between the causes of accident and fatalities. The outcome of R is in Tables 2 and 1. The outcome of SPSS is in Tables 3, 4, and 5 below. The values of significance P from both packages were below 0.05, implying significance influence.

Table 2. ANOVA result of all causes of machine accidents

Variables	Degree of freedom	Sum of square	Meansq	F-statistics	P-value
Cause	27	61.1	2.26	12.2	5.95 *10-41
Residuals	560	104.0	0.185		

From the result of the analysis on Table 2, a P-value of 5.95 x 10^{-41} was computed. As a result, of this value being extremely less than the significance level 0.05, it means the null hypothesis is rejected and this means there are significant differences between the number of fatalities and the selected causes. This means there is association between causes of accidents and fatality.

From the Within-Subjects Effects ANOVA Table 6, the F test indicates a significant implement effect, F = 985.069, P = <0.001. Thus, the type of factor (number of accidents) used does affect the accident that an individual sustain. This buttresses the outcome reveal on Table 2. When there is any reason to doubt the symmetry assumption tests of within-subjects effects, then analysis can be made by reducing the degrees of freedom contributed by the within factors. These adjustments are due to Greenhouse and Geisser and to Huynh-Feldt as on Table 5.

Table 3. ANOVA result of Tests of Within-Subjects Contrasts

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	factor1	Type III Sum of Squares	df	Mean Square	F	Sig.
factor1 (no of accident)	Linear	46753.593	1	46753.593	985.069	.000
factor1 * Cause	Linear	91716.050	27	3396.891	71.570	.000
Error(factor1)	Linear	26578.857	560	47.462		

Table 4. ANOVA result for Tests Between-Subjects Effects

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	48921.960	1	48921.960	989.621	.000
Cause	95146.921	27	3523.960	71.285	.000
Error	27683.619	560	49.435		

These tests are based on degrees of freedom adjustment factor known as ε (epsilon). Although ε must be in the range of 0 to 1, the Huynh-Feldt epsilon can be outside this range. When this happens, the epsilon is set to one. Both Greenhouse and Geisser and Huynh-Feldt epsilons values are revealed on Table 5. The lowest value possible for ε is indicated. Both the numerator and denominator degrees of freedom are multiplied by ε and the significance of the F ratio evaluated with the adjusted degrees of freedom. The adjustment to the F-test is presented below.

Table 5. ANOVA result of Tests Within-Subjects Effects

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	46753.593	1	46753.593	985.069	.000
	Greenhouse-Geisser	46753.593	1.000	46753.593	985.069	.000
	Huynh-Feldt	46753.593	1.000	46753.593	985.069	.000
	Lower-bound	46753.593	1.000	46753.593	985.069	.000
factor1 * Cause	Sphericity Assumed	91716.050	27	3396.891	71.570	.000
	Greenhouse-Geisser	91716.050	27.000	3396.891	71.570	.000
	Huynh-Feldt	91716.050	27.000	3396.891	71.570	.000
	Lower-bound	91716.050	27.000	3396.891	71.570	.000
Error(factor1)	Sphericity Assumed	26578.857	560	47.462		
	Greenhouse-Geisser	26578.857	560.000	47.462		
	Huynh-Feldt	26578.857	560.000	47.462		
	Lower-bound	26578.857	560.000	47.462		

4.3. Analysis of the questionnaire survey

From the survey analysis, 56% agreed there were delays due to accidents, 70% agreed accidents ends in disputes. All respondents agreed accidents cause huge financial losses and because of accident, victims incur huge medical expenses. However, none among the respondent agreed to or indicated any case of loss of life. This does not imply there were no loss of life in the industry, but could indicate that organizations where fatalities were recorded were not among the surveyed organizations.

According to the survey, the factor with the most significant influence is to have skilled, experienced and possibly licensed plant operators. The impact of unqualified machine operators extends to poor maintenance of machines and equipment, which may eventually lead to accidents, waste time, or even delay projects.

5 Conclusion and Further Research

The univariate tests for within-subjects effects require some assumptions for the probabilities provided by the ordinary F test to be correct. Specifically, these tests require certain patterns of variance-covariance matrices. In the fixed effect analysis of variance, we assume that the observations are mutually independent normally distributed and have equal variances.
Fatalities in construction work does not have a pattern for occurring and their occurring are not planned for. They randomly occur, which may be avoided by taking adequate responsibility to adhere strictly to precautionary steps. The increasing tendency of fatal accident due to machine use in construction must be control, since there will be continued use of more machines in construction site, safety behaviour must be enforced using every useful avenue. From the tests and discussions above, conclusion can be reached that most fatal accidents are attributable to non-adherence to safety and health protocols during construction activities.

There is a tangible association between the rate of accidents in construction sites and the number of fatalities. Tests of Within-Subjects Effects, Tests of Between-Subjects Effects, and Tests of Within-Subjects Contrasts involving all the 27 causes all agree that fatality due to machine use in construction business depends on the causes of accident. All computed significance values of $p < 0.00001$.

According to Figure 2, the portion of fatal accidents attributed to motorized equipment is high compare to other causes. It is almost triple the frequency of occurrence in the next cause. This calls for the use of qualified and experienced professionals to handle moving equipment. Reducing fatalities in motorized equipment will change many variables, and this is one of the causes, which experience, age and training can put the value at almost zero.
In the execution of construction projects, aligning to safety and health monitoring is key to maintaining safe construction delivery. The invest in gadgets and safety technology, which may include; wearing of protective personal equipment, safety evaluation at the beginning of construction projects, continuous reminder of the importance of safety and health, knowing it is the responsibility of project participant.

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A leadership and strategic decisions framework for construction company survival

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Abstract:
Like some other counterparts across the globe, the construction industry in South Africa is experiencing challenging times, which has led to the failure of notable large contractors. While some studies have suggested different reasons for this, a stream of scholars has argued that the company leadership can make the difference either directly or otherwise. However, studies on leadership in construction have been mostly at project levels, considering that construction is a project-based organisation. This study, therefore, examined the leadership of construction organisations from a strategic perspective, considering how it influenced the long-term performance and sustainability of large contractors. The study was based on a systematic review of literature, mainly using theoretical perspectives to realise the study's objective. Related keywords were developed and searched in relevant journal articles and conference proceedings. This exercise was performed in order to, establish the leadership attributes and strategic decisions responsible for sustainable construction business organisation performance. The findings suggest that construction company leaders can operate their companies more innovatively, ethically, and sustainably by adopting Honesty-Humility, Extraversion, Agreeableness, Conscientiousness, and Openness (HEXACO), a transformational leadership style, conceptual and catalytic skills, and strategic leadership functions. However, the findings of the study are based on literature review and need grounding with primary data. Further research is required to incorporate the South African context to test the proposed leadership framework's generalizability using a convergent mixed-method research approach.

Keywords:
Construction performance, large contractors, leadership, Strategic decisions, South Africa

1 Introduction

This study investigated the functional role of the upper echelons of South African large contractors in the sustainability of their organisations. The construction industry in South Africa is experiencing challenging times, leading to notable large contractors' demise (Odendaal, 2018). Group Five, Basil Read, and NMC have liquidated, ESOR and Liviero are in business rescue and trying to sell out, while Murray & Roberts and Stefanutti Stocks have restructured (Hindle, 2018). Aveng had an accumulated debt of R3.25 billion in 2018, whereas it was once considered the leading construction firm in South Africa (Planting, 2020). A similar situation was reported of Clugston Group, Bardsley construction, and McGill & Co. in the UK (Kelly, 2020; Korman and Reina, 2018). According to the US Department of Commerce, construction and contracting businesses have the highest failure rate (Clayson, 2019). Wong and Ng (2010) also provided substantive evidence for Chinese construction companies' business failures based in Hong Kong. There are several reasons behind the plunging and failure of large construction businesses, and scholars have divergent views. While some have connected failure to the complexity and the risky nature of the contracting business, high legislative loads, and changing industry dynamics (Mcintyre, 2011), other scholars have attributed the failure to increasing global turbulence and economic recession leading to cyclic market patterns, cash flow problems, and non-payment or delay in payment for contractors (Brooks and Spillane, 2015; Odendaal,2018).

A stream of researchers has identified a lack of strategic leadership as the reason for large construction companies' failure (Borkovskaya, 2018; FMI Corporation, 2016). The FMI's study found that 76% of large contractor's failure is due to poor strategic leadership, submitting that strong leadership can serve as a cornerstone for success in even the most challenging market conditions. Similarly, Rivero (2014) showed that a lack of leadership and poor leadership exists within construction companies in the USA, China, UK, Sweden, and Australia, impacting construction performance negatively. Mcintyre (2018) reported that Carillon's collapse was due to leadership failure. Given that leadership behaviour is a subset of the personality models, De Oliveira and De Lacerda (2015) suggested that leadership effectiveness in any organisation is a multi-dimensional construct comprising four dimensions: traits, skills, behaviours, and processes. Scholars have also called for a closer integration of leadership personality research in organisations (De Vries, 2018). Still, there is no known substantive empirical study or a detailed leadership framework of a leader-focused assessment for companies' performance in the South African context. This study responds to this knowledge gap.

2 Literature Review

There have been extensive studies on the subject of leadership. It has vast literature, as it is a central concern, *and* universal appeal (Northhouse, 2019). As a field of study, leadership has expanded dramatically in more organisations due to its recognised importance in the twenty-first century (McManus and Perruci, 2015). Studies have shown that leadership is the key driver responsible for organisational effectiveness (Alade et al., 2020; Goleman, 2004). Leadership a process of social influence that employs management tools to yield superior results and attribute causation to individual social actors (Kruse, 2013; Lunenburg, 2011). The role of theory in research has been noted by scholars, given that theories generate complex and comprehensive understandings of the phenomenon that are not easily explained, such as leadership that this study is investigating (Reaves & Hean, 2013). Further combining theories is plausible, especially when deciding on a complex phenomenon (ibid). As such, this study on the Upper echelon's theory (Hambrick and Mason, 1984), the Full Range Leadership Model (FRLM, Bass and Avolio, 1994), and the Strategic leadership theory (Finkelstein et al., 1996). The Upper echelons theory proposed that organisations reflect their top manager's cognition and values. Simultaneously, the strategic leadership theory suggested that the psychological makeup of the leader's specific knowledge, values, and preferences influences their assessment of the environment and strategic decisions. The FRLM, on the other hand, differentiates effective from ineffective leaders at all organisational levels based on their style. Studies researching leadership in the construction sector have mostly zeroed in from the Project level, considering that construction organisations are project-based (Graham et al., 2020; Zheng et al., 2019; Ismail and Fathi, 2018; Simmon et al., 2017). The investigations have distinguished the components of leadership to the complex construction climate showing that due to the multi-faceted nature, leadership in construction is more challenging. They included visioning, team building, safety leadership, innovation, technical expertise, mentoring, trust, and ethical leadership as helpful components that affect the success of sustainable construction projects. However, concerning the components of strategic leadership in construction business organisations little is known and regarding the South Africa context.

2.1 Leadership traits

Leadership traits are the natural or acquired ability to lead and the innate qualities that differentiate leaders from followers and non-leaders (Dinh & Lord, 2012). The empirical study of Lo (2017) revealed that personality traits form the foundational antecedents to leadership. These are stable attribute patterns that form the leader's characteristics and influence people towards organisational goals (Sunindijo et al., 2007). Trait theory has been criticized for its unpredictability of the environment that may necessitate changes in the behaviour of leaders, there is a consensus emerging around the "HEXACO" (Honesty-Humility, Emotionality, Extraversion, Agreeableness, Conscientiousness, and Openness to Experience) personality framework, and domains (Breevaart and De Vries, 2017; Gow *et al.,* 2016; Carmeli *et al.,* 2012; Peterson, et al., 2012). The current leadership trait proponents indicated that the HEXACO model is relatively stable and a better predictor of leadership, to be more associated as the basic structure connecting leaders with the current and future firm outcomes.

2.2 Leadership skills

The leadership skills theory is on the notion that leadership is a potential that emerges through experience and capability to learn and benefit from the expertise (Mumford *et al.,* 2000). The proponents of the skills theory of leadership argue that organisational leadership skills are capabilities and competencies that can be developed and improved over time through formal or informal education, practice, and experience (Mumford *et al.,* 2007). The leadership skills strataplex suggested that different leadership skills are required at different levels of the organisation. Whereas cognitive skills such as investigating, monitoring, information gathering and disseminating, general and essential cognitive capacities are required at junior levels of the organisation, interpersonal skills such as supervision, negotiating, human relations, people-orientation, social complexity, social judgment, and social capacities, are most needed at the mid-level of organisational leadership. However, at the organisational apex, strategic skills, mainly conceptual, take a systems perspective to understand complexity, deal with ambiguity, and influence the organisation. Liphadzi et al. (2015) recognized driving attributes of construction and project managers in the South African construction industry, which affect the accomplishment of construction projects.

2.3 Leadership styles

Leadership style is the leader's approach to providing direction, implementing plans, and motivating people for possible organisational outcomes (Serrat, 2020; Avolio, 2007). The concept of leadership style originally emerged from the work of Burns (1978). The literature revealed that using the appropriate leadership style is an essential factor that influences leaders' effectiveness (Sadeghi and Pihie, 2012). The Full Range Leadership Model (FRLM) condenses all leadership approaches into transformational (motivation, stimulation, and influencing), transactional (management-by-exception and contingent reward), and laissez-faire behaviours. Scholars have argued that leaders' behaviour towards providing direction, implementing plans, and motivating people will differ in different scenarios. According to Chan *et al.* (2014), transformational leadership is positively associated with innovation climate and organisational effectiveness in construction. Al Khajeh (2018) also inspected the effect of leadership styles on organizational performance. The attention was on six significant leadership styles - transformational, transactional, autocratic, charismatic, bureaucratic, and democratic.

2.4 Leadership and organisation performance measures in construction

Organisation performance (OP) is identify as one major indicator to evaluate leadership effectiveness (Oyewobi, 2016; Hove and Banjo, 2015). Ismail and Fathi (2018) recognized leadership as one element that adds to construction organisation success. Additionally, they saw that decisive leadership is fundamental in any organization to accomplish organisational objectives and advance individual expert accomplishment. Oyewobi (2016) considered that the essence of measuring an organisation's performance is to provide viable and valuable information to decision-makers within an organisation. According to Tan et al. (2012), the main goal of measuring performance is to add value to its stakeholders. The current construction management literature indicates that several models were develop for measuring performance using critical success factors, performance measures, and indicators. However, organisations' performance indexes have traditionally concentrated on financial performance, tending to measure only what was easily measurable (Orozco, 2014). Samimi et al., (2020) and Kagioglou, et al (2001) suggested that companies include non-traditional measures while Oyewobi et al. (2019) used financial and non-financial measures of organisational performance to evaluate the achievement of companies in South Africa.

2.5 Mediation role of strategic decisions in the relationship between company leadership and construction organisational performance

According to Samimi et al. (2020), making strategic decisions is the first function of leaders at the organisational apex. Strategic decisions are extensive, risky, and hard-to-reverse decisions with significant long-term effects on the organisation (Papadakis and Barwise, 2012). These decisions are mostly concerned with the company's acquisition of sustainable competitive advantage. It is perceived that leaders sway emphatically or contrarily on organisational performance through their decisions. This declaration has incited researchers to examine the effect of strategic decisions on organizational performance. Scholars (Oyewobi et al., 2019; Borkovskaya, 2018; Dikmen et al., 2009) have also stressed the need for strategic perspectives leaders in construction companies. Most studies of strategy in construction revealed that strategic decisions significantly contribute to the company's performance. Simmons et al. (2017) concluded that the construction leaders' ability to develop quality strategic decisions in their context determines how the organisation will operate and perform sustainably. Isik *et al.* (2009) considered five strategic decisions as representative of the characteristics of the construction industry in Turkey: differentiation strategies, procurement strategies and Project Management strategies, investment strategies, and organisation planning/management.

3 Research Methodology

Through a systematic review of the literature, we searched keywords to measure the key variables of this study, "leadership," "strategic decisions," and "construction organisation performance." The search keywords include CEO leadership, leadership traits, leadership skills, strategy, strategic decisions, and company performance. The literature survey was on the study's objective to examine the role of the construction upper echelon leaders in their organization's sustainability performance. The journal articles, conference proceedings, online articles, and other related texts from Science Direct, Web of Science, Scopus, and Google scholar were the database used. The search process covered the year 1982-2020. The research articles in the leadership domains are quite broad, generating an initial output of over 45,000 articles. However, the keywords and the objectives narrow the dataset to the appropriate research fields for measurable outcomes. As indicated in the preceding section, construction organizations with leaders high in specific leadership components and strategic decision-making stand a better chance of survival in today's competitive environment. Hence, using the variables described in the preceding sections, the next segment presents the conceptual framework developed for the study based on theoretical insights. The following factors: "HEXACO" personality framework, Multi Leadership Questionnaire (MLQ), and the Catalytic Leadership Inventory questionnaire (CLI) are used to determine leadership attributes of the construction executives. Further, the leadership roles profile, strategic decisions, and company performance ratings of the executives will be determine using the variables previously identified in the literature.

4 Findings and Discussion

The strategic leadership framework drawn from the literature review are reflected in Figure 4. It is premised on the Upper echelon's theory, Strategic leadership theory, and the Full Range Leadership Theory (FRLT) earlier discussed and supported in the literature (Samimi et al., 2020; Alade et al., 2020; Borkovskaya, 2018). Taking a gander at the diverse leadership frameworks proposed in past investigations spotlights project leadership performance but not from a strategic perspective.

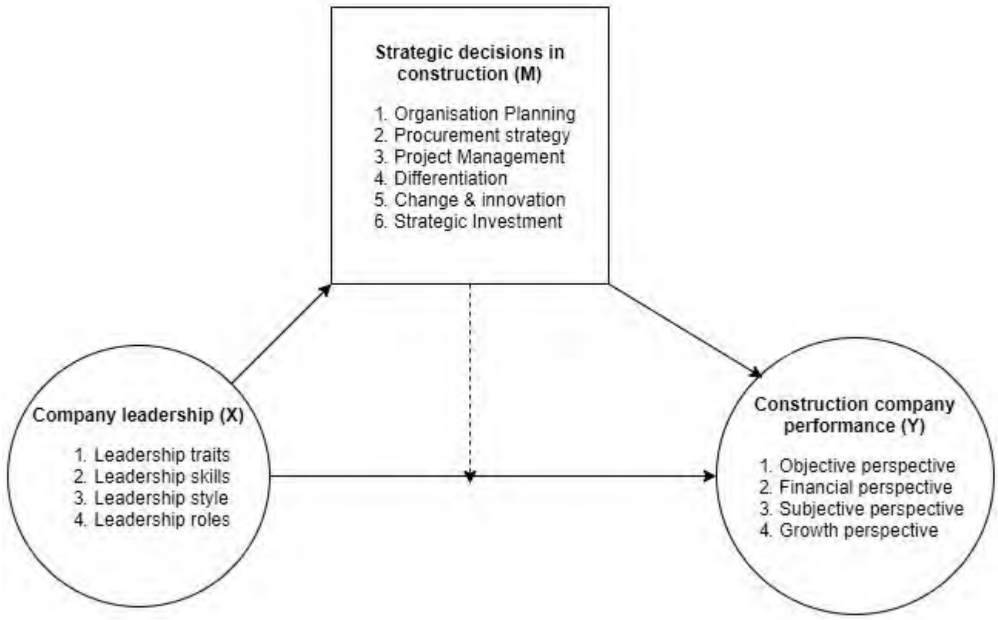

Figure 4. The Strategic leadership framework developed for the study.

The framework developed here suggests that the relationship between the CEO/company leadership components (traits, style, skills, role) and construction organisation performance is mediated by the strategic decisions of the company leaders. From a technical perspective, construction is a project-based industry and thrives on projects that imply that the procurement and execution of work are essential. However, considering studies alleging that the project performance pressures often obscure the broader social, economic, and professional context for strategic discussion in construction, this study included strategic decisions about broader issues of change, innovation, and strategic investment. Compared to their manufacturing and related industries, construction organisational leaders appeared rigid and slow in responding to change and innovation. The attitude of the company leaders vis-a-vis the constant rapid changes in the business and global world will be explicit from the framework. These changes are by the advancements in technology, communication, industrial revolutions, and sometimes disasters such as the recent Covid-19 pandemic that bedevilled the globe. Further, owing to the nature of construction as a capital-intensive and unpredictable venture, strategic investment decisions of the construction company leaders are determined by three lines: financial investment (FI), human resource/training (HR), and corporate social responsibility (CSR). In the framework, therefore, the strategic roles of the construction company leaders in organisation, planning, procurement and project management, differentiation of their business, change and innovation and investment will be determined in relation to their leadership attributes HEXACO, (Honesty-Humility, Emotionality, Extraversion, Agreeableness, Conscientiousness, and Openness to Experience), leadership skills, and leadership style variables. The mediating role of the strategic decisions and how the leadership components affect the construction company performance will be predictable from the different viewpoints, which are objective, financial, subjective, and growth perspectives. This finding could explain why some construction organisations survive in difficult times and others fail in South Africa.

5 Conclusion and Further Research

Various studies have indicated that company leadership plays a significant role in organisations ‘performance outcomes. Considering the failure rate of large contractors in South Africa, it is evident that not every leader in the construction enterprise understood the parameters for operating a sustainable construction business. The findings of this review would be a steppingstone towards bringing construction leadership research in line with broader leadership theory. The strategic leadership framework developed could inform construction company leaders in their structural roles to envision more innovatively and operate their companies more sustainably. Further, leaders in construction could benefit immensely from using this framework to recognise potentials for succession planning and reduce the risk associated with failure of their construction business. However, this study has only used theoretical perspectives to develop metrics for measuring strategic leadership and performance in construction organisations. The implication of this is that further empirical research will be required to determine generalisability. The future study will use a convergent mixed-method approach where priority is for qualitative techniques to provide deep and robust narratives that will help to understand the company leaders’ profile, strategic decisions, and outcomes. The quantitative aspect will measure the identified variables in the South African context. Respondents will be selected from a sample frame that consists of the large contractor category in South Africa (cidb Grades 7-9), the Master Builder Association (MBA), South African Forum of Civil Engineering Contractors (SAFCEC).

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Factors influencing student's accommodation selection

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Abstract:
Selecting accommodation for occupancy is challenging as various factors are considered by the occupier to achieve maximum satisfaction from the premises. The study's objective was to identify the factors considered by tertiary students when selecting their off-campus accommodation. A quantitative approach was adopted for the study, using closed and open-ended questionnaires to collect data from conveniently selected 98 off-campus tertiary students from the University of the Free State. Statistical Package for the Social Sciences (SPSS) was used to calculate the frequencies and percentages for the data collected. Data were collected from only off-campus students at the University of the Free State; albeit, the findings may be applicable in other similar settings. The results indicate that the most significant factors influencing students' accommodation selection are the safety of the premises, the apartment's rental value, the inclusion of furniture in the rooms, facilities available at the apartment, proximity to lecture halls, and privacy. Other new and emerging factors identified are Wi-Fi availability, the inclusion of water and electricity in the rent, gender-based accommodation, rules and regulations given to students, freedom, and a big yard for the dogs. There is an urgent need for private developers to be aware of contemporary students' needs and incorporate them in developing students' accommodation for their businesses' sustenance. Again, in assessing and approving off-campus housing for student usage, the authorities should be guided by these factors in the approval processes to ensure occupants' satisfaction.

Keywords: Accommodation, factors, off-campus, selection, students

1 Introduction

Housing is, without any doubt, a basic need of humans. The World Health Organization (WHO) defines housing (accommodation) as a shelter used by humankind that consists of the neighbourhood, environment when looking at residential aspects, or the structure and the environment of the built structure. It also includes necessities in the form of facilities and services required for the physical health and the social wellbeing of the occupants (Bondinuba et al., 2013). In various developed and developing countries globally, student enrollment growth in higher education institutions (Universities) has surpassed universities' ability to provide adequate accommodation to students, which leads to accommodation becoming more expensive for students (Ackermann and Visser, 2016). Studentification can be explained as a series of social, environmental, economic, and physical practices whereby many students move into a particular area of the city or town where the desired universities are situated. This happens because the students want to be closer to the selected institution, student atmosphere, student resources, and activities without physically residing on the universities' grounds (Smith, 2007).

South Africa is a developing country with good quality infrastructure and significant socio-economic problems (Layne, 2020). However, student accommodation's financial aspect has been of great concern for a majority of students worldwide. All the universities in South Africa heavily rely on private investors to provide student housing around the University's campus periphery to augment the accommodation shortfalls (Bondinuba et al., 2013). These accommodations situated outside the universities' perimeters are termed off-campus student accommodation, mainly privately owned; therefore, rates cannot be regulated by either the government or university management to ensure uniformity (Bondinuba et al., 2013). Since the rental amount regulation and the standard of the private developer's infrastructure are not under the government and university authorities' armpit, there should be a basis for a student to select among these off-campus housing. According to Ackermann and Visser (2016), variables such as accommodation quality, satisfaction, location, type of structure, availability, etc., may motivate occupant's choice of accommodation. A study by Lockyer (2002) identified factors such as hotel cleanliness, bathroom and shower quality, room maintenance, the comfort of mattress and pillow as the primary determinant of choosing a hotel by business guests. On the other hand, Tsang and Qu (2000) also focused on service quality in hotels in China by concentrating on tourists who use the hotel. More recently, Simpeh and Shakantu (2020) studied how on-campus prioritize the service available in their houses.

It is thus evident that many studies have focused on the factors considered in selecting accommodation among occupants and guests for hotel facilities and the prioritization of facilities available. This study concentrates on students at tertiary institutions and investigates the main determinants for choosing off-campus accommodation as they pay a substantial amount for the residences. The research focuses on students at the University of the Free State in Bloemfontein, South Africa. The study's outcome may also alert private developers on accommodation attributes considered significant by student occupants to guide future development.

2 Literature review

2.1 The concept of housing

The field of studying housing is a multi-faceted field with varied regions of interest. By looking at housing in a multi-faceted aspect, it is one of the crucial basic needs of a given individual and/or family in any society (Ghani and Suleiman, 2016). Houses are frequently built at a low density and cannot establish the required limits to support a city's functions effectively. Settlements are inappropriately located when accessing socio-economic facilities (Massyn et al., 2015). Due to the low efficient demand for housing at market-related costs by the low-class income to middle-class income households, the final costs of the houses being developed are mostly less than the costs and the profits needed to develop the housing (Massyn et al., 2015). Due to this, less housing is developed in the inner parts of cities in South Africa. Any idea directed towards increasing residential developments within the inner cities must consider the factors that drive the costs of the developments (Massyn et al., 2015).

Therefore, the concept of value versus cost is fundamental when planning a development, whether it be for low-, middle- or high-class income housing. The connection between value and cost is significant to determine and understand the type of development that will be taking place, when it will happen and what form the development will take. Therefore, a feasibility study must be conducted to evaluate the interaction between the value and cost (value vs. cost) of a development (Massyn et al., 2015). A house is of utmost importance to humans, leading to feeling secure and safe against external physical elements. It aids in leading a productive, happy, and fulfilling life to reach high living standards and modern times. Housing should not merely be a structure designed for shelter and protection but should include all the social services and values that make the neighbourhood and/or community a habitable environment (Ghani and Suleiman, 2016). By furthering this perspective on modern time housing, Ghani and Suleiman (2016) opined that in the contemporary time, housing is supposed to include some basic infrastructure facilities, including the provision of clean water, sanitary facilities, and fittings, electricity, a kitchen, basic services, sewerage and drainage, and road access to be considered a house.

Housing has a substantial impact on humans in both positive and negative ways. Accessing healthy housing is crucial for living healthy and vital to social conduct, equity, efficiency, and the community's general welfare. Housing has a heavy influence on the community and the poor's general welfare, health, and social conduct; improper housing can lead to stress, health problems, and depression within a community and/or individual (Ghani and Suleiman, 2016). With the increasing wealth and high life expectations in developed and developing countries, the focus has been on raising housing quality and standards. This influence has led to the changing housing definition over time from only a shelter to a more thorough and clear description; a structure offers a combination of infrastructure facilities and services (Ghani and Suleiman, 2016). In a study done by Elsinga and Hoekstra (2005) concerning housing satisfaction among European communities, it was revealed that except Austria, tenants are discontent compared to homeowners since freedom and finances are derived from homeownership. Housing provision in South Africa has focused on providing ownership housing at the cost of other forms of occupancy and housing types. It assumes that people stay close to the area in which they work (Poulsen, 2010).

2.2 Housing satisfaction and selection factors

Satisfaction measures the difference between consumers' actual and anticipated needs (Kobue et al., 2017). According to Amole (2009), satisfaction is highly instrumental in housing evaluation as it indicates success level, determines user's happiness and identifies an exasperating aspect of living environment and user's future environmental responses. Again, it also assists in identifying factors contributing to satisfaction, differences among identified factors, and the relationships between various residential environments. Besides, satisfaction plays an essential part in determining a person's life quality, happiness, and wellbeing (Hammad et al., 2013; Muslim et al., 2012). Previous studies have proposed various models to measure living satisfaction; one such model is the neighbourhood and dwelling context (Azadeh et al., 2016). Adedeji (2011) suggests that a persons' satisfaction and loyalty levels are highly related because satisfied customers are loyal compared to dissatisfied customers. According to Kobue et al. (2017), students always look for accommodation that meets their needs and expectations, including the residence location. Students prefer to stay in residence near the school, where public transport is easily accessible and the neighbourhood suitable for effective learning (Kobue et al., 2017). Residence satisfaction is a necessity for only the occupants (students) but their visitors and all those accessing the building for business purposes (Mohit et al., 2010). Thus, appropriate conditions in student's residences are key indicative factors for personal wellbeing and performance. This is because building functions is vital for owners and occupants as it may measure their satisfaction. Therefore, it can be deduced that influencing factors for occupancy choice will subsequently determine the level of satisfaction. Kobue et al. (2017) opine that there should be unrestricted room for creativity and innovation in developing student accommodation to cater to their needs sufficiently.

Some studies in the United States concerning student accommodations have shown that students are becoming more particular regarding accommodation quality and convenience, including the accessibility of facilities such as laundry rooms, computer labs, and gymnasiums within the premises (Najib et al., 2011). According to Kobue et al. (2017), there is enough evidence showing that staying in a professionally managed residence, harmless, and safe residences has social and academic advantages, especially for the new students with poor backgrounds. This is because they are susceptible at this stage due to their unfamiliarity with the new environment. Decent, affordable, and well-maintained student accommodation may be a conduit for students to concentrate on their academic works, thus improving their academic success probability (Kobue et al., 2017). Kenna (2011) states that environmental settings encourage expressive tertiary experience, and students' academic performance depends on their place of abode. The Higher Educational Institutions (HEI) students living experiences are different due to the variety of housing and environment options available (Kobue et al., 2017). Thus housing occupant's satisfaction level influences their accommodation selection. Various studies have come with different factors occupants consider in selecting accommodation. Khozaei et al. (2010), on the other hand, stated convenience in terms of walking distance to lecture halls and being able to return to the residence to bath in-between lectures. Other factors such as accommodation fee, proximity to lecture halls, availability of electricity and water, and calm and peaceful environment have been identified as the main determinants for student's accommodation selection (Atkinson, 1988; Mahama et al., 2016; Oyetunji and Abidoye, 2016; Zortovie, 2017; and Adama et al., 2018). Therefore, it is undeniable that what influences people to choose a dwelling place differs depending on the satisfaction expected and preferences.

3 Methodology

A quantitative research approach was used for this study. According to Goertzen (2017), the findings generated from quantitative research uncover trends and not the reason behind the trends. Using a quantitative approach provided an opportunity to narrow down and filter responses from many respondents regarding the factors they consider in selecting off-campus student accommodation. Convenient sampling was used for the study. Convenient sampling is a non-probability sampling in which respondents are selected from the target population readily available as sources for research data (Blumberg et al., 2008). Thus, any off-campus students staying in a rented hostel and readily available to answer the questionnaire were included in the study. A questionnaire was used as an instrument to collect quantitative data. The data from a quantitative survey is widely used to explain behaviours, opinions, and predictions (Naoum, 2007). The study used closed-ended and open-ended questions where the respondents had to tick the applicable answer and express their opinions. The closed-ended questions related to demographic features and other questions relating to their accommodation (see Tables 1 to 5). The open-ended question was about the factors respondents consider in selecting the accommodation (see Table 6). Open-ended questions were used for the main research objective to allow the respondents to decide on the appropriate answer without being forced to choose an answer (Creswell, 2014). Due to COVID-19 restrictions and social distancing rules, the questionnaires were distributed via the survey monkey platform. The link to the questionnaire was sent to the respondents through WhatsApp or email. The researcher gave the respondents a week to fill in the questionnaire.

The research ethics clearance was received from the University of the Free State ethics committee before data collection. The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) to translate and process the data into functional and individual explanatory parts to support the study's objectives. The data was firstly encoded, and errors and outliers were detected. Frequencies and percentages for the respondent's responses were generated. According to Blumberg et al. (2008), frequencies and percentages are basic statistics that are not difficult to interpret and can present qualitative and quantitative data. The data was then be presented using tables.

3.1 Respondent's demographic information:

From Table 1, the respondents' demographic features indicate that the majority (65%) of the students are female students. Also, most of the students (89%) are between 18 and 25 years, indicating that they are within the school-going age; most of them are the third (47%) and fourth (29%) years. Also, 96% of the students study on a full-time basis, whilst 73% of them are unemployed.

Table 1: Respondents demographic features

Nature of Respondents	Frequency	Percentage		Nature of Respondents	Frequency	Percentage
Gender				**Current level of education**		
Male	34	35%		First-year	9	9%
Female	64	65%		Second-year	8	8%
Total	**98**	**100%**		Third-year	46	47%
Age				Honours	29	30%
18 - 25	87	89%		Masters	0	0%
26 - 30	11	11%		PhD	0	0%
31 - 40	0	0%		**Total**		
40 and over	0	0%		**Employment Status**		
Total	**98**	**100%**		Unemployed	72	73%
Type of student				Working on a part-time basis	21	21%
Part-time Student	4	4%		Fully employed	5	5%
Full-time Student	94	96%		**Total**	**98**	**100%**
Total	**98**	**100%**				

4 Findings

4.1 Respondents accommodation selection procedures

The purpose of this question was to determine whether the respondents chose their accommodation or if the universities did the accommodation placements on behalf of the students, leading to the respondents having no choice in their accommodation selection. This will influence the students' satisfaction because they must be satisfied with what is provided and cannot search for better accommodation. The findings to question are shown in Table 2.

Table 2: Respondents' accommodation placement

Who chose the respondent's student accommodation?	Frequency	Percentage
Respondent (I) chose	98	100%
The institution chose	0	0%
Total	**98**	**100%**

Table 2 reveals that 100% of the respondents chose their accommodation. This implied that most respondents (students) had to look at various factors and consider them in selecting the accommodation.

4.4 Facilities available at the respondents' accommodation

The purpose of this question was to determine the facilities available at the respondent's off-campus accommodation to decide which facilities are more and less freely available to students. The findings to question are indicated in Table 5. Table 5 reveals that 100% of respondents have water and electricity available, 98% have a bath or shower. This shows that all respondents have water and electricity freely available at their accommodation. Most respondents (87%) have study desks in their rooms. Computer facilities are not freely available at all accommodations as only 24% have computer facilities available. The remaining 76%, therefore, must obtain their own computers or only work on campus. Most of the residences have kitchen appliances such as kitchen sink, stove/ hotplate, kitchen cupboards, microwave, washers, dryers, and kettle. Gym facilities are only available to 4% of the respondent, making it a very scarce facility within the student accommodation. Alarm systems are only available to 35% of the respondents. Shuttle services are also only available to 6% of the respondents, making them walk to class or use their transportation.

Table 5. Available facilities at respondents' accommodation

Available Facilities	No of respondents	Frequency	Percentage	Ranking
Water and Electricity	98	98	100%	1st
Bath/ Shower	98	96	98%	1st
Built-in cupboards	98	90	92%	2nd
Study desk in the room	98	87	89%	3rd
Kitchen sink	98	86	88%	4th
Stove/ hotplate	98	84	86%	5th
Wi-Fi (Wireless Internet)	98	84	86%	5th
Kitchen cupboards	98	82	84%	6th
Microwave	98	76	78%	7th
Washers and dryers	98	72	73%	8th
Kettle	98	69	70%	9th
Furnished rooms	98	58	59%	10th
Garage facility	98	45	46%	11th
Communal Garden	98	43	44%	12th
Dining hall/ room	98	41	42%	13th
Alarm Systems	98	34	35%	14th
Study Room	98	26	27%	15th
Computer facilities	98	24	24%	16th
Just a bed provided by the institute	98	21	21%	17th
Air Conditioning	98	20	20%	18th
Shuttle services	98	6	6%	19th
Gym facilities	98	4	4%	20th

4.5 Factors considered by the respondents when choosing an accommodation

This question aimed to determine the main factors the respondents considered to ensure their satisfaction when they choose the accommodation. The findings to question are indicated in Table 6. Table 6 reveals that 22.3% of the respondents considered safety when choosing student accommodation, 4.1% considered gender-based accommodation, and 10.6% took proximity to lecture halls into consideration. Fourteen percent (14%) considered the nature of the structure, 16.8% the rental value of the apartment, 11.4% facilities available at the apartment, 4.4% friends' companionship. Again, 14.5% considered the inclusion of furniture in the rooms, 10.1% considered privacy, 0.5% considered Wi-Fi availability, availability of water, electricity, and considered whether water and electricity are included in the rent, respectively. Also, 0.3% considered rules and regulations provided to students, how modern the place is, freedom, and a big yard for dogs into consideration, respectively.

Table 6. Main factors that are taken into consideration by respondents when choosing accommodation

Main factors considered in accommodation selection	Frequency	Percentage	Ranking
Safety	86	22.2%	1st
The rental value of the apartment	65	16.8%	2nd
The inclusion of furniture in the rooms (e.g., desk, bed, cupboard, etc.)	56	14.4%	3rd
Facilities available at the apartment	44	11.3%	4th
Proximity to lecture halls	41	10.6%	5th
Privacy	39	10.1%	6th
Friends companionship	17	4.4%	7th
Gender-based accommodation	16	4.1%	8th
The nature of the structure	14	3.6%	9th
Availability of Wi-Fi	2	0.5%	10th
Availability of electricity and water, and Wi-Fi	2	0.5%	10th
Electricity and water included in the rent	2	0.5%	10th
Rules and regulations given to students	1	0.3%	11th
How modern the place is	1	0.3%	11th
Freedom	1	0.3%	11th
Big yard for the dogs	1	0.3%	11th

5 Discussion of the Findings

5.1 Factors to consider in selecting student's accommodation

The factors considered by respondents in choosing their accommodation have been identified in table 6 and ranked in order of importance. Kobue et al. (2017) state that satisfaction factors have vast influences on student's occupancy choices as they seek accommodation that meets their needs and expectations. Security is ranked high as a factor considered when choosing accommodation. It is a requirement and priority to ensure student's safety when residing in student accommodation, especially privately-owned student accommodation. Mahama et al.'s (2016) study in Nigeria states that hostel security has become the most significant factor among students when choosing off-campus housing due to increased social vices among university students. Adama et al. (2018) also opined that occupants are concerned chiefly about their safety when renting or buying apartments. Accommodation safety and security have also been identified as a priority among occupants even in the hospitality industry (Weaver and Oh, 1993; Lockyer and Roberts, 2009). It has been argued by Kobue et al. (2017) that harmless and safe residence is academically and socially advantageous to especially newly admitted students as they are vulnerable at that stage; thus, they look for a secured environment in selecting where to stay.

The second student consideration factor in selecting accommodation is the rental value. This is not surprising as the students pay for the rent themselves. Even where the student has a bursary, the student looks for affordability to save some of the money for other necessary needs. In Adama et al. (2018), the result indicated that accommodation fee was the first consideration in selecting hostel apartments by the students. Again Oyetunji and Abidoye (2016) identified rental value as the second and third factor in choosing accommodation, respectively. The inclusion of furniture in the rooms (e.g., desk, bed, and cupboard) was considered a factor in selecting the apartment. This finding defies literature as various studies have not identified this as a factor considered by accommodation occupants. Although Lockyer and Roberts (2009) mentioned kitchen facilities as the second factor considered by tenants in rented accommodation, they were no specifics regarding the desk and bed availability. Again, Zortovie (2017) and Adama et al. (2018) mentioned the availability of study areas as the fourth factor in selecting accommodation by students in their study; it might not have been related to room-specific but a general study area within the complex. Thus this finding may be a new trend in student accommodation selection criteria.

Factors such as facilities available at the apartment, proximity to lecture halls, privacy were also considered among the top six. Therefore, it is not surprising that most (77%) of the students stay in a single room (see table 4). This finding is also in line with Adama et al.'s (2018) findings, where the need for privacy was ranked the 3rd factor. Proximity to lecture halls has also been considered a topmost priority in selecting student's hostels. According to Kobue et al. (2017), students prefer staying near the school for learning convenience. A study by Oyetunji and Abidoye (2016) and Zortovie (2017) identified hostel proximity to campus as the first factor considered by the students in selecting accommodation. Khozaei et al. (2010) suggest that students prefer to shower in-between lectures; thus, they prefer to stay off-campus hostels where they could quickly go and shower and return for the following lecture. Again, Najib et al. (2011) suggest that students in the United States search for computer labs, laundry rooms, and gymnasiums within the apartments where they stay for convenience; these facilities influence where they choose to stay. It is therefore not surprising for the study's respondents to state this as the 4th factor. Again Lockyer and Roberts (2009) state that outdoor facilities (swimming pool, spa, gymnasiums) are highly sought after by occupants and consider them when selecting accommodation. According to Adama et al. (2018), the availability of other necessary facilities within the premises was considered an essential factor in choosing a student hostel.

Water and electricity availability was not considered among the topmost consideration for accommodation selection in this study, contrary to the study of Mahama et al. (2016); Zortovie (2017), and Adama et al. (2018) in Nigeria, where students ranked this factor 2nd, 6th, and 7th respectively. This may be because students in South Africa consider water and electricity as basic services readily available in the cities, unlike Nigeria; thus, they value these services as not critical in selecting a place to stay. This is supported by the findings in Table 5, where all respondents confirmed the availability of water and electricity at their apartments. Friend's companionship was also stated as a significant factor in selecting accommodation. Students want to be closed to their friends; thus, they intend to look for apartments where their friends stay. This factor was also identified by Adama et al. (2018), where the desire to be closed to friends was stated as a determinant factor. With regards to the modernity of the place, a study by Oyetunji and Abidoye (2016) identified similar factor in their research, where students cited the type of dwelling as a factor they consider in selecting hostels, whilst Adama et al. (2018) identified aesthetics (beauty) of building as a factor considered in hostel selection. It has been argued that a decent and well-maintained student accommodation allows students to concentrate on their academic activities because it reduces a situation where they have to follow up on default issues and thus enhance their academic success (Kobue et al., 2017).

5.2 New trend of student's accommodation selection factors

It is interesting to know that there is an emerging trend in the factors considered by the student in deciding on off-campus accommodation. These emerging factors are Wi-Fi availability, the inclusion of water and electricity in the rent, gender-based housing, rules and regulations given to students, freedom, and a big yard for the dogs. The Wi-Fi facility's consideration is also a new emerging factor considered by the students before selecting off-campus accommodation.

Note that internet services are now becoming a tool for tertiary studies in the developing world; thus, students rely on it for many school-related activities. Since data is expensive for them, they will rather prefer to stay where internet services are freely available. According to Kenna (2011), there is a correlation between facilities available within students' hostels and students' academic performance; thus, where internet services are freely available, students will use them to enhance their learning strategies. As a result of increasing water and electricity, modern students will now prefer to rent accommodation that includes electricity and water in the rental value. This may prevent a situation whereby they have to think about the water and electricity bills they need to pay as they use these services daily. Gender-based as a factor for accommodation selection is rarely found in the literature. Students now consider whether the accommodation is earmarked for either males or females before deciding to rent. This may be due to the recent increase in gender-based violence; thus, staying where only, for example, females are allowed may reduce the probability of being attacked. The property owners' rules and regulations are also becoming a deciding factor in accommodation selection. Perhaps, students want freedom; thus, any rules in the tenancy agreement that restrict them from exercising their liberty may discourage them from renting that apartment. According to (Najib et al., 2011), students are now looking for accommodation convenience; thus, an unfriendly environment may discourage them from staying. Again, concerning a spacious yard to accommodate pets, it was surprising for a student to use this as a factor for accommodation selection. Usually, pets are not allowed in the apartment. Perhaps a student may decide to rent a whole house, thus making this a selection factor. In a study by Adama et al. (2018) and Lockyer and Roberts (2009), respondents mentioned spacious and well-ventilated rooms as a factor for accommodation selection; however, their finding is different from this study's findings as the current factor refers to the size of the entire compound but not just a room.

6 Conclusion and recommendation

As a result of an increased number of students yearning to study in tertiary institutions in South Africa, the government and the university authorities struggle to meet the students' on-campus accommodation requirements. Having realized the student accommodation shortages, private developers have taken advantage of developing residences around the universities' periphery. Students thus heavily rely on these off-campus accommodations to meet their needs. However, as private developers aimed at making a profit, students have to pay a hefty amount to secure a place within any of these residences. This study looked into what students consider before deciding on the accommodation to rent. The findings revealed the top six factors students consider in selecting any off-campus housing as safety, the rental value of the apartment, the inclusion of furniture in the rooms (e.g., Desk, bed, cupboard, etc.), facilities available at the apartment, proximity to lecture halls and privacy. Besides these factors, the study identified a new trend of accommodation selection factors hardly found in the related literature. These factors are Wi-Fi availability, water and electricity availability in the rent, gender-based accommodation, rules and regulations given to students, freedom, and a big yard for the dogs. These findings imply that, aside from traditional accommodation selection factors, modern students consider other factors that may challenge the private developers to meet these new factors in the future development to sustain their businesses. Based on the findings, it is recommended that off-campus accommodation developers should consider incorporating these new factors in future housing development to attract students into their apartments. Private developers may have to research students to ascertain their needs and requirements before any students' accommodation development and incorporate them in the developmental process for their businesses' sustenance. As more and more developers enter the property market, the competition increases; thus, developers who can meet the tenants' demand will suffice.

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Determinants of Small and Medium Enterprises Financing Sources: Evidence from Ghana

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Abstract:
At all stages of development, SMEs are constrain financially. The purpose of this study was to assess the characteristics of SMEs and their choice of financing at the startup, daily operations, and expansion stage of their business. This study used a quantitative research methodology. The data collection were from 688 SMEs, through a survey questionnaire in the Accra/Tema and Kumasi Metropolitan areas in Ghana. Descriptive statistics and logit regression analysis were used to assess the characteristics of SMEs and their influence on the source of financing they chose. The study used the personal/manager attributes and firm attributes to determine SMEs source of financing decisions in the service sector, which serves the construction sub-sector. Most SME start-ups use informal sources, but this gradually improves at the business operations and expansion stages to using financing from formal sources. Financiers and policymakers should target SMEs at the start-up stages, as most use informal sources of finance more than during daily operations or at the expansion of business stages, even at that the other stages should not be ignored.

Keywords: Financing decisions, SME challenges, SME characteristics, source of finance

1 Introduction

The three main sectors of the economy of Ghana are the industry, agriculture, and service sectors. The service sector constitutes about 50% of businesses in Ghana and serves the industry and agricultural sectors. It is made up of businesses that operate in a wide range of activities including wholesale and retail trade, transportation and storage, accommodation and food service activities, information and communication and financial and insurance activities (IBES II, 2018). These various activities are evident that the sector provides services for the other sectors of the economy. Construction on the other hand is a subsector of the Industry sector that is made-up of mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation activities and construction. The construction sub-sector contributes the highest revenue in the Industry sector. It is very vibrant in the economy of Ghana as it utilizes local human and material resources in the development and maintenance of housing and infrastructure to promote local employment and improve the economy (Anaman & Osei-Amponsah, 2007). Studies on SME financing decisions is limited in the literature on Ghana. This study seeks to understand the relationship between SME attributes and their financing sources decisions. The three objectives guiding the study are as follows:

1. *To determine the source of financing used by services SMEs at the startup, during daily operations, and at the expansion of business stages.*

2. *To examine the SME owner/manager characteristics that influence the source of financing decisions at the startup, during daily operations, and at the expansion of business stages.*
3. *To determine firm characteristics that influence SME sources of financing decisions at the startup, during daily operations, and at the expansion of business stages.*

2 Literature Review

Small and medium enterprises (SME's) form a significant part of the economies of most countries and are very important in the role they play in employment creation and contributing to the Gross Domestic Product (GDP) (Balogun et al., 2016). They are termed the engines of economic growth in most economies in both the developing and developed worlds (Ayyagari et al., 2017). SME's form about 90% of businesses in Ghana, which is similar to countries in the Sub-Saharan African regions (Quartey et al., 2017a). Even though SMEs are so key in most economies, they are faced with many challenges which the literature has elaborated (Owens & Wilhelm, 2017). Access to finance has been identified as one of the main challenges faced by SMEs (World Bank Reports, 2015). Several studies have explained this phenomenon as being attributed to information asymmetry challenges (Berger et al., 2001; Bergh et al., 2019) and suggested diverse ways of improving SME access to finance (Rahman et al., 2017). However, the SME owner makes all the decisions in the business (Mensah, 2004) and therefore the choice of financing will be influenced by their characteristics.

SMEs seem to possess qualitative characteristics such as the owner having a closer overview of the enterprise, a stronger connection to the business, and the ability to make quick decisions (Buculescu, 2013; Hauser, 2005). Neeley & Van Auken (2009) analyses SME owner-managers characteristics using education, age and gender to assess their financing decisions and conclude that whilst entrepreneurs with college-level education (high) use the self-funded bootstrapping method the business owners who did not attend college did not. Moreover, less educated entrepreneurs use more inventory-focused bootstrapping methods than college-level entrepreneurs did, whilst younger owner-managers used more customer-based bootstrap (invoice promptly, stop serving late payers, and prefer fast payers) than older owner-managers. Further studies analyzed SME owner attributes on their ability to access loans from banks. Being a male, the probability of a loan application being accepted is low. The education of the manager did not seem to have any impact on the loan application being granted, whilst the age of the borrowing entrepreneur positively affects the success of the loan application, such that, older entrepreneurs have a higher chance than younger ones in accessing a loan (Campanella &Serino 2019). SMEs possess similar characteristics and linkages across sectors (Mensah, 2004) including the construction sector.

The construction industry has several linkages with the other sectors of the economy. Whilst it receives material inputs from the manufacturing sector, the inputs are supplied by the commerce and services sector (Ofori 2012). Furthermore, the construction sector relies on financial and professional services and these services need construction at some point. One of the challenges faced by the construction industry is the higher initial cost required for their activities (Djokoto et al., 2014). Financing seems to be a challenge faced by SMEs in both the services and construction sub-sectors and hence the relevance of this study to understand the relationship between SME attributes and their financing decisions, which can guide policy decisions regarding SME financing.

3 Research Methodology

The population of the services sector SMEs in the Greater Accra and Ashanti Regions of Ghana are 27,836 and 18,409 businesses respectively, totalling 46,245 businesses in the two regions (IBES II, 2018). In all, 800 SMEs were survey. Sixty percent (60%) of these were from the Greater Accra Region (Accra/Tema) and 40% from the Ashanti Region (Kumasi). The face-to-face questionnaire survey method was adopted. A total of 688 participants were involved in the survey. 388 were from Accra/Tema and 300 were from Kumasi. The survey method through questionnaire administration was used because SMEs have less publicly available information (Abraham & Schmukler, 2017). The simple random sampling approach was adopted once services sector SMEs were purposely identified through their associations. The questionnaire was made up partly of Likert scaled questions and open-ended questions. Both the reliability and validity of the instrument were determined and are appropriate for the study by relying on expert advice and conducting a prior pilot study. The Cronbach's Alpha range of 0.6 - 0.75 was acceptable for the reliability of the variables measured. The results were analyzed using frequency and regression analysis because the responses were binary, to determine the relationship between the attributes and the financing decisions.

4 Findings and Discussion

4.1 Description of participants

The majority of the respondents were males (50.9%). Most of the respondents were in the age group 30 to 39 years. Over 92% of the SME owners were literate with the majority (26.6%) having Basic Education Certificate. In terms of experience, those that have between 1 to 5 years of experience (53.1%) in the business predominate. Over 65% of the SME owners did not have their parents engaged in businesses. Close to 70% had not had any form of business training. However, for those who had had some form of training, it had been in marketing, management and information technology and were mostly self-funded. For firm characteristics, most of the participants' businesses were sole proprietorships (87%), followed by partnerships (10%) and limited liability companies (3%). These were engaged in accommodation, education, trade, entertainment, transport and other services. Most of the businesses were Ghanaian owned businesses (96%). About 82% of the businesses were formally registered, the owners founded 91% of the businesses, and the rest were either inherited or bought. About 66% of the businesses leased their premises, whilst the rest owned their business premises.
The study set out to address three objectives.

4.2 Objective 1: Sources of financing used by Services Sector SMEs.

Table 1 indicates the source of financing of business at the three stages – at the startup, during business operations and at the expansion of business stages. The category of financing sources were own savings, family/friends assistance, informal Susu/money lenders, credit unions, microfinance institutions, banks, government agency, venture capital, private non-bank institutions, savings and loans, suppliers credit, buyers credit, Non-Governmental Organizations (NGOs), equity savings (retained earnings) and other. Participants were required to select one or more categories of financing they had used at any of the three stages. It was observe that SMEs tend to use multiple categories or financing sources for their businesses at each of the three stages. At the startup stage, most SMEs (90%) used their own savings, whilst three out of every ten (29.65%) also used assistance from family and friends to start their businesses in addition to their own equity. Only 3% used financing from banks when

they began their business. The rest of the factors were insignificant. Government agency, buyers' credit and non-governmental organizations (NGOs) were not use at all at start-up.
During daily operations, seven out of every ten businesses used their own savings (71.8%), and or equity savings (34.45%) and support from family and friends (11.9%). Informal Susu or moneylender and suppliers' credit were use by less than 10% of businesses. The use of formal financing from banks and savings and loans increased slightly at this stage, in addition to suppliers' credit. The rest were insignificant. For the expansion of business, again most SMEs used their own savings (70%) and or equity savings (36%). The use of external financing increased at this stage from the previous stages and together represented about 26% of the source of financing used. The use of supplier's credit also increased at this stage to 8.8%. The trend of financing sources where internal sources (own savings and equity savings) seems preferred first before the use of external sources (banks and savings and loans companies) is endorsed by the Pecking Order Theory (Shyam-Sunder & Myers, 1999) which postulates this trend and further supported by other studies (Ahmad & Atniesha, 2018; Osei-Assibey et al., 2012). From the study, SMEs hardly rely on venture capital or government agencies for the financing of their business as the patronage of these were quite insignificant.

Table 1. Source(s) of finance for businesses

Category	**start-up (%)**	**daily operations (%)**	**expansion of business(%)**
Own savings	624(90.7)	494(71.8)	482(70.06)
Family/friends assistance	204(29.65)	82(11.92)	82(11.92)
Informal Susu/money lenders	7(1.02)	57(8.28)	10(1.45)
Credit Union	3(0.44)	11(1.6)	8(1.16)
Micro finance institutions	3(0.44)	14(2.03)	22(3.2)
Banks	21(3.05)	25(3.63)	103(14.97)
Government agency	-	1(0.15)	3(0.44)
Venture capital	3(0.44)	3(0.44)	14(2.03)
Private None Bank Financial Institutions	2(0.29)	-	8(1.16)
Savings and Loans	10(1.45)	25(3.63)	76(11.05)
Suppliers credit	6(0.87)	42(6.1)	61(8.87)
Buyers credit	-	21(3.05)	17(2.47)
NGO Equity savings (retained earnings)	-	3(0.44)	5(0.73)
Equity savings (retained earnings)	32(4.65)	237(34.45)	248(36.05)
Other	4(0.58)	-	1(0.15)

4.3 Objective 2: SME owner/manager characteristics that influence source of financing decisions.

The underlying assumption of the multiple binary logistic regressions is that the significance is at 1%, 5% and 10%, whilst the confidence interval is at 99%, 95% and 90% respectively. At the start-up stage (see Table 2), parents' engagement in business were significantly predictive ($p<0.001$) of the use of personal savings as a source of finance. The rest of the variables such as age, gender, and education were not significant in predicting the use of personal savings to start a business. Male, older age (40-49 years) and working experience (1-5 years) were at 5%, 1% and 1% level of significance respectively in predicting the use of personal savings for operating business daily. In contrast, SME owners between the ages of 30-39 years used equity savings during daily operations of their businesses. The rest of the characteristics were not significant in predicting the use of equity savings for daily operations. SME owners with work experience between 1 to 5 years were predictive of using personal savings for expansion of business as this variable was statistically significant at $p<0.001$. On the contrary, those with over 5 years of experience were predictive of using equity savings for expansion of their business as the variable age was statistically significant at 1% ($p<0.001$). Those with tertiary level of education and had parents who were engaged in business were predictive of the use of equity savings for the expansion of their business. Receiving business training was not significant in predicting any of the financing sources used. Since about 70% of the participants had not received any training in business, this is an opportunity for policy decisions to support SMEs to be train in various areas to influence their choice of financing used. These variables (age and parents' involvement) were statistically significant at 5% and 1% respectively.

Table 2. Personal characteristics and source of financing used.

	Starting business from Personal savings		Operating business from Personal savings		Operating business from Equity savings		Expanding business from Personal savings		Expanding business from Equity savings	
	aOR(95% CI)	P-value	aOR(95% CI)	P-value	aOR(95% CI)	P-value	aOR(95% CI)	P-value	aOR(95% CI)	P-value
Sex		0.217		0.005		0.064		0.921		0.018
Male	1		1		1		1		1	
Female	0.71(0.41 - 1.23)		0.59(0.41 - 0.86)		1.38 (0.98 - 1.93)		1.02(0.71 - 1.47)		1.52 (1.08 - 2.15)	
Age (in years)		0.978		<0.001		0.0002		0.006		0.099
18-29	1		1		1		1		1	
30-39	0.83(0.35 - 1.97)		1.22(0.73 - 2.05)		1.07 (0.65 - 1.74)		1.89(1.11 - 3.22)		0.62 (0.38 - 1.04)	
40-49	0.91(0.37 - 2.21)		3.06(1.7 - 5.51)		0.52 (0.31 - 0.89)		2.87(1.6 - 5.13)		0.53 (0.31 - 0.91)	
>=50	0.92(0.33 - 2.52)		2.86(1.47 - 5.56)		0.43 (0.23 - 0.8)		2.03(1.08 - 3.82)		0.77 (0.42 - 1.41)	
Educational Level		0.762		0.021		0.095		0.037		0.002
None	1		1		1		1		1	
Primary	0.51(0.11 - 2.35)		0.45(0.13 - 1.49)		1.58 (0.5 - 5.01)		1.23(0.37 - 4.04)		3.09 (0.95 - 10.09)	
Secondary	0.66(0.12 - 3.54)		0.25(0.07 - 0.92)		1.97 (0.58 - 6.67)		0.7(0.2 - 2.49)		3.25 (0.93 - 11.43)	
tertiary	0.52(0.1 - 2.73)		0.25(0.07 - 0.9)		2.6 (0.77 - 8.75)		0.67(0.19 - 2.37)		5.89 (1.69 - 20.45)	
Working Experience		0.029		<0.001		0.964		<0.001		<0.001
None	1		1		1		1		1	
1-5years	2.18(1.03 - 4.62)		1.08(0.63 - 1.83)		1.01 (0.63 - 1.62)		1.39(0.83 - 2.34)		1.42 (0.85 - 2.36)	
>5years	1.03(0.48 - 2.18)		0.36(0.21 - 0.64)		1.06 (0.63 - 1.79)		0.29(0.17 - 0.49)		2.94 (1.71 - 5.07)	
Literacy		0.167		0.006		0.25		0.494		0.092
Yes	1		1		1		1		1	
No	0.43(0.13 - 1.42)		0.23(0.08 - 0.65)		1.77 (0.67 - 4.71)		0.69(0.24 - 1.98)		2.37 (0.87 - 6.45)	
Parents into business		<0.001		0.038		0.048		0.074		<0.001
Yes	1		1		1		1		1	
No	3.27(1.88 - 5.67)		1.48(1.02 - 2.14)		0.71 (0.5 - 1)		1.4(0.97 - 2.02)		0.46 (0.33 - 0.65)	
Received Business training		0.94		0.222		0.044		0.817		0.569
Yes	1		1		1		1		1	
No	1.02(0.56 - 1.86)		0.78(0.52 - 1.16)		0.69 (0.48 - 0.99)		0.95(0.65 - 1.41)		0.9 (0.63 - 1.29)	

aOR=Odds Ratio; CI=Confidence interval; P-value significance at 0.0 (1%), 0.005 (5%), 0.010 (10%).

4.4 Objective 3: Firm characteristics that influence SME sources of financing decision

Table 3. Influence of Firm Characteristics on Source of Financing

	Starting business from Personal savings		Operating business from Personal savings		Operating business from Equity savings		Expanding business from Personal savings		Expanding business from Equity savings	
	aOR(95% CI)	P-value	aOR(95% CI)	P-value	aOR(95% CI)	P-value	aOR(95% CI)	P-value	aOR(95% CI)	P-value
Operating in Service Sector		0.001		0.017		0.216		0.009		0.001
No	1		1		1		1		1	
Yes	4.9 (1.97 - 12.14)		2.68 (1.19 - 6.03)		0.59 (0.26 - 1.36)		3.03 (1.32 - 6.96)		0.25 (0.1 - 0.58)	
Different businesses operating		0.443		0.964		0.851		0.111		0.798
One	1		1		1		1		1	
2+	0.8 (0.45 - 1.42)		0.99 (0.67 - 1.48)		1.04 (0.7 - 1.53)		0.73 (0.5 - 1.07)		1.05 (0.72 - 1.53)	
Business is a Sole Proprietor		0.001		0.85		0.549		0.122		0.915
No	1		1		1		1		1	
Yes	2.86 (1.51 - 5.43)		1.05 (0.61 - 1.81)		1.18 (0.69 - 2)		1.5 (0.9 - 2.49)		1.03 (0.61 - 1.73)	
Member of any business/trade association		0.725		0.024		0.011		0.009		0.34
Yes	1		1		1		1		1	
No	1.11 (0.62 - 1.98)		1.53 (1.06 - 2.22)		0.62 (0.43 - 0.9)		1.63 (1.13 - 2.36)		0.84 (0.58 - 1.2)	
business formally registered		0.724		0.315		0.207		0.468		0.103
Yes	1		1		1		1		1	
No	0.85 (0.34 - 2.12)		0.75 (0.43 - 1.31)		1.39 (0.83 - 2.3)		1.23 (0.7 - 2.18)		1.6 (0.91 - 2.82)	
Has registered address		0.616		0.926		<0.001		0.027		0.217
Yes	1		1		1		1		1	
No	1.21 (0.58 - 2.54)		1.02 (0.65 - 1.62)		2.41 (1.57 - 3.68)		0.6 (0.38 - 0.94)		0.75 (0.47 - 1.19)	

aOR=Odds Ratio; CI=Confidence Interval; P-value significance at 0.001 (1%), 0.005 (5%), 0.010 (10%)

Table 3 indicates the firm characteristics and the financing used. Being a business owner in the service sector was significantly predictive of starting their businesses with personal savings and equally significant in the use of personal savings and equity savings in the expansion of the business. These variables were statistically significant at 1% (p<0.001) and 10% (p<0.010) respectively. Similarly, sole proprietors significantly start their business with personal savings. Businesses operating in the service sector and belonging to a trade/business association had a greater significance of expanding business on personal savings as the significance of these variables were at 10% each. Those belonging to a trade/business association and having registered business formally did not significantly influence the choice of financing.

4.5 Determinants of Financing Decisions

From the analysis, the determinants of SME owners' choice of financing source at the start up included their parents being involved in the business. A male owner of a business, who is older (40-49years) and have up to five years of working experience, will choose personal savings for their daily operations. Similarly, a business owner with five years or more experience in the business will again choose personal savings for the expansion of their business. Having a tertiary education with parents engaged in the business as well determines the choice of using equity savings for the expansion of business. SMEs are said to be challenged in accessing financing from banks especially at the startup stage because of the risk perception that the business will fail (Abraham & Schmukler, 2017). Hence, the use of their own funds and reliance on family and friends for financing (Balogun et al., 2016).

Service sector SMEs tend to use their own savings at the startup because their capital requirement is unlike that of the construction sector which requires a bigger capital to start (Domeher et al., 2017; Ofori, 2012). From the analysis, being a sole proprietor as a business type determines the use of personal savings at the start up stage of the business. Majority of registered businesses in Ghana are sole proprietorships whilst most businesses are even informal (Mensah, 2004). Sole proprietorships are challenged in sourcing financing for their businesses at all stages of their growth as their characteristics such as poor record keeping, lack of financial accounts and erratic decision making makes them unattractive to financial institutions (Hasan et al., 2021; Quartey et al., 2017b). Table 4 outlines the determinants of SME choice of finance in terms of the owner and firm characteristics.

Table 4. Determinants of SME Choice of Finance

SME Owner Characteristics			Firm Characteristics		
Determinants	**Financing Source**	**Stage**	**Determinants**	**Financing Source**	**Stage**
Parents engagement in business	personal savings	startup	Service sector	personal savings	startup
Male	personal savings	Daily operatons	Service sector	equity savings	startup
Age 40-49 years				personal savings	
1-5 years experience			Sole proprietor	personal savings	startup
1-5 years experience	personal savings	expansion of business			
More than 5 years experience					
Tertiary education	equity savings	expansion of business			
Parents engagement in business					

Balogun et al. (2016) indicated that SME owner and firm characteristics influence their access to financing in the construction industry which is similar to other sectors of the economy where these characteristics in addition to the macroenvironment tend to influence financing decisions for formal or informal sources of finance (Lin et al., 2020). Kwak (2020) concludes that, informationally opaque firms tend to prefer internal and informal sources of finance.

5 Conclusion and Further Research

This study contributed to the literature on SME financing decisions in addition to some policy recommendations and future research. Firstly, the approach of assessing financing decisions of SMEs at the three stages: startup, daily operations and expansion of business help to understand the financing decisions at these stages which is different from the perceived once-off decision of financing made by SMEs (Osei-Assibey et al., 2012; Quartey et al., 2017a). The category of financing types listed for participants to choose multiple options they have used is not only broad and encompassing but also unique and gives a deeper understanding of the choices of financing they opt for. The evidence that SMEs opt mostly for internal financing sources (own savings, family/friends, equity savings) at all three stages implies that there is room for financiers and policymakers to address how they can meet the financing needs of SMEs. One recommendation will be for stakeholders to provide training for SMEs across sectors so that they can develop all the necessary technical knowledge to not only run their businesses efficiently but also project their businesses as worthy of external financing. Policies can include different financing schemes targeted at the startup, during daily operations and at expansion phases of the SME financing stages. Conditions of the schemes could include SMEs formalizing their businesses by formally registering the businesses, maintaining records and submitting annual financial information to reduce the incidence of opaqueness associated with this group of businesses.

The study had its limitations in the sampling, methodology and type of analysis chosen. Future research could focus on other methods and approaches to achieve other perspectives in SME financing decisions.

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Impact of Policy in Innovating and Transforming Procurement in Infrastructure Projects Managed by Commercial State Owned Enterprises (SOEs)

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Abstract:
To explore how infrastructure projects in commercial SOEs can achieve the public procurement principles of value for money, efficiency, competitiveness and fairness as stipulated in the preferential procurement policy framework act (PPPFA). An exploratory, qualitative approach was adopted to demonstrate the value that public policies can add in the procurement of products services in infrastructure projects. Data were gathered through documents and analysed using the thematic analysis method. Government interventions through procurement policies have the potential to achieve anticipated results when implemented appropriately. The findings indicate that commercial SOEs with adequate support from the state can utilise mall, medium and micro-enterprises SMMEs to penetrate new markets and leverage on the private sector participation, thereby enhancing entrepreneurial practices and competitive advantage in large infrastructure projects. Preferential treatment policies also have the ability to drive innovation. The study however recommends that close partnerships or relationships with suppliers should be preferred only when the risks outweighs the benefits. This is one of few studies conducted on infrastructure projects in commercial SOEs. The results can therefore only be generalised to similar SOEs. The study has the potential to contribute knowledge in the management of preferential procurement and application of PPPFA in public infrastructure projects managed by commercial SOEs.

Keywords: Commercial enterprises, competitive bidding process, SMME, PPPFA, mandatory sub-contracting policies

1 Introduction

Public procurement serve as an important mechanism employed by the state to achieve multiple social and economic objectives (Konadu, Sen, Grandia and Meehan; 2017, 2018, 2017). It accounts for a major part of the gross domestic product (GDP) in many countries (Patil , Sen, Bhagat; 2017, 2019, 2017), and provides the best prospects for commercial state owned enterprises (SOEs) to achieve their mandates. On average, public procurement represent for 10% and more of the world-wide GDP (Muñoz-Garcia and Vila, 2019). In emerging economies, public procurement can be 50% or more of overall government spending (Fourie and Malan, 2020). In South Africa the estimate is approximately 22% of gross domestic product (GDP), while the latest annual procurement expenditure is roughly R500bn (Bolton, 2016). A substantial amount of this public funds is thus made accessible to commercial SOEs to ensure effective purchasing and contracting out of products, services and works in public projects inclusive of infrastructure projects (Marimuthu, 2020; Rosyda and Raharja, 2020).

Public procurement is also highly regulated (National treasury, 1999). Strategic sourcing is one of the rising areas of supply chain management (SCM), and also key element in unlocking strategic value such as efficiency, competition, value for money and innovation in the purchasing of products and services (Siljeur, 2017). It is thus commendable that the National Treasury has taken the decision to implement strategic sourcing to unlock value for the country (National Treasury, 2017). At a primary level, the South African National Treasury through the Public Finance Management Act (PFMA) demands an effective purchasing system that is unbiased, impartial, transparent, competitive and economical (National treasury, 1999). Public procurement at a secondary level, aims at addressing the consequences caused by past unfair discriminations (Manu et al., 2021). Also at this level, the state through commercial SOEs aims to advance preferred individuals and businesses through the allocation of contracts from amongst others big infrastructure projects (SA National Treasury, 2020).

Despite its strategic role, to date limited studies have examined the role played by public procurement and the legislations guiding the public procurement in promoting efficiency, entrepreneurship, competitive advantage and innovation in infrastructure projects (Suhonen et al., 2019). It is for this reason that this study was conducted. The purpose is to discover how infrastructure projects in commercial SOEs can achieve the public procurement value of efficiency, innovation, competitiveness and fairness as stipulated by the Preferential Procurement Policy Framework Act (PPPFA). The aim of the study is to analyse the impact of the PPPFA in infrastructure procurement. In particular, attention are given to the following objectives: (1) To explore the linkages between PPPFA and the principle of competition in order to leverage benefits from the private sector participation (2) To explore linkages between PPPFA and the principle of efficiency to determine whether innovation initiatives were adequately supported. The exploratory qualitative research method was used as an appropriate method to demonstrate the value that public policies can add in the purchasing of products services in infrastructure projects.

2 Literature Review

2.1 Public policy and the procurement principle of competitiveness

Private sector enterprises (PSE) in South Africa, have long recognised the need for a differentiated approach to the procurement (Siljeur, 2017)). These enterprises have since identified strategic sourcing as an effective approach to unlock significant value in procurement. This fact makes private sector participation pertinent to the public sector efficiency. In this regard, section 4 of the PPPFA addresses the pre-qualification criteria and the advancement of SMMEs. The section stipulates that public entities such as commercial SOEs must advertise bids with condition that only bids with one or more of the below characteristics may respond"

(A) B-BBEE level within the specified threshold
(B) Specified small and medium enterprises, supplier and/or contractors
(C) Subcontracting intentions of 30% or more to the specified enterprises

Section 9 of the PPPFA further addresses subcontracting conditions to specified enterprises and suppliers. Conditions are as follows

(1) Where practical to subcontract in a contract of R30 Million and more, public entities, must contract the specified small and medium suppliers.
(2) Where public entities intend to apply subcontracting conditions, the condition of 30% and more of contract value must be clearly communicate to these small and medium enterprise and suppliers.

Section 4 and 9 strives to activate private sector participation and entrepreneurship through the contracting of SMMEs (Reijonen *et al.,* 2016). This is very prevalent in South Africa, where sub-contracting in infrastructure projects can enhance competition between small enterprises. One such example is the collaborations formed between commercial SOEs and SMMEs through preferential procurement initiatives such as competitive Supplier Development Program (CSDP) targeted at Eskom and Transnet (Vermeulen 2017, Eskom Holdings 2019, Transnet 2019). The competitiveness of SMMEs was viewed from two dimensions: profitability and innovative solutions (Edler and Georghiou, 2017). This is reinforced by Makwara, (2019), who demonstrated that SMMEs including those sub-contracted by commercial SOEs for public infrastructure projects have the capacity to nurture innovation, thereby enhance entrepreneurship practices. The study findings by Singh and Subrahmanya (2018) elaborate on how innovation performance of SMMEs in Asian improves when subcontractors receive assistance from large businesses.

Although, SMMEs have demonstrated their ability to nurture entrepreneurship and innovation, they are often hindered by capacity challenges including limited access to capital and funding (Mphela and Shunda 2018, Olusegun and Akinbode 2020, Hove and Banjo 2018). According to Adediran and Windapo, (2017) large investments are required in construction industry for contractors to obtain and maintain their own facilities and equipment while making the most of its utilisation. Given this substantial investment in plant and equipment, larger businesses in the construction industry, tend to win government contracts thus disadvantaging SMMEs (Normanyo, Ansah and Boakye 2016). The legislation framework is unfavourably position SMMEs against large businesses (Tammi *et al.,* 2017). For example, several studies have highlighted a negative impact on the growth and effectiveness of mandatory subcontracting policies that enforce work to be contracted out to SMMEs without financial and technical support or technical development (Mambwe *et al.,* 2020, Cheelo and Liebenthal 2018). With all these challenges very few small contractors or SMMEs have progressed to becoming well established suppliers in the construction industry (Manu *et al.*, 2021).

2.2 Public policy and the procurement principle of Efficiency

Despite its ability to reduce cost, increase profits and improve quality products and services, innovation practices are rarely included in public tender contracts, particularly in the awarding of construction and engineering projects (ECP) (Taherdoost and Brard, 2019). The justification for this from two areas: 1.) Traditional approach to procurement that primarily focus on price, thereby neglecting innovation and other factors (Georghiou *et al.,* 2014, Edler *et al.,* 2015) and 2) extensive technical specifications that limit the skills and originality of potential suppliers in offering innovative solutions (Laryea and Watermeyer, 2014). For quite some time, the old-fashioned approach to choosing supplier has been centred on price (Wong, Holt and Cooper, 2014). However, businesses have started to realise that selecting supplier's solely on price, as a sole factor is not sustainable. Hence the inclusion of other factors such as quality and performance and technical capability (Hu and Liu, 2018). In this regard, section 6 and 7 of the PPPFA stipulates that:

> *State entities must specify the preference point system that is appropriate to the in the bid documents, and that the lowest bid will be used or selected*

At face value, the preference point system may appear to support the perception of Eriksson et al., (2019) that most public sectors, still uses the traditional lowest bid method to award contracts. The PPPFA, however, also stipulates that the:

- *"Award of contracts to bidders that do not achieve the highest points may be granted only in agreement with section 2(1)(f) of the Act,*
- *(2) If the state entity plans to use the objective criteria in terms of section 2(1) (f) of the Act, the objective criteria must be specified in the bidding documents".*

Given these conditions, the preference point system may also seem to support Taherdoost and Brard, (2019) who stated that "even in the case of multi-criteria evaluation, the criterion of the bid price often weights more than 70% making it obvious that this criterion carries a significant influence in the efficiency of the tender process particularly those in construction projects". About the PPPFA, this assumption can be disputed, since quality that is referred to as functionality is considered. Including quality or functionality has been identified as a vital factor in public procurement evaluation method that has the potential to spur innovation (Stake, 2017) and improve project delivery performance (Kiundu, 2018, Micheli and Cagno 2016, Ottou, Baiden and Nani 2020). A survey conducted among 102 independent retailers in Soweto, supports quality as a vital factor where supplier performance is concerned (Makhitha, 2017). Ninety–five percent (95%) of the respondents agree to this fact. A study that analysed the supplier selection criteria of more than 110 suppliers, reported that the criteria will continue to change to include traditional aspects of performance, functionality and price, in addition to modern features such as innovation or process improvement (Cheraghi, Dadashzadeh and Subramanian, no date).
The use of functionality in the pre-qualification phase during competitive bidding requires detailed specification to capture user specifications. This is discouraged by several researchers due to the negative impact on innovation and project deliver performance (Edquist, Vonortas 2015, Zabala-Iturriagagoitia 2015, Nganu and Mwangangi 2019). On the contrary, in EPC a "preliminary market consultation" to engage with suppliers prior to the evaluation stage is common and preferred over detailed specifications is preferred (Bolton, 2016). As a result, close supplier partnership-style relationships are established and deemed appropriate in such strategic procurement (Czarnitzki, Hnermund and Moshgbar, 2018). The traditional arm's length approaches such as competitive bidding remain suitable for regular and non-complex procurement (Micheli and Cagno, 2016). The preference for preliminary market consultation" is substantiated by Koubaa, (2016) in their perception that "too many suppliers" weakens the supply chain performance in a business" resulting in delays and increased costs

3 Methodology

The qualitative approach enabled the researcher to explore the significance of public policy in the procurement of goods and services for infrastructure projects in commercial SOEs. From the exploratory perspective, the study is deem appropriate since studies in this area are limited. Data were collected through appropriate documents from approved journal articles, mainly from Elsevier, Science Direct, Scielo, Sage, Research gate. Thematic analysis in this case complemented the document analysis (Bartlett and Vavrus, 2017), and enabled the use of both the inductive and deductive reasoning (Vaismoradi and Snelgrove, 2019). Thematic analysis also allowed data comparison from the literature review, which resulted in the establishment of themes upon which the discussions and findings were reached. Regarding validity of the study, dependability was achieved through adopting a logical and detailed process which can be documented and followed easily (Nowell et al., 2017, Friese, Soratto and Pires, 2018).

4 Findings and Discussions

The first objective for the study was aim at exploring the linkages between public policy and competition. Table 1 indicates the themes that were developed and analysed:

Table 1. Themes related to public policy and competitiveness

Category	Themes	Journals
Studies in support of innovation, and Entrepreneurship	Innovation, Policy support	(Love and Roper, 2015), (Rankhumise E and Masilo K, 2018), (Manu et al., 2021) (Singh and Subrahmanya 2018)
	Entrepreneurship, private sector participation	(Edler and Georghiou, 2017); (Makwara, 2019).
Studies that oppose innovation and Entrepreneurship	Low SMME participation in public contracts	(Olusegun and Akinbode, 2020);
	Inefficient Public procurement policies	(Mphela and Shunda; 2018), (Uyarra et al., 2014); (Mambwe et al., 2020)
	Capacity and financial challenges	(Hove and Banjo, 2018), (Adediran and Windapo, 2017), (Normanyo, Ansah and Boakye, 2016).

4.1 Themes in support of the principles of innovation and entrepreneurship

Based on the above themes, there seem to be strong linkages between the principle of competition and entrepreneurship. The PPPFA has proven to be effective in supporting the collaboration between SOEs and SMMEs in driving innovation and competitive advantage (Rankhumise E and Masilo K, 2018). This is aligned to the finding which suggests that adequate amount of subcontracting support is a contributing factor to the innovation capability of SMME (Nwokocha, Nwankwo and Madu, 2019). It thus becomes evident that participation from the private sector, through the sub-contracting of SMME introduces entrepreneurial practices since SMMEs are forced to operate more efficiently (National treasury, 2015).

4.2 Themes opposing the principles of innovation and entrepreneurship

Literature entails that SMMEs need to be profitable in order to achieve innovation and entrepreneurial value (Edler and Georghiou, 2017). Despite the great contribution of SMMEs to innovation and competition, the South African National Development Plan estimates SMME contribution to GDP at 45%, one of the lowest in the world. In addition, very little is still unknown regarding the CSDP performance. The majority of SMMEs in public infrastructural contracts have also been found to be weak at commercial services as a result of limited and inadequate financial support calls for government intervention (Ancarani et al., 2019). All these factors indicate that the advancing of SMMEs through preferential treatment is unsatisfactory.

It is therefore apparent that if the state wants to reduce the high rate of SMME failure, appropriate financial and non-financial support must be made available to commercial SOEs in order to enable SMMEs to leverage entrepreneurships and innovation practices from the private sector (Mphela and Shunda, Georghiou, Edler, Uyarra, Yeow, 2018, 2014). Moreover, the legislation should be drafted with clarity and intention highlighting the risks of mandatory subcontracting rules and how the policy intents to support SMMEs in this regard (Rosli and Mustaffa, 2018, Mphela and Shunda, 2018).

The second study objective aims at examining relationships between Public policy and Efficiency to determine if the current legislative adequately support innovation practices.

Table 2. Themes related to public policy and innovation

Category	Theme	Journals
Studies that support Efficiency and competition	Multi-criterion decision making	
	Quality-Price criterion	(Makhitha, 2017), (Wong, Holt and Cooper, 2014), (Nganu and Mwangangi 2019), (Singh, Nkwe and Karodia, 2015).
	Multi-factor decision criterion	(Cheraghi, Dadashzadeh and Subramanian, no date), (Edquist, Vonortas, and Zabala-Iturriagagoitia 2015).
Studies that oppose of Efficiency and competition	Detailed specifications / Prequalification	Czarnitzki, HHnermund and Moshgbar, (2018), (Stake, 2017), (Laryea and Watermeyer, 2014)
	Close supplier relationships "Preferred" suppliers	(Basant, 2018), (Abutabenjeh, Gordon and Mengistu, 2018), (Sayed et al., 2019), (Pooe 2016, Israel and Kazungu, 2019; Hansen, 2020; Ettmayr and Lloyd, 2017).

4.3 Themes that support Efficiency and Competition

The above themes indicate strong linkages between the principle of Efficiency and innovation. The PPPFA recognises that relying solely on the cost considerations as a supplier evaluation criteria might raise quality issues, hence quality is considered (Cheaitou, Larbi and Al Housani, 2019). The innovation related themes also revealed that in order to achieve the required level of quality in innovative procurement, close supplier partnerships are deemed appropriate in EPC projects. We can thus deduce that like most public procurement policies, the PPPFA supports the use of multi-factor decisions which incorporates cost, innovation and quality factors (Singh, Nkwe and Karodia, 2015). This in turn adequately addresses the principle of efficiency, particularly in the supplier evaluation and selection stages

4.4 Themes that oppose of Efficiency and competition

Whilst it is clear that close supplier partnerships are preferred in EPC, the approach, when employed inappropriately can create challenges for commercial SOEs to enforce preferential procurement policies (Basant, 2018). Since such relationships oppose the competitive bidding strategy; the public procurement principle of competition is also compromised (Abutabenjeh, Gordon and Mengistu 2018, Sayed et al., 2019). This may also defeat the strategic sourcing objective, established by the PFMA to reach as many suppliers as possible, particularly in the private sector to leverage on entrepreneurial and cost reduction practices. Moreover, global supply chains and foreign investment opportunities might also be sacrificed since a larger supplier base, known to offer businesses opportunities that establish new sources of innovation is reduced (Pooe 2016, Israel and Kazungu, 2019; Hansen, 2020; Ettmayr and Lloyd, 2017).
The study thus recommends that preferred suppliers or close supplier partnerships be favoured only when the risks outweighs the benefits and within the conditions set out in the PPPFA (Sorte Junior 2016, Laryea and Watermeyer 2014). Open communications between contractors should be encouraged where there is an opportunity to enhance technical efficiency (Hu and Liu, 2018) without compromising benefits of open bidding or competition.

5 Conclusion and Further Research

This study investigated the impact of the procurement policy on infrastructure projects in commercial SOEs. The findings from the study reveal that government interventions through preferential procurement policies have the potential to achieve anticipated results when implemented appropriately. This indicates that commercial SOEs with adequate support from the state can utilise SMMEs to penetrate new markets and leverage on the private sector participation, thereby enhancing entrepreneurial practices and competitive advantage.
Preferential treatment from the state also has the ability to drive innovation through close supplier a partnership-style relationship. However, such supplier approach may contradict principles of open competition. In such instances, the study recommends that the approach should be used only when the risks outweighs the benefits or with approval from the South African National treasury as stipulated by National treasury instruction note 3 of 2016/2017 (National Treasury, 2017). The paper is limited to infrastructure project steered by commercial SOEs. The paper is also a literature review paper and thus limited to desk research. Future research should be undertaken to add practical validation to conclusions in this paper.

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Capability factors influencing the adoption of Building Information Modelling (BIM) by South African AEC organizations

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Abstract:
Building Information Modelling (BIM) has been identified as a possible moderating solution to the construction industry's challenges, such as delayed projects, high costs of construction, and compromised quality of products. However, the adoption of BIM processes has been slow within South African AEC organizations. This research identifies the capability factors influencing BIM adoption from organizations that have successfully adopted BIM. A qualitative analysis was conducted using a case study research design that incorporated semi-structured, personal interviews of AECs in South Africa and site observations. The interview questions were designed to figure out the level of BIM adoption, the capability factors that enable the adoption of BIM, and the main capability factor influencing BIM adoption within South African AEC firms. The three case studies revealed that the level of BIM adoption is still developing. The capability factors identified from the three case studies were grouped into three main categories - human resources, process and technology. The main capability factor discovered was the cost which falls under the process category. The findings presented in this paper aim to provide an insight into the needs and concerns of AEC firms regarding BIM adoption.

Keywords: AEC, BIM adoption, capability factors, competency

1 Introduction

The building's life cycle processes are managed with tools such as Building Information Modelling, which will administer the crucial building design and project data in a digital format for an easy flow of information. Aouad et al. (2006) and Succar (2009) note that the success of construction projects depends on the ability of the stakeholders, contractors, clients and other project teams to consider and communicate multi-disciplinary issues, constraints, goals and perspectives holistically. The construction industry recognizes Building Information Modelling as having significant potential to impact project delivery and performance positively. The BIM tools and processes have been developed to improve productivity in the construction industry. BIM allows the project team to aim towards improved construction site practices across the supply chain as it enables more accurate data, greater precision and reliable construction processes, and ease of operations and maintenance (Azhar, 2011; Khosrowshahi et al., 2012; Wortmann, 2016).

The construction industry plays a crucial role in the South African economy as it contributes to the country's economic growth. Success on projects is measured in terms of performance in time, quality and cost. However, success in these three main aspects is rarely achieved due to constraints such as delays that affect cost and quality. Events such as delayed finances and payment of work stemming from the client, improper planning and general mistakes from the contractor, preparation and long waiting times for approval of documentation from consultants are some of the causes (Akintola et al. 2017; Babu and Suresh, 1996; (Odeh and Battaineh, 2002). These constraints are difficult to eradicate, and BIM is acknowledged as a possible solution. However, most AECs in South Africa have not successfully implemented and adopted BIM (Kiprotich 2014).

The point of interest in this research was to determine the capability factors influencing BIM adoption in the South African AEC industry to determine the extent organizations need to go to acquire these enablers of BIM adoption. BIM mainly operates on three characteristics: processes, technology, and human resources, with the latter, is usually the main challenge facing many organizations in successful adoption (Rogers et al., 2015). Other factors are significant as well, and while BIM capability factors are inexhaustible, a few are worth mentioning, mainly focusing on these three overarching aspects.

Arayici (2011) suggests the following as leading influencers of adoption: people's understanding of the value of BIM over traditional models, the training of workers to use BIM as well as finding a work team that understands its functionality, the adaptation to the high-quality hardware resources and networking facilities to run BIM applications and tools efficiently, and knowledge of the role of different stakeholders in the new process by construction lawyers and insurers. A survey done by Shakantu et al. (2014) aimed to assess the level of BIM awareness and adoption in South Africa. This survey showed that the innovation adoption by South African architects is 53% and for BIM awareness is 79%, whilst South African contractors had an awareness of 27% and adoption of 12%. These statistics have also been motivated by the South African government showing no interest in driving BIM practices as there are no government BIM standards or specifications required in practice (Wortmann et al., 2016).

The research focused on the capability factors of AEC organizations in adopting BIM in their workspace. An evaluation from organizations that have successfully adopted BIM was done. Capability is the power or ability to perform a task but, in this regard, the question being asked is what capabilities an organization needs in order to be BIM capable. Firstly, these capabilities include technical/physical resources such as adopting the necessary hardware, software availability, and network infrastructure availability. Secondly, administrative and strategic capacity such as IT Budget, BIM research and maturity, BIM research and development and clear BIM vision. Thirdly, BIM modelling capacity such as BIM standards and internal information management (Mahamadu et al., 2017). South African AEC Organizations have been adopting BIM at a languid pace compared to other countries globally. It is being used in an isolated environment mainly by architects instead of using a collaborative tool for the entire project team (Kiprotich 2014; and Shakantu & Froise, 2014). The objectives to be achieved in this research are to identify the level of BIM adoption within South African construction firms, identify the capability factors that influence its adoption, establish the key capability factors and determine the capability factor with the most significant influence on BIM adoption.

2 Literature Review

This chapter starts by giving an overview of the challenges faced in the Architectural, Engineering and Construction Industry to draw some attention to why BIM adoption is an innovative solution to solving the many problems. It then speaks on BIM adoption and the degree to which it has been implemented globally, and the capability factors that influence this adoption. These capability factors were stated and discussed in detail before categorizing them into three main capability factors: people, process, and technology. Different authors have defined BIM in different ways; BIM is seen as a single project database in the form of an electronic data model to which professional bodies collaborate throughout the design to operation and maintain the building (Gann et al. 1996).

2.1 Challenges faced in the Architectural, engineering and Construction Industry

The construction industry has been facing challenges over the years, and one of the main challenges has been the fragmented nature of the industry (Nawi et al., 2014). Fragmentation in this respect means the separation of the design stage and construction stage, including the actual construction of the structure itself. Fragmentation also relates to the construction procurement process itself, which separates designers, contractors and facility managers in the initial stages of a project (Nawi et al., 2014). Owolabi et al. (2014) identified delay as a major challenge faced by the AEC worldwide. Owolabi et al. (2014) mentioned the factors that affect delays, including changes in drawings, a lack of communication amongst project participants, incomplete work from consultants, and variations. Architects, engineers and contractors use BIM to help overcome some of the stated challenges. Building information modelling (BIM) seeks to integrate processes throughout the entire lifecycle and is seen as a tool to improve or look upon some of the challenges faced in the AEC industry (Aouad and Arayici, 2010).

2.2 Overview of BIM adoption

BIM adoption has been generally slow worldwide (Gu and London 2010; Azhar, 2011; Elmualim, 2014; Jung, 2015). In the South African context, BIM has predominantly been adopted by organizations in KwaZulu-Natal, Western Cape, and Gauteng provinces in commercial and residential building projects. The research also showed that the most prevalent software used are ArchiCAD, Autodesk Revit, WinQS and QSPlus (Ogwueleka, and Ikediashi, 2017; Abubakar, 2014; Jung, 2011; Kouch, 2018; Liu, 2015). Kekana et al. (2015) investigated the level of BIM adoption in three key South African areas: Johannesburg, Tshwane, and Ekurhuleni. Of the questionnaires sent, the fifty that returned revealed that the usage of BIM, amongst those participants, was at 80%. BIM experience was also found since BIM usage was common amongst management and designers in construction organizations.

2.3 Capability factors influencing BIM adoption in South Africa

The introduction and adoption of any new technology such as BIM require the capability factors that will positively affect the adoption to be identified and addressed for the successful take-up of the innovations (Abubakar et al., 2014). These capability factors that lead to the adoption of BIM are documented in the previous literature above. These capability factors are of different categories as defined by different experts. Eastman et al. (2011) categorized these capability factors according to process and technology. The process factors deal with the business, including legal and organizational issues that influence the adoption of BIM, while technology factors relate to the readiness and implementation of the actual BIM processes. Sun et al. (2017) had a third category: personnel; the personnel factor refers to the professional-related capability factors. Table 1 below shows a summary of the capability factors identified in the literature review when categorized according to process, technology and human resources:

Table 1: Capability factors

Category	Capability Factors	References
Process	• Presence of standards or guidelines • Cost • Business Environment • Organizational Structure	Azhar et al. (2012); Gu and London (2012); Hong et al. (2016)
Technology	• Interoperability between software platforms and users • Hardware and Software	Sun et al. (2017); Liu et al. (2015); Succar et al. (2013); Hong et al. (2016); Ezeokoli et al. (2016); Gardezi et al. (2014); Memon et al. (2014)
Human resources	• Attitude towards BIM • Structure/culture of the industry • Level of knowledge and awareness	Succar and Sher, (2014); Barison and Santos, (2011); Succar and Kassem (2015); Arayici et al. (2011)

2.4 Main Capability Factors

2.4.1 Process

The process relates to the number of activities an organization does in successfully implementing BIM. A capability factor that influences processes in BIM adoption is cost. Cost, in this context, refers to the cost of software, licenses and cost of the staff implementing BIM processes. Hong et al. (2016) mention that costs can influence the adoption of BIM by organizations.

2.4.2 Technology

The BIM-based software packages are also called BIM tools. The technological factors refer to BIM tool-related factors limiting BIM application, such as the cost of the technology, maintenance of the hardware and software, and interoperability between software platforms and users (Sun et al., 2017).

2.4.3 Human resources

For the Human factor of BIM, construction organizations speak of the promotion of an educational principle that looks at how to create a framework with components that help in enabling BIM adoption within an organization. The attitude of individuals influences their willingness to learn and practice improving their skills and knowledge. The skills and knowledge were identified as capability factors that influence adoption (Barison, 2011; Kassem, 2015). In terms of expertise, Arayici (2011), Barison (2011) and Eastman (2011) note that a competent BIM Manager knows about Information Technology, design and construction processes, management, BIM standards, BIM workflow, coordination practices, project management, construction drawings and costs, schedules and financial risks, parametric object-based design and other disciplines.

3 Research Methodology

This study employed semi-structured interviews to elicit research information from the case study participants. The chosen approach for this research was the case study design, which involved interviews and observations in collecting data. This approach required a constructive approach that required more interaction between the researcher and the participants. In addition, the questions were framed in a way that would help the researchers in answering the three research objective as well as determine the key capability factor influencing BIM adoption. This would be possible through a thematic analysis of the data.

This research method was employed because of the three distinctive characteristics that were outlined by Hancock and Algozzine (2017). The first characteristic is that it describes the social phenomena as they occur naturally with no attempt to manipulate the study; secondly, it looks at the collection of the qualitative data, and the last characteristic looks at the qualitative sampling techniques that are concerned with seeking information from specific groups and subgroups within a population. For the purposes of this study, the study population consists of all Architectural, Engineering and Construction (AEC) organisations based in South Africa that have adopted BIM. A purposive sampling technique was used in selecting AEC firms based in South Africa and in identifying BIM managers, architects, engineers, construction managers, quantity surveyors who work for these organisations.

All interviews were recorded on smartphones after consent from participants, and the recordings were then manually transcribed through listening to the voice recording and manually typing word for word. In addition, the researchers had to visit the actual workplaces of the interviewees, which also allowed brief observations of the area in terms of actual hardware and software implemented and BIM models and applications used. The interviews were conducted on three AEC firms in Cape Town that have adopted BIM, and the selection criteria for the firms was that the firm must have: adopted BIM for more than five years; implement BIM on all projects; a cidb Grade of 8 or 9 and been practising architecture, engineering or construction. Based on the criteria outlined above, the firms interviewed were two architectural firms and one engineering firm. Research participants were chosen from architects, BIM managers, and quantity surveyors and the main requirements were BIM competency and at least five years of BIM experience.

For Case Study 1, referred hereafter as CS1, the organization has adopted BIM for ten years now, and they have a footprint in six continents. CS1 is an architectural organization and develops high-end residential and commercial building in South Africa. They are currently on Level 3 of BIM adoption, and the one interviewee has been BIM manager for ten years now for the organization. Case Study 2, referred hereafter as CS2, conducted a group interview style.CS2 is an architectural organization that also adopted BIM in 2009. CS2 does architectural and design work in the urban commercial spectrum as well as individual and interior design. CS2 volunteered to have their whole BIM team interviewed, a total of five architects, which included an eight-year-BIM manager veteran as well as four architects who have been using BIM since 2009. While Case Study 3, referred hereafter as CS3, the organization is an infrastructure firm providing planning, designing, engineering, construction and consulting solutions worldwide. CS3 adopted BIM for all of its projects since 2014 and has been ranked in the top three in the Transportation and General Building in *Engineering News- Record*'s 2018 and 2019 "Top 500 Design Firms". The interviewee has been a lead BIM expert for projects all around the African continent for CS3 and a quantity surveyor for the past thirty years.

A thematic analysis of the interviewee responses was done to determine the findings of the investigation. First, each interview's responses were grouped into their respective questions. Then, the semi-structured questions and the responses received each interview's key responses that answered the questions, and the research objectives were highlighted to separate relevant responses from less relevant information. The same was done for each interview, and a final document that listed all the questions responses from the three case studies were then drafted into three columns. This then allowed a cross-reference of the information to evaluate the responses and check for any similar themes, contradicting themes and entirely new insight.

4 Findings and Discussion

Table 2 provides a summary of the findings within the three case studies.

Table 2. Summary of Findings

Findings	**CS1**	**CS2**	**CS3**
Year of adoption	2009	2009	2014
BIM Leve of maturity	Level 3	Level 1	Level 3
Employee training	In-house training	- One-off BIM training courses - Weekly workshops	In-house training
BIM Standards	UK BIM standards	UK BIM standards South African standards	UK BIM standards
Hardware and Software	- Revit and ArchiCAD - In-house software maintenance	- Revit - Outsource software maintenance	- wings, DivX, CostX, Tekla, ArchiCAD and Revit - In-house software maintenance
Technology	- i7 processors and cloud sharing system - virtual reality	i7 and i9 processors, advanced RAM, graphics cards and cloud sharing system	i7 and i9 processors, BIM 360, virtual reality and cloud sharing system
Cost	Licensing and subscriptions Hardware	Licensing and subscriptions Cloud services	Software updates and licenses
Organizational Structure	Inclusion of BIM manager and collaborative decision-makers	Inclusion of BIM manager	Senior BIM leader and inclusion of BIM manager

It emerged that each case study was on different levels of BIM adoption (Maturity level). For example, while CS1 and CS3 were on Level 3, CS2 was on Level 1. Furthermore, as outlined by the three case studies, the training of employees is a significant factor. The interviewees within the three case studies emphasized how the training of employees was of the essence for the successful adoption of BIM. The three case studies had different strategies for training the employees. The most common one within the case studies was the in-house training; this supports what was stated in literature by Sacks et al. (2010) that the implementation of BIM has a ninety per cent success rate; there is extensive training of employees to avoid any potential errors or misuse. All three case studies had advanced technology, hardware and software within their organization. The technology included high-speed fibre, real-time collaboration, storage, powerful graphics card, and software used by various organizations such as Revit, WinQS, DivX and ArchiCAD.

Table 2 indicates that all three case studies use the same BIM standards, which were the UK BIM standards; the respondents reasoned that the UK already established UK standards, similar to that of South Africa. At a later stage, CS2 was able to adopt the South African BIM standards. The use of standards supports previous studies (Bin Zakaria et al., 2013; Abubakar et al., 2014; Ezeokoli et al., 2016) that government should support BIM adoption. This support should be in the form of standards/implementation guidelines. The costs of adoption identified by the interviewees within the three case studies were the cost of the software's license. The cost was referred to as being expensive, and a considerable expense for the organization, and this supports what was stated by Sureman et al. (2008) that an organization must have the necessary funds required to buy the software needed for BIM. CS2 also incurs the cost of the skilled staff because these employees require high salaries.

After adopting BIM, new roles and responsibilities were established within the organizations of the three case studies. CS1 had a BIM manager and sub-leaders who had the knowledge required to make decisions, and this responsibility was taken away from the directors as they were initially responsible for all the decision making. CS2 and CS3 also had a new role for BIM manager; in CS2, the BIM manager was responsible for the project design team. CS3 had a senior leader who was responsible for developing the organizations BIM vision and goals.

There are attitudinal differences to implementing new technology within an organization towards the new change (Brewer and Gajendran 2012), which was similar to the research findings. For example, CS1 and CS3 had employees who wanted to adhere to the traditional ways of doing things, while in CS3, it was a mixed bag comprised of some employees who embraced the new technology and others who preferred doing things the old way.

Overall, the findings suggest that cost is the key capability factor in BIM adoption in an organization. Therefore, an organization should cover the hardware, software, and implementing BIM costs to adopt BIM successfully.

5 Conclusion and Further Research

The low adoption levels of BIM within the South African AEC context, despite the benefits of adopting the technology, were the driving factors for this research. The research aimed at determining the key capability factor that influences the adoption of BIM in the AEC industry in South Africa. However, to achieve this primary aim, firstly, the research looked at the capability factors influencing BIM adoption through a literature review and, after that, personal interviews and a qualitative cross-case data analysis. The study found that the level of BIM adoption was low across the three cases and that BIM capability factors could be classified under three main categories: human resources, technology, and process. The process factor was identified as the main capability factor influencing BIM adoption within South African AEC organizations. It also emerged that attitude towards BIM adoption, costs of training employees, maintaining software and hardware, and licensing are capability factors towards BIM adoption, and the cost of adopting BIM processes was identified as the main capability factor.

This research adds to the body of knowledge by determining the factors influencing BIM adoption in South Africa, particularly by AEC firms. This research provides an understanding of why BIM adoption is low amongst AEC firms in South Africa and factors that need to be considered in adopting the software technology. Further research can examine how best software and hardware maintenance strategies can be conducted to mitigate the costs of BIM processes. The main limitation of this study is the relatively small sample size used for this investigation. The reliability of the findings can be improved by investigating more organizations.

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Impact of construction for the expansion of National Highways on the local environment in India

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Abstract:
Increased traffic has led to a higher demand for construction and expansion of National Highways (NH) in India. Along with positive transformations, the construction of NHs create environmental ailments in the vicinity of the road construction sites and impacts the local environment. However, the impact of construction or expansion of NHs on the local environment and measures to alleviate the ill effects are undermined in India. Therefore, using the study context of National Highway expansion projects in the Odisha state of India, the study assessed the various environmental impacts of construction and explored strategies to mitigate environmental ailments. Data was collected by using survey research methods. A perception survey among the local communities and stakeholders and a Delphi survey among experts were conducted to collect data. Both descriptive and inferential statistics were used to analyse the data. Findings suggested that severe health ailments and air, water, noise pollution and land severance are experienced. The Environmental Impact Assessment (EIA) process has significant gaps and does not adequately consider the local environment. The current mitigation measures adopted are marginal and not sufficient to meet the challenges of environmental degradation. Appropriate strategies related to procedural, socio-economic, wildlife-related, land and road alignment and technical aspects would likely assist in mitigating or preventing environmental degradation at the local level because of NH construction or expansion. The identified gaps could strengthen the EIA process, and the implementation of the suggested strategies could alleviate the local environmental challenges because of the impacts of NH construction.

Keywords:
Construction, Environmental Impact, National Highways, Pollution, Technology

Introduction

National Highways (NH) bring significant socio-economic and mobility benefits across the Globe (Asturias, Garcia-Santana and Ramos, 2019). However, they are the major reasons for environmental degradation at the local and global levels (Chandra and Thompson, 2000; Handa, Aggarwal and Bhardwaj, 2019). So, it is essential to create and operate the NHs without hampering the environment. In India, the increase in population and socio-economic activities created a significant rise in the demand for movement of good and traffic at city, regional and national scale. Consequently, a huge increase in traffic on the major roads, including NHs and State Highways (SH) is experienced. This situation created a necessity to build new National Highways and upgrade the existing ones. As a result, construction activities in terms of new construction, expansion, and upgrades of the roads were undertaken in the last few years.

While this new construction and up-gradation of the roads are expected to positive transformations in the socio-economic and mobility scenarios, it has created significant socio-economic, spatial and environmental ailments in and around the road construction sites. Specifically, from the environmental point of view forests and hills and wildlife were observed to become vulnerable because of the construction activities. Furthermore, the environmental pollution created not only endangered the environment but also caused health ailments among the people living in the villages and towns in the vicinity of road construction sites (Handa, Aggarwal and Bhardwaj, 2019)

India enacted several laws and rule and regulations for environmental protection, which also apply to road construction as relevant. Environmental Impact Assessment (EIA) is generally conducted and environmental clearance is obtained before implementing any highway projects. However, field observations and according to the perceptions of the stakeholders, it is found that several environmental and ailments are experienced during and after the road construction, specifically where large scale construction activities are undertaken for a considerable period (Handa. Aggarwal and Bhardwaj, 2019; Solanki, Ahamed, Gupta, and Nongkynrih, 2016; Walia, Aggarwal and Bhardwawaj, 2017). Despite the availability of elaborate environmental protection laws and rule and regulations, the impact of construction on the local environment and measures to alleviate the ill effects are undermined in India. In the absence of understanding and assessing the impact of road construction on the local environment, both the environment and the people continue to suffer unabated, which needs investigation. Therefore, using the study context of a National Highway expansion project in the Odisha state of India, the study assessed the various environmental impacts of construction and explored strategies to mitigate environmental ailments.

The National Highway 55 was used as the study context for data collection. The NH 55 connects two important cities of Odisha state of India such as Cuttack and Sambalpur, passing through several major district headquarters, towns, and industrial centres. Also, it provides access to the coal mines of Talcher and NH149. The length of expansion work constitutes about 151 Kilometers. The major expansion work includes expansion of the lanes and road to make it a four-lane road. Moreover, other associated works include constructing both major and minor cross drainage works, including bridges. Since,

Literature Review

1.1 Impact of road construction on the environment

The construction of highways or roads in addition to offering both accessibility and mobility as relevant in the context depending on the type of road constructed, assists in bringing changes into the structure of the settlement pattern and land uses, creating more significant economic opportunities, employment generation, etc. (Asturias, Garcia-Santana, and Ramos, 2019; Chandra and Thompson, 2000; Sengupta, Coondoo and Rout, 2007; Walia, Aggarwal and Bhardwawaj, 2017). However, the construction activities for new highways or expansion or up-gradation of the highways may lead to significant environmental ailments if its impacts are not appropriately assessed and measured for the mitigation or prevention of the adverse effects are not taken (Walia, Aggarwal and Bhardwawaj, 2017). One of the significant and direct consequences is the destruction and removal of existing ecosystems and the reconfiguration of local landforms. The construction engenders diverse ecological effects on both terrestrial and aquatic ecosystems (Hansen, Knight, Marzluff, 2005). Similarly, highway construction, specifically through land clearing, ground excavation, cut and fill, and pavement construction, is a major source of particulate matter into the atmosphere, impacting the air quality adversely.

Moreover, road construction also creates significant noise pollution (Kumar, Mulheron and Claudia, 2012). Furthermore, pollutants emerging out of construction activities cause physical, chemical and biological degradation of the natural water bodies such as rivers, lakes and streams (Aslam, Khan and Khan, 2011; Qian, et al., 2011; Walia, Aggarwal and Bhardwawaj, 2017). Also, it was found that as a consequence of the construction activities and consequent pollution, the health risk of the people living and working close to the construction increases significantly (HEI, 2010). Thus, the construction of new highways of expansion has significant environmental impacts at the local level, which need to be taken care of.

1.2 Environmental protection laws and regulation for road construction

Countries across the world have enacted laws and regulations and developed regulations for the protection of the environment. These laws and regulations are also valid for the construction of roads as relevant. Environmental Impact Assessment (EIA) is generally conducted and environmental clearance is needed before implementing any transportation project (ARBITA, no date; European Transport Agency, 2020; Handa, Aggarwal and Bhardwaj, 2019). For example, every transportation project must undergo an environmental review and approval process in the USA before any construction is permitted. The various acts which govern such review and approval process include Clean Air Act (CAA), the Clean Water Act (CWA), the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA) and climate change (ARBITA, no date). In Europe, similar provisions are available in different countries to reduce the adverse effect of transportation including road construction (European Transport Agency, 2020).

In most Asian countries, including South Asia, similar acts and rules and regulations are available in some form or other. India particularly has promulgated a series of environmental legislations between 1980 and 2005 to ensure that adverse impacts on the environment remain under control and timely mitigation measures are taken (Handa, Aggarwal and Bhardwaj, 2019; Walia, Aggarwal and Bhardwawaj, 2017). The laws also established detailed procedures for assessing the environmental impacts of the proposed projects and how clearances for the projects should be given. In recent years one of the most important enactment is the Environment Impact Assessment Notification, 2006 (EIA 2006), which lays out a detailed process for obtaining prior environment clearance for any new projects or activities or the expansion or modernisation of existing projects and projects seeking capacity addition with change in strategy or technology (Sharma, Dhyani, and Gangopadhyay, 2013).

However, the challenge is that most of the acts and rules and regulations are considered effective at the macro level. For example, according to these new regulations, environment clearance is not required for road development projects other than State Highways and National Highways, State Highway widening projects located below an altitude of 1000m MSL, State Highway widening projects not located in an ecologically sensitive area, National Highway widening projects of up to 100km length, National Highway widening projects of more than 100 km length involving the additional right of way or land acquisition up to 40m (at any place) on existing alignment and 60 m (at any place) on re-alignments or bypasses IRC (2017). Such restrictions have been made to facilitate and expedite infrastructure development. However, on the other hand, the environmental challenges and adverse impacts at the local habitation level have been undermined. Moreover, studies on such aspects in the Indian context are scarce.

2.3 Mitigation measures – challenges

Across the world, several mitigation strategies have been developed to reduce the adverse impacts of highway construction. For example, in the USA, Canada and Europe, the environmental assessment and landscape-scale planning process of its roads are conducted to address road system development, maintenance, and funding to meet current and future land and resource objectives and uses (Reed et al., 1996). However, in many countries worldwide, the mitigation measures include taking a strategic approach, using structured assessment and planning, undertaking on-the-ground mitigation techniques, effective monitoring, etc. Similarly, site-level field techniques such as staying away from vulnerable sites, giving extensive thought to road routes, road design, drainage, and road-stream crossings, relocating or realigning roads to avoid vulnerable areas and human habitations, use of appropriate construction, upgrading, and maintenance methods, provision of buffer zones, etc., have been proposed (Daigle, 2010). In developing countries, local and appropriate technologies have been argued to make road construction sustainable and reduce environmental impact (Newman, Hargroves, Desha, et al., 2012). In India, EIA is conducted based on the Environmental Protection Act as a prevention measure before the project is implemented and construction is undertaken (IRC, 2017). However, most mitigation or prevention measures are considered at the macro level and impact on the local level or areas in and around constriction sites have been undermined.

Research Methodology

3.1 Data

Data on the environmental consequences of road construction, current mitigation measures, challenges and gaps in the EIA process to protect the local environment and plausible strategic measures from mitigating the challenges and protecting the local environment were collected. For this purpose, two kinds of the survey were conducted. First, a perception survey was conducted among the people engaged in road construction and local communities to explore the perceptions of these stakeholders on the consequences of road construction on the local environment and the current mitigation measures adopted. The stakeholders include the local communities and construction workers, project managers, site engineers, supervisors, technician, and contractors. This was done to get a balanced view and perception of stakeholders on the issues related to the local environment. A questionnaire was prepared and then administered among 160 respondents, of which 120 belonged to local communities and 40 belonged to construction. A Likert scale with pointer ranging between 1 and 5 (1 indicates very low, 2- low, 3- average, 4-high, and 5 indicate very high) was adopted to collect the data. The survey was conducted by using a random sampling process from 8 construction sites and local villages and small towns around the construction sites.

Further, a Delphi survey (Ludwig, 1997) was conducted among 30 experts related to the environment (5), law (4), road construction (7), public service (4), academicians (4), NGOs (3), health and medicine (3) and technology (3). This survey was conducted to obtain the expert opinion or perception of the experts on the challenges and gaps in the EIA process to protect the local environment and plausible strategies to improve the situation as these aspects are specific and need adequate understanding and knowledge. For this purpose, a questionnaire survey was also conducted. The same Likert scale ranging between 1 and 5 was adopted. The survey was undertaken iteratively in two rounds.

3.2 Data Analyses

Relevant descriptive and inferential statistics were used to analyse the data collected from both types of survey. A Cronbach α test was first conducted to find the reliability of the data and then standard deviations were calculated to observe the consistency in the responses. Followed by perception indices on the various attributes and variables were computed to evaluate the level of influence of the variables on the concerned aspects. The perception index was calculated by considering the mean value of the responses obtained on the Likert scale. However, the mean Likert scale values were supported by Z-probability values and p-values obtained from the Z tests conducted. The evaluation of the various parameters was conducted on the concurrent consideration of perception indices and statistical significance observed from z-probability and p values. A perception index of more than 3 was considered fairly influential and more than 4 was considered highly influential. However, a p-value <0.05 was considered statistically significant for a 95% confidence level.

Findings and Discussion

The results are presented under four aspects: health and environmental consequences of the road construction, current mitigation measures adopted, gaps in the EIA and implementation process, and plausible strategies to prevent or mitigate the adverse environmental impacts of road construction. These aspects are presented in the following subsections.

1.3 Environmental consequences of road construction

The health and environmental consequences of road construction at the local level are presented in Table 1. According to the people surveyed, respiratory diseases are the most important adverse health impact on people at the local level. This occurs because of the heavy amount of dust particles, smoke and other gases generated from the construction site and float towards the human habitations around the construction site, which people inhale continuously for the whole construction period. This ailment is followed by a sleep disorder, waterborne diseases and deafness. Sleep disorder occurs because of air and noise pollution. Waterborne diseases occur because of water pollution due to the mixing of gas and oil in the water the bodies located in the local area. Although deafness is relatively less, it primarily occurs because of persistent noise generated from the road construction sites. According to the respondents' perception, air pollution and noise pollution are the two most important environmental impacts, followed by water pollution and land severance. Furthermore, road construction also causes landslide and soil erosion, loss of flora and fauna and adversely impact the wild animals to a certain extent.

Table 1. Health and Environmental Consequences of Road Construction

Consequences	**PI**	**SD**	**Z score**	**Z test p-value**
Human health-related				
Respiratory diseases	4.30	0.81	1.62	0.000
Water-related diseases	3.72	1.08	0.68	0.000
Deafness	3.21	1.04	0.20	0.004
Sleep disorder	3.77	1.0	0.76	0.000

Physical harm due to accidents	2.96	0.99	-0.04	0.699
Other health-related issues	2.88	0.92	-0.12	0.947
Environmental degradation				
Air pollution with dust and smog	4.39	069	1.99	0.000
Water pollution	3.81	1.01	0.80	0.000
Noise Pollution	4.02	0.87	1.17	0.000
Land severance	3.78	0.95	0.83	0.000
Landslide and soil erosion	3.34	0.83	0.41	0.000
Loss of flora and fauna	3.31	0.82	0.38	0.000
Impact on wild animals	3.17	0.83	0.21	0.002
Pollution of cultivable lands	2.93	0.62	-0.11	0.924

4.2 Current mitigation measures

Table 2 presents various current measures that have been adopted by the relevant authorities and companies to mitigate the adverse health and environmental impact of road construction in the local area. The results revealed that only two measures, such as information and awareness of the work zone, and soil stabilization, were conducted albeit to a certain extent. However, other measures such as water spraying in work zones, shifting and rehabilitation, use of technology and anti-pollution measures were not likely undertaken. This indicates that no significant mitigation measures at the local level are taken to mitigate or prevent the adverse environmental impacts of road construction.

Table 2. Current mitigation measures

Current mitigation measures	PI	SD	Z score	P values
Information and awareness of the work zone	3.21	0.81	0.27	0.000
Soil stabilization	3.09	0.74	0.13	0.044
Water spraying in work zones	2.91	0.73	-0.11	0.936
Shifting and Rehabilitation	2.69	0.89	-0.34	0.998
Use of technology and anti-pollution measures	2.54	0.85	-0.53	0.998

4.3 Challenges and Gaps in the EIA process to protect the local environment

EIA is generally conducted to observe the environmental challenges and explore mitigation measures. However, the EIA for road construction is generally done at a macro or regional scale. Therefore, in this study, the challenges and gaps in the EIA process are explored and presented in Table 3. According to the perceptions of the respondents, there lies a gap in the EIA process which includes a lack of consideration of local context, not making the process inclusive with participation and consultation among all the stakeholders, including local people. The EIA is perceived to be too bureaucratic and a technical exercise with consultants, bureaucrats and other technical and administrative stakeholders. It is more or less procedural. The role of civil society and people at large is undermined.

Table 3. Challenges and gaps in the EIA process

Challenges	LI	SD	Z Score	P values
Consideration at the macro level and undermining of local contexts	3.98	0.85	1.16	0.000
Lack of consideration of human health at the local level	4.09	0.79	1.39	0.000
Lack of consideration of wildlife at the local level	3.74	0.93	0.79	0.000
Lack of clarity on the use of preventive or mitigation measures	3.67	0.88	0.75	0.000
Lack of direct and adequate consultation with local stakeholders	4.23	0.77	1.60	0.000

Too bureaucratic and technical with consideration of the impact on civil society	3.62	0.89	0.69	0.000
Lack of clarity on the use of advanced technology	3.56	0.85	0.66	0.000

4.4 Strategic measures to mitigate the challenges and protect the local environment

Strategic measures belonging to five different aspects, such as procedural, social and economic, wildlife, flora and fauna, land and road alignment, and technical, were evaluated to examine the most appropriate measures that should prevent or mitigate the environmental challenges that occur road construction at the local level. The results of the evaluation are presented in Table 4. It is found that procedural strategies such as the inclusion of local context in the EIA and more direct consultation with stakeholders are the two most important strategies that should improve the situation and meet the environmental challenge at the local level. However, a strategy to include a local leader in the EIA appraisal committees will not likely be beneficial.

Table 4. Plausible strategies to improve the local environmental protection

Strategies	PI	SD	Z score	P values
Procedural				
Inclusion of local context in EIA	4.16	0.91	1.28	0.000
More direct consultation with stakeholders	4.06	0.87	1.23	0.000
Inclusion of local leaders in the EIA appraisal committees	2.87	0.89	-0.15	0.791*
Social and economic				
Temporary relocation and rehabilitation	2.93	0.91	-0.08	0.656*
Adequate health facilities and compensation to deal with ailments related to pollution and accidents	4.07	0.86	1.22	0.000
Dissemination of information and creation of awareness	3.77	0.94	0.82	0.000
Liasion between local people and construction companies to protect environment	3.9	0.75	1.19	0.000
Wildlife, flora and fauna				
Alternative pathways for the movement and crossing for wildlife	3.13	0.73	0.18	0.156*
Creation of protective barriers for wildlife	2.73	0.78	-0.34	0.968*
Identifying and avoiding zones with significant wildlife and flora	3.53	0.68	0.78	0.000
Land and road alignment				
Alternative alignment to avoid both important forest area and human habitations	3.56	0.73	0.77	0.000
Restrictions on severing major agricultural, horticultural and protected forest area	4.07	0.83	1.29	0.000
Avoiding areas requiring significant cuts in hills and mountains	4.03	0.81	1.27	0.000
Preference to tunneling	3.73	0.91	0.81	0.000
Technical				
Adoption of advanced technology to reduce water and air pollution	4.1	0.80	1.37	0.000
Advanced soil stabilization and construction methods	3.6	0.85	0.70	0.000
Use of low noise equipment	3.57	0.81	0.69	0.000
Use of technology to clean polluted air and water	3.96	0.81	1.12	0.000

Under the social and economic strategic measures, provision of adequate health facilities and compensation to deal with health-related ailments because of road construction-related pollution and accidents is the most important preferred strategy. Followed by liaison between local people and construction companies to protect the environment, disseminate information, and create awareness could be beneficial. However, temporary relocation and rehabilitation as a strategy to mitigate the environmental challenges due to road construction may not be effective. As wildlife, flora and fauna is an important constituent of the local environment, a strategy that could identify the zones with significant wildlife, flora and fauna and avoid such areas from large-scale road construction is likely to help prevent the local environment.

However, alternative pathways for the movement and crossing for wildlife and protecting wildlife barriers may not be useful. It is also found that two strategic measures such as restrictions on severing major agricultural, horticultural and protected forest area, and avoiding areas requiring significant cuts in hills and mountainous regions would assist enable protection land and, consequently, the local environment, Also, preference to tunnelling and alternative alignment to avoid both important forest area and human habitations could be beneficial. As found out from the evaluation, the adoption of advanced technology to reduce water and air pollution and the use of technology to clean polluted air and water are the two most important strategies that need to be considered to meet the environmental challenges at the local level. Also, advanced soil stabilization and construction methods to reduce dust and air pollution and the use of low noise equipment to prevent noise from the construction zones are essential.

Conclusions

Environmental degradation at the local level due to the construction or expansion of Highways in India is a significant concern. Although EIA was conducted before implementing the projects, it is largely conducted at the macro level and the local areas remained outside its purview. In this study, assessing the various environmental impacts of the construction of national highways was conducted and plausible strategies to mitigate the environmental ailments were explored. Findings revealed that two crucial environmental-related consequences, such as health ailments and environmental pollution, occur in the study area because of the construction activities of the highway. The major health ailments include respiratory diseases, sleep disorder, waterborne diseases and deafness. Air pollution with dust and smog, water pollution, noise pollution, land severance, landslide and soil erosion, loss of flora and fauna, and impact on wild animals are the major environmental problems experienced. Scarcely any significant mitigation measures are undertaken to improve the scenario. Also, important gaps in the EIA process was found such as the local environment is not largely considered and direct consultation with the local communities are not conducted.

However, the major strategies that should help mitigate or prevent environmental degradation at the local level include the inclusion of local context in EIA, more direct consultation with stakeholders, adequate health facilities, and compensation to deal with pollution and accidents. Other strategies include liaison between local people and construction companies to protect the environment, dissemination of information and creation of awareness, identifying and avoiding zones with significant wildlife and flora, restrictions on severing major agricultural, horticultural and protected forest area, avoiding areas requiring significant cuts in hills and mountains, preference to tunnelling, adoption of advanced technology to reduce water and air pollution and to clean polluted air and water, advanced soil stabilization and construction methods and the use of low noise equipment. The study's findings contribute to identifying the gaps in the EIA and strategies needed to alleviate the challenges of environmental impacts of road construction at the local level in the Indian context.

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Exploring the use of Drones for sustainable construction in developing countries

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Abstract:
Construction is faced with the challenges of economic and environmental ailments in developing countries. Low productivity in construction work, delays in construction, occurrence of accidents, and environmental pollution are experienced. Despite using various strategic measures and technology to plan, design, execute, monitor and control, construction related challenges continue to occur. It is argued that the use of Drone can enable alleviating various construction related challenges and assist in achieving sustainable construction. Using the context of South Africa and India's construction industry, this study explored for what purposes Drones can be used in construction and how they can contribute to the sustainability of construction in developing countries. A survey was conducted among various construction industry stakeholders, such as construction industry professionals and Drones technology experts, to obtain data. The collected data was analysed by using relevant descriptive and inferential statistics. Findings suggested that Drones can be used in several construction activities in developing countries and offer significant advantages such as gathering real-time information and tracking construction activities, virtual accessibility of non-accessible areas, obtaining high-resolution and 3D images. However, lack of knowledge, competency and trained personnel, Government regulations, piloting license requirements etc. are major barriers. The use of Drones can have significant implications on the construction industry, such as reduction in delay and cost and assisting in real-time decision making.

Keywords:
Construction, Developing countries, Drone, Sustainability, Unmanned aerial vehicles

Introduction

Sustainable construction in developing countries is argued to be a challenge. Many developing nations, including South Africa and India, face several social, economic, environmental, infrastructural, legislation, and technical challenges that lead to unsustainability in construction. For example, a significant proportion of construction projects experience cost overruns and delay in project delivery in India and South Africa (Das, 2015; KPMG and PMI, 2012; Watermayer and Philip, 2016). Further, rework, wastage of materials, and poor utilisation of labour and equipment are other major challenges experienced in construction (Aiyetan and Das, 2015; Das and Emuze, 2021; Bon-Gang & Lay Peng, 2013; Han et al., 2013; Love et al., 2011). Furthermore, environmental problems, including air pollution, water pollution and noise, are recurrent phenomena in the vicinity of the construction sites. Consequent to this, loss in productivity in the project, delay in project delivery, environmental pollution, health ailment among the people in and around the construction projects are experienced.

Different construction companies have adopted several project management and construction management strategies to attain sustainable construction and prevent or mitigate the challenges. For example, project management techniques for the whole project life cycle starting from initiation to closure of the projects are generally adopted in many projects. Similarly, Environmental Impact Assessment (EIA), Total Quality Management (TQM), material, equipment and resource management techniques are also used. Moreover, advanced techniques and software such as BIM are also used to predict various scenarios that would enable implementing strategic measures to either prevent or resolve the construction challenges. However, challenges continue to occur at the construction project sites, which sometimes need information and real-time intervention. For example, construction activities are sometimes carried out in relatively inaccessible or less accessible areas. The gathering of information from such areas by conventional means might be time consuming and expensive. Similarly, there might be a need for real-time monitoring of construction works in the project sites by the project managers and construction engineers and to provide instructions. However, handling such situations is observed to be difficult by the use of conventional methods.

Therefore, there is a need for more advanced information gathering technique to meet such challenges. With the advent of advanced technologies and equipment such as light detection and ranging technology (LiDAR) and unmanned aerial vehicle (Drone) with both photographic and video cameras and the ability to assess information in real-time, it is argued that Drones would enable alleviating various construction related challenges and assist in achieving sustainable construction. Although such techniques are in some way used in developed countries, their use in developing countries, for example, India and South Africa, which are engaged in large scale construction activities, is scarce. Therefore, using the context of the construction industry of South Africa and India, this study explored for what purposes Drone' can be used in construction and how they can contribute to the sustainability of construction in developing countries.

Literature Review

1.4 Drones: The technology, benefits and challenges

Unmanned Aerial Vehicles (UAVs) can be traced back to 1793 and evolved significantly over the years. However, UAVs in the form of 'Drone' technology have been developed and used since 2010 (www.consortiq.com). A Drone is essentially a powered, Aerial vehicle that performs its functions without carrying a human operator on board. It can be expendable, recoverable, and can carry a lethal or nonlethal payload (www.TheFreeDictionary.com). Two types of Drones are observed. One that is fully automated performs all the functions as programmed without any human interventions (Hu & Lanzon, 2018; Sharma, Basnayaka & Jayakody, 2020). On the other hand, another type of Drone is generally operated under remote control by a human operator with various degrees of autonomy (Cary & Coyne, 2012).

Although Drones originally used for missions that are very difficult and dangerous for humans (Tice, 1991), the use of Drones have now been expanded to conduct aerial photography, product deliveries, agriculture, policing and surveillance, infrastructure inspections, data collection for scientific research and finding criminals or monitoring smugglers and Drone racing (Lalrochunga, Parida & Choudhury, 2020; Koparan, Koc, Privette & Sawyer, 2020;

Umar, 2020). The advantages of Drones are that they can be used for military, civilian and commercial purposes (Hu & Lanzon, 2018; Lalrochunga, Parida & Choudhury, 2020; Sharma, Basnayaka & Jayakody, 2020). Also, they can carry a payload of 500 kilograms and have a range of up to 300 Kilometres. (Lalrochunga, Parida, & Choudhury, 2020). However, the major disadvantages are that they can create security and privacy challenges and cause safety concerns for the Air Traffic movement, specifically in developing countries that do not have adequate rules and regulations to control the use of Drones (Lalrochunga, Parida & Choudhury, 2020).

1.5 Drone in developed and developing countries

The use of Drones in the developed and developing countries have increased significantly after their acceptance for commercial use. While it is used for a whole range of purposes such as aerial photography, data collection for science, agriculture, healthcare, dropping off packages and so on in the developed countries, it is used mainly for recreation in developing countries (Lalrochunga, Parida, & Choudhury, 2020). Moreover, it is also observed that Drones are not predominantly used in the construction sector. Also, in developed countries such as the USA, UK, Germany, France, Australia and Japan, the policies, rules and regulations relating to the use of Drones have been developed and being implemented (Lalrochunga, Parida & Choudhury, 2020). However, although the developing countries are not far behind, the policy framework and the rules and regulations are not at par with the developed countries (Lalrochunga, Parida & Choudhury, 2020). Furthermore, the operational areas of Drones in developing countries are far smaller than that of the developed countries (Lalrochunga, Parida & Choudhury, 2020).

2.3 Drone in construction

Although it is alleged that the construction industry adopts advanced technology at a slower rate (Holt et al., 2015), an increase in the use of advanced technology such as BIM and Drone has been experienced, specifically in the developed countries (Vacanas, Themistocleous, Agapiou, & Hadjimitsis, 2016). Drones have been used for or proposed to be used in construction for earth-moving operations, health and safety, quality control, material tracking, structural damage assessment, on-site data collection, vehicle detecting and tracking, land surveying, productivity, human performance, equipment planning and damage assessment (Lin, Han, & Golparvar- Fard, 2015; Morgenthal & Hallermann, 2014; Wang, Chen & Yin, 2016; Wen & Kang, 2014). Specifically, it is argued that Drones can assist in help in real-life monitoring of construction projects (McCabe et al., 2017; Hamledari, McCabe & Davari, 2017). They can enable the collection of high-quality visual data in the form of high-resolution images, which can also be transformed into 3D models, that can help in the analysis of different critical aspects of construction (Bang, Kim & Kim, 2017; Fleming et al., 2016; Julge, Ellmann & Köök, 2019; Kim, Park, Cho & Kang, 2019; Mahami, 2019). In other words, Drones can influence every aspect of construction that include surveying, site monitoring, project planning, project execution, monitoring, control, inventory management, equipment management, health and safety and so on (PWC, 2018). Moreover, it can also assist in the post-construction phase to monitor the risk or hazards, stock-taking of resources, including materials and equipment (PWC, 2018).

Research Methodology

The study was conducted by using a survey research method for data collection and descriptive and inferential statistical methods for data analyses. The following subsections present the detailed data collection and data analyses methods used.

3.1 Data

A survey was conducted to collect data among the construction industry stakeholders in South Africa and India. A purposive sampling process was used. Initially, a list of several stakeholders was drawn. These stakeholders who would participate in the survey were selected based on their association, engagement and experience in the construction industry and Drone technology in the respective countries. The stakeholders who are engaged in the construction industry and have significant experience were chosen.

Similarly, experts or users of Drone technology were selected. The respondents were contacted and selected for the survey based on their willingness to participate in the survey. The respondents constitute 54 stakeholders from South Africa and 40 stakeholders from India, totalling a sample size of 94. The respondents include project managers, engineers, consultants and designers, contractors, supervisors, surveyors, safety professionals, lawyers, academics, and Drone technology experts. The respondents selected had at least three years of experience and higher than Diploma qualification in the relevant field.

The survey was conducted using a questionnaire developed by incorporating questions relating to various aspects such as the advantages of Drones, barriers against the use of Drones, construction-related activities that can be performed by using Drones and the plausible impacts of Drones in construction. The respondents were asked to respond to the questions on a five-point Likert scale in which 1 indicates very low, 2 indicates low, 3 indicates average, 4, indicates high and 5 indicates very high. The survey was administered through a digital questionnaire survey platform and also through emails.

3.2 Data Analyses

The data was analysed using both descriptive and inferential statistics. First, the data collected was checked for consistency and reliability. Cronbach alpha test was conducted to check the reliability of the data. Further Standard Deviation (SD) was calculated to find the consistency of the data. The influence or impact of the various variables or attributes under each aspect was evaluated using the perception index. The Likert mean scores of the responses assigned by the respondents were used as the Perception indices (PI) on the various attributes. Further, the Z-test was conducted for each variable to observe the statistical significance for a confidence level of 95%. A p-value of ≤ 0.05 for $\alpha \leq 0.05$ was considered statistically significant. The influence of the variable was assessed based on the concurrent analyses of perception index value and its statistical significance. A perception index of more than three and less than four with $p \leq 0.05$ was considered fairly influential or influential to a certain extent. Similarly, a perception index value ≥ 4 with $p \leq 0.05$ was considered highly influential. However, if the perception index is less than three or $p > 0.05$, the variable was considered as not influential. The evaluations were first made separately country wise and then on an aggregate basis.

Findings and Discussion

The results based on the respondents' perceptions on the plausible advantages of the use of the Drones, barriers against their use, construction activities that can be facilitated and the impact of the Drones in construction are presented and discussed in the following sections. The responses from the respondents from South Africa and India were analysed separately. Furthermore, aggregate analyses were conducted as the results obtained from South Africa and India show similar trends. A Cronbach α value of 0.792 (>0.74) indicates the reliability, and low SD values ranging between 0.61 and 0.99 indicate consistency of the data set, and thus was used for further analyses.

1.6 Plausible advantages of the use of Drones in construction

The plausible advantages of the use of Drones in construction are presented in Table 1. It was found that respondents from South Africa and India provided similar responses on various advantages of the use of Drone. So, the aggregate result is presented and discussed. According to the respondents, the most important advantages are gathering real-time information and tracking construction activities, easy but virtual accessibility of non-accessible areas and obtaining high-resolution images through mapping. These findings corroborated the findings of previous studies, specifically in the context of developed countries (McCabe et al., 2017; Hamledari, McCabe, & Davari, 2017). Also, Drones can assist in getting three-dimensional images and photos and providing virtual accessibility to underground information without excavation if integrated with LiDAR. However, resolving site related bottlenecks and challenges, monitoring hazards, health and safety, and performing inspections of construction work were statistically insignificant with the use of the Drones. Therefore, it may not be advantageous, which is also in alignment with previous studies in the context of Gulf Cooperation Council construction (Umar, 2020).

Table 1. Plausible advantages of the use of Drones in construction

Advantages	South Africa		India		Overall	
	PI	Z test p values	PI	Z test p values	PI	Z test p values
Easy accessibility of non-accessible areas	4.33	0.000	4.25	0.000	4.20	0.000
Real-time information and tracking of construction activities	4.51	0.000	4.40	0.000	4.47	0.000
High-resolution images	4.05	0.000	3.90	0.000	3.98	0.000
Three-dimensional images and photos	3.79		3.95		3.87	0.000
Accessibility to underground information without excavation if integrated with LiIDAR	3.42	0.000	3.45	0.000	3.44	0.000
Resolution of site-related bottlenecks and challenges	3.17	0.061*	3.05	0.387*	3.11	0.113*
Monitoring health and safety, and hazards	3.01	0.426*	3.11	0.192*	3.06	0.223*

Performing inspections	2.70	0.995*	2.86	0.848*	2.77	0.995*

4.2 Barriers in the use of Drones in construction

The barriers to the use of Drones in construction are presented in Table 2. Scrutiny of the results revealed that the response provided by both South African and Indian respondents are similar with very marginal variations; therefore, the aggregate results were considered. According to the respondents, the two most important barriers include lack of knowledge, competency and trained personnel, and piloting license requirement. The other essential barriers are government regulations, risks of accidents and weather conditions. However, resistance to change and threat to human labour were statistically insignificant, so these aspects are not likely to become obstacles in the use of Drones in construction in developing countries.

Table 2. Barriers in the use of Drone Technology

Barriers	South Africa		India		Overall	
	PI	Z test p values	PI	Z test p values	PI	Z test (pvalues
Weather conditions	3.31	0.008	3.43	0.0016	3.37	0.000
High cost	3.44	0.000	3.45	0.000	3.44	0.000
Lack of knowledge, competency and trained personnel	4.31	0.000	4.47	0.000	4.40	0.000
Requirement of piloting license	4.09	0.000	4.20	0.000	4.14	0.000
Government regulations	3.70	0.000	3.84	0.000	3.77	0.000
Risks of Accidents	3.33	0.000	3.18	0.055	3.26	0.000
Resistance to change	2.94	0.703	2.86	0.855	2.91	0.871
Threat to human labour	3.03	0.351	3.09	0.241	3.06	0.291

4.3 Activities facilitated by Drones

Various activities which can be facilitated or performed by the Drones were categorised under pre-construction, during construction and post-construction phases. The aggregate evaluation of the responses revealed that Drones could perform surveys (Aerial) significantly in the pre-construction phase. Also, it can assist in planning and design to a certain extent as the data gathered from the survey by Drones can provide useful information to be considered in planning and design (Table 3). During the construction phase, Drones can perform monitoring of the construction activities significantly. Moreover, monitoring of delay, hazards and safety can be performed, and the deployment of materials and equipment and labour can be facilitated to a certain extent. Besides, they can help in the communication of decisions to a certain extent too. These findings are in line with the findings of previous studies in the context of developed nations (Lin, Han & Golparvar- Fard, 2015; Morgenthal & Hallermann, 2014; Wang, Chen & Yin, 2016; Wen & Kang, 2014). However, monitoring of defects may not be possible by the use of Drones (Table 3). Finally, in the post-construction phase, Drones are likely to assist in the stock-taking of resources and making surveillance and monitoring of criminal activities such as vandalism or theft to a certain extent (Table 3). Therefore, it is revealed that Drones can assist in most construction activities throughout the life cycle of the projects.

Table 3. Activities facilitated by Drones

Activities	South Africa	India	Overall

	PI	Z test p values	PI	Z test p values	PI	Z test p values
Pre-construction						
Survey	4.25	0.000	4.16	0.000	4.21	0.000
Planning and Design	3.20	0.084	3.13	0.155	3.17	0.042
During construction						
Monitoring of construction activities	4.20	0.000	4.11	0.000	4.16	0.000
Deployment of materials and equipment	3.61	0.000	3.75	0.000	3.67	0.000
Deployment of labour	3.55	0.000	3.61	0.000	3.59	0.000
Monitoring of defects	3.05	0.289	3.02	0.438	3.04	0.316
Monitoring of delay	3.77	0.000	3.75	0.000	3.77	0.000
Monitoring of hazards and safety	3.61	0.000	3.5	0.000	3.56	0.000
Communication of decisions	3.29	0.001	3.43	0.000	3.36	0.000
Post-construction						
Stock-taking of resources	3.38	0.000	3.29	0.016	3.34	0.000
Monitoring of safety	2.66	0.999	2.79	0.938	2.72	0.999
Surveillance and monitoring of criminal activities such as vandalism or theft	3.83	0.000	3.95	0.000	3.89	

4.4 Impact of the use of Drones in construction

The impacts of the use of Drones in construction were evaluated from the responses of the respondents. The results of the evaluation are presented in Table 4. It is found that the impacts of the use of Drones in South Africa and India are similar. The aggregate evaluation showed that Drones could significantly assist in reducing delay, saving the cost of projects and real-time decision making. Furthermore, they can, to a certain extent, help in real-time communication, appropriate deployment of material and equipment, and adequate and timely deployment of labour. Also, hazards can be avoided by the use of the information gathered from Drones. Therefore, Drones can have significant positive impacts and contribute to the sustainability of construction in developing countries.

Table 4. Impact of the use of Drones in construction

Impact	South Africa		India		Overall	
	PI	Z test p values	PI	Z test p values	PI	Z test p values
Saving in cost	4.24	0.000	4.13	0.000	4.19	0.000
Reduction in delay	4.44	0.000	4.36	0.000	4.41	0.000
Real-time communication	3.85	0.000	3.81	0.000	3.83	0.000
Real-time decision making	4.07	0.000	4.20	0.000	4.13	0.000
Appropriate deployment of material and equipment	3.27	0.000	3.40	0.000	3.34	0.000
Adequate and timely deployment of labour	3.62	0.000	3.72	0.000	3.67	0.000
Avoiding hazard	3.33	0.000	3.40	0.000	3.37	0.000

Conclusions

Drones are argued to play an important role in construction and assist in the automation of construction activities. The study's objective was to explore how Drones can be used in construction, what advantages they can bring, what barriers would be faced, and how they would impact the construction industry in developing countries. Findings revealed that the major advantages of using Drones in construction are gathering real-time information and tracking construction activities, virtual accessibility of non-accessible areas, and obtaining high-resolution images, including 3D images. The major barriers to using Drones in developing countries include lack of knowledge, competency and trained personnel, and requirement of piloting licenses, Government regulations, risks of accidents and weather conditions. They can be utilised in pre-construction, construction and post-construction phases. For example, surveys can be done in the pre-construction phase, monitoring construction activities during construction and surveillance, monitoring and stock-taking after the construction. They can assist in reducing the delay, cost of construction and real-time decision making. The study contributes to the opportunities and challenges of Drones in construction in developing countries, which could assist in decision-making for their use in the pursuit of attaining sustainability in construction. The limitation of the study is that it was conducted based on limited perception survey data. Also, cost-benefit analysis and comparative analysis of the use of Drones in construction between developed and developing countries were not included in the scope of the study and are considered further scope of research.

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A scoping study of barriers and drivers of sustainable design and construction in Nigeria

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Abstract:
Construction stakeholders have been under pressure to reduce the industry's environmental footprint by adopting new technologies. In a two-round Delphi survey, a panel of 12 experts were required to rate and rank the importance of 75 drivers and 21 barriers to sustainable design and construction. After the second round of the survey, 61 drivers and 15 barriers were rated with a high degree of group agreement (Kendall's W =.511; p.001). A high Spearman's rank correlation.value (rho = 0.923, p <.001) indicated a strong degree of convergence between rounds. Also, the result (Kendall's W = 0.76; p < 0.000) indicated a high panel consensus on ranked barriers items with lack of government policy, misconception of construction cost overrun, no reflection of recovery of long-term savings in service fee structure, conflicting public policy and/ or regulations, lack of awareness from clients (Owner/ Developer), a limited knowledge and understanding of sustainable issues by customers, deployment of resources to back technological changes, and lack of knowledge and understanding from design professionals were ranked low as barriers to sustainable design and construction. The findings from the study would provide information on regulatory and socio-economic factors that impact sustainable design and construction in Nigeria, and strengthen the implementation of sustainability in the construction industry.

Keywords:
Infrastructure, Sustainable construction, Sustainability, Urban development, Urban growth

Introduction

By 2050, approximately 68 percent of the global population will be living in cities, with new urban dwellers in India, China, and Nigeria accounting for about 35 percent of this (UN DESA, 2019). By 2030, it is expected that developing countries (mostly in Asia and Africa) will account for roughly 80% of those living in urban areas (UN-HABITAT, 2006). According to some estimates, about half of Nigeria's population will have moved to urban areas by 2020 (Bloch, Monroy, Fox, & Ojo, 2015). Rapid population growth has been related to urban growth and expansion (Sharifi & Hosseingholizadeh, 2019; Zhang & Xie, 2019), negatively impacting sustainable development (Ejaro, 2009). Therefore, fast-growing cities like Abuja will have pronounced growth, such that current space and facilities would be insufficient to accommodate the increasing population and expanding area. Indeed, rapid urbanisation has had a detrimental effect on the FCT's long-term growth (Ejaro & Abubakar, 2013). Serious and persistent construction sustainability challenges have been observed in FCT Abuja (Ekpetere, Faith, & Eziechi, 2019; Windapo & Rotimi, 2012). Using Abuja (the Federal Capital Territory) as a case study, this paper seeks to identify the primary drivers and barriers to sustainable design and construction in Nigeria's construction industry.

It uses Delphi techniques to study the views of a panel of expert and determine the major drivers and barriers of sustainable design and construction. Findings from the study would provide information on regulatory and socio-economic factors that impact sustainable design and construction in Nigeria.

Literature Review

The demand for affordable housing, transport systems, and other infrastructure increases with urban growth. However, this would have negative consequences. Indeed, it is well recognized that urbanisation and spatial changes have significant environmental, social, and economic implications for long-term sustainability (Keivani, 2010). Cities are responsible for a greater percentage of greenhouse gas (GHG) emissions (Hoornweg, Sugar, & Trejos Gómez, 2011). Efforts at mitigating these harmful emissions should be targeted at areas with higher socio-economic and health benefits (Urge-Vorsatz & Novikova, 2008). The construction industry should strive to balance the various aspects (social, economic, and environmental) of human activity, by encouraging the implementation of construction processes that incorporate basic sustainable development objectives of sustainable (Liu, Pypłacz, Ermakova, & Konev, 2020). These three dimensions of sustainable construction are discussed in detail, highlighting the key themes and principal issues (Akadiri, Chinyio, and Olomolaiye (2012).

Sev (2009) classifies sustainable construction into environmental, social and economic dimensions. Sustainable construction processes bring about a profitable and competitive industry capable of addressing changes in user requirements (Raynsford, 2000). This enables environmental responsibility, social awareness, and economic profitability, and provision of facilities for the wider community. There are observations that the focus of the construction industry is no longer limited to the minimization of energy consumption, but has extended to other functions of planning of sites, waste management, materials selection and design, which are critical to solving environmental crisis caused by the industry’s activities (Mir-Babayev, Gulaliyev, Shikhaliyeva, Azizova, & Ok, 2017). Kibert (1994) conceptualises sustainable construction as a tripartite interaction of stages or phases, required resources, and principles in the design and execution of construction projects.

Various factors that enhance or inhibit sustainable design and construction have been extensively studied and documented in earlier studies (Ahn, Pearce, Wang, & Wang, 2013; Augenbroe & Pearce, 2009; Hale, Legun, Campbell, & Carolan, 2019; Ifije & Aigbavboa, 2020; Lopez-Chao, Casares Gallego, Lopez-Chao, & Alvarellos, 2020; Mohammed & Abbakyari, 2016). It has been suggested that a major factor that drives the implementation or adoption of sustainable construction practices is a buy-in or concern by the management of an organisation (Shen, Tam, Tam, and Ji, 2010).

Research Methodology

1.7 Study Location

Abuja FCT occupies a land mass of about 8000km^2 in the Guinea-Savanna vegetation zone (Idoko & Bisong, 2010). It is situated between latitude 7°25′N and 9°20′N and longitude 5°45′E and 7°39′E (Enoguanbhor, Gollnow, Walker, Nielsen, & Lakes, 2020), and bounded by Kaduna State in the North, Nasarawa State in the East, Kogi State in the South, and Niger State in the West (Musa, Oguche, & Onyekwulu, 2020). Abuja, Nigeria's largest construction area, has been described as an unsustainable city (Obiadi, Onochie, & Uduak, 2019).

1.8 Delphi Panel and Consensus Criteria

Expert opinion was sorted through a two-round Delphi survey to identify and rank the importance of the key drivers and barriers of sustainable design and construction in the construction industry in Nigeria. Seventy-five drivers (grouped into four sustainable dimensions (Chao et al., 2020), and twenty-three barriers identified from the review of web of science and literature were presented to the panellists. Fifteen potential panel members were invited through email to participate in the study, twelve indicated interest to participate. The purposively sampled panel consisted of twelve (*n =12*) sustainable design and construction experts (two academics, one urban planner, four architects, and five construction professionals), seven of whom have experience ranging between 11-25years. The qualification of the panellist ranged from degree (5), Master's degree (4) and PhD (3).

A questionnaire with a total of ninety-eight questions related to drivers and barriers of sustainable design and construction was developed for the panel of experts. Experts were asked to rank the factors on a scale between 1 and 5 (1= Not at all important, 2=Somewhat unimportant, 3=Neither/not important, 4=Somewhat important, 5=Extremely important). In the first round, the experts were asked to rate the relevance of the items in driving sustainable design and construction, while in the round 2, the experts were asked to rank in addition the barriers items to sustainable design and construction among construction industries. Consensus was reached on a questionnaire item based on 75% of respondents rate of an agreement on individual items on 5-point Likert scale. Kendall's coefficient of concordance (Kendall's W) ($\geq .5$; $p> .05$) and Spearman rho ($\geq .9$; $p> .05$) was employed to compute level of consensus among individual experts in a round; and stability or convergence of expert response between Delphi rounds respectively. Delphi method is a suitable technique used to reach a consensus on a complex research problem in which there is no precise information available (Linstone & Turoff, 2011)

Findings and Discussion

The results of the rounds of the Delphi expert rating of drivers of sustainable design and construction in Nigeria are presented on Tables 1 to 4. In the first round, 12 experts out of 15 contacted participated. The expert panel has an understanding of sustainable design and construction practices, with experiences and interest in the green construction market. The result of the first round revealed a good agreement (≥75 % of agreement) in 63 of the 75 items across the four dimensions. However, the level of consensus among the experts was low (Kendall's W = .369; p<.00). This indicates that the experts had strong agreement on selected items. However, no consensus was achieved among panel in the first round. Delphi process is iterative and incremental; thus, second around is required to review panel judgement. In the second round, the 12 experts were asked to reassess their responses, taking into account the results in the first round. In this round, the result revealed a good agreement (≥75 % of agreement) in 63 of the 75 items across the four dimensions. However, the level of consensus among the experts was high with an increase in Kendall's coefficient of concordance (W = .511; p<.00). In the second around, under the environmental sustainability criteria, the experts maintained their position on 'Waste reduction and management - reuse and recycle '(item 7), renewable energy, (item 9) ‘preserve and enhance bio-diversity’(item 11), ‘creating a non-toxic environment – including high indoor air ’(item 12), ‘protect and enhance sensitive landscapes including scenic, cultural, historical and architectural’(item 16), and ‘balance between natural and the built environment’(item 21), which failed to gain consensus.

In the economic sustainability dimension, ‘recognition of commercial buildings as productivity assets’ (item 6), gain expert agreement in first round failed in the second round, while the 'using life cycle costing' (item 14) gained expert acceptance (≥75(75.0). The expert panel maintained their position on ‘support of local economies’, Whole/Integrated building design approach’, ‘decreased initial project costs’, and ‘New cost metrics based on economic and ecological value systems’, which failed to gain consensus. In the social sustainability dimension, 'improving human health and productivity' (item 8), and 'recruitment and retention' (item 20) failed to gain expert agreement in the second round along ‘diversity (cultural diversity) in development planning’ (item 16) and equality (item 21). In the governance dimension, the experts maintained a level of agreement of all items in both rounds. The difference in the level of agreement between rounds may be due to the different backgrounds of the panel group. Consensus was not reached on environmental factors (waste reduction and management – reuse, preservation and enhancement of bio-diversity, creation of a non-toxic environment, and protection and enhancement of sensitive landscapes, achieving a balance between natural and built environment); economic factors (whole/integrated building design approach); social factors (improvement in human health and condition, seeking intergenerational equity and reducing cost for future generations, recruitment and retention, as well as equality).

Table 15: Environmental Sustainability Drivers

	Variables	R1 Mean	R1 Consensus (%Agreement)	R2 Mean	R2 Consensus (%Agreement)
	Environmental Sustainability Criteria				
1	Energy conservation and efficiency	4.63	≥75(100)	4.58	≥75(100)
2	Water conservation and efficiency	4.88	≥75(100)	4.67	≥75(100)
3	Environmental /resource conservation	4.50	≥75(75)	4.17	≥75(75)
4	Indoor environmental quality	3.87	≥75(91.6)	4.42	≥75(100)
5	Land use regulations and urban planning policies	4.63	≥75(100)	4.75	≥75(100)
6	Plans and design (urban structure, open spaces and green areas	5.00	≥75(100)	4.83	≥75(100)
7	Waste reduction and management - reuse and recycle	3.62	**≥75(50.0)**	3.67	**≥75(58.3)**
8	Pollution minimization (Land, Water, Noise (and efficiency)	4.50	≥75(100)	4.42	≥75(100)
9	Renewable Energy	3.75	**≥75(50)**	3.25	**≥75(50)**
10	Resource conservation	4.23	≥75(75)	3.58	≥75(75)
11	Preserve and enhance bio-diversity	3.50	**≥75(66.7)**	3.17	**≥75(41.7)**
12	Creating a non-toxic environment – including high indoor air	4.13	**≥75(50.0)**	3.50	**≥75(68.0)**
13	Visual impact	3.75	≥75(75.0)	3.75	≥75(100)
14	Site and design (land use, conservation, reuse)	4.88	≥75(100)	4.83	≥75(100)
15	Transport – including provision of public transport	4.88	≥75(100)	4.83	≥75(100)
16	Protect and enhance sensitive landscapes including scenic, cultural, and historical	4.75	**≥75(50.0)**	4.17	**≥75(66.7)**
17	Creating a healthy, non-toxic environment – including high indoor air quality	4.50	≥75(100)	4.33	≥75(100)
18	Environmental Impact (process and product)	4.50	≥75(100)	4.58	≥75(100)
19	Re-use existing built assets	4.38	≥75(88.8)	4.33	≥75(88.8)
20	Green building rating systems (LEED, Green Globes)	4.38	≥75(100)	4.25	≥75(100)
21	Balance between natural and the built environment	3.87	≥75**(66.7)**	3.67	≥75**(66.6)**
	Number(n)	12		12	
	Kendall's W[a]	0.333		0.465	
	Significance	.000		.000	

Table 26: Economic Sustainability Drivers

S/N	Variables	R1 Mean	R1 Consensus (%Agreement)	R2 Mean	R2 Consensus (%Agreement)
	Economic Sustainability Criteria				
1	Proactive role of materials manufacturers	3.88	≥75(100)	4.17	≥75(100)
2	Financial affordability for intended beneficiaries	4.63	≥75(100)	4.50	≥75(100)
3	Product and material innovation and/or certification	4.25	≥75(75.0)	3.50	≥75(75.0)
4	Support of local economies	4.00	≥75**(66.7)**	3.50	≥75**(50.0)**
5	Adoption of incentive programmes	4.50	≥75(75.0)	3.83	≥75(75.0)
6	Recognition of commercial buildings as productivity assets	4.50	≥75(75.0)	2.25	≥75**(41.7)**
7	Whole/Integrated building design approach	4.50	≥75**(50.0)**	4.00	≥75**(66.6)**
8	Decreased initial project costs	3.88	≥75**(66.6)**	3.92	≥75**(66.6)**
9	Viability	4.25	≥75(75.0)	4.33	≥75(91.7)
10	Client worries in profitability	5.00	≥75(100)	4.67	≥75(100)
11	Competitiveness	4.63	≥75(100)	4.42	≥75(100)
12	Productivity	4.88	≥75(100)	4.58	≥75(100)
13	Value for money	4.13	≥75(100)	4.17	≥75(100)
14	Using life cycle costing	4.75	≥75**(66.6)**	4.50	≥75(75.0)
15	Creating and maintaining high and stable levels of employment	4.13	≥75(100)	4.17	≥75(100)
16	Investment (green products and in the use of renewable resources	4.00	≥75(100)	4.08	≥75(100)
17	Use of Key Performance Indicators (KPIs)	4.63	≥75(91.6)	4.50	≥75(100)
18	Maintaining high and stable levels of economic growth	4.50	≥75(100)	4.67	≥75(100)
19	New cost metrics based on economic and ecological value systems	4.38	≥75**(50.0)**	3.33	≥75**(66.7)**
20	Encourage use of local resources	4.63	≥75(75.0)	3.75	≥75(100)
	Number(n)	12		12	
	Kendall's W[a]	0.179		0.383	
	Significance	.000		.000	

Table 37: Social Sustainability Drivers

	Variables	R1		R2	
		Mean	Consensus (%Agreement)	Mean	Consensus (%Agreement)
	Social Sustainability Criteria				
1	Education and training	4.00	≥75(100)	4.42	≥75(100)
2	New kinds of partnership and project stakeholders	4.50	≥75(100)	4.33	≥75(100)
3	Improving occupants' productivity	4.00	≥75(100)	4.00	≥75(100)
4	Improving indoor environmental quality	4.75	≥75(100)	4.50	≥75(100)
5	Increase of awareness from clients	4.38	≥75(100)	3.42	≥75(75.0)
6	Community and social benefits	4.63	≥75(100)	4.42	≥75(91.7)
7	Building strong communities	4.00	≥75(100)	4.08	≥75(100)
8	Improving human health and productivity	4.38	≥75(100)	3.67	≥75(**66.7**)
9	Protecting and promoting human health and wellbeing	4.38	≥75(91.7)	4.33	≥75(91.7)
10	Participation of stakeholders –including community involvement	4.75	≥75(91.7)	4.58	≥75(91.7)
11	Improving public space quality	4.38	≥75(100)	4.50	≥75(100)
12	Making provision for social self-determination/enhancement	4.75	≥75(100)	4.75	≥75(100)
13	Training and development (skills training and capacity enhancement)	4.13	≥75(100)	4.33	≥75(100)
14	Equitable distribution of the social costs and benefits of construction	4.00	≥75(100)	4.58	≥75(100)
15	Seeking intergenerational equity and reducing cost for future generations	4.13	≥75(100)	4.08	≥75(100)
16	Diversity (cultural diversity) in development planning	3.87	≥75(**50.0**)	4.27	≥75(**63.6**)
17	Social inclusion	4.88	≥75(100)	3.92	≥75(91.7)
18	Improving image/reputation	5.00	≥75(100)	4.92	≥75(100)
19	Employment –including equal employment opportunities	4.50	≥75(100)	4.08	≥75(75.0)
20	Recruitment and retention	4.75	≥75(75.0)	4.25	≥75(**66.6**)
21	Equality	3.38	≥75(**66.6**)	4.00	≥75(**66.6**)
22	Accessibility	4.88	≥75(100)	4.25	≥75(75.0)
23	Work in occupied premises	4.38	≥75(100)	4.25	≥75(100)
24	Working environment	4.50	≥75(100)	4.33	≥75(100)
25	Security (minimising crime)	4.63	≥75(100)	4.75	≥75(100)
26	Satisfaction (workforce and user satisfaction)	4.25	≥75(100)	4.75	≥75(100)
	Number(n) Kendall's W[a] Significance	12 0.207 .000		12 0.339 0.000	

NOTE: The items that did not gain consensus are in **bold** typeface on Tables 1 to 3; %Agreement**:** ≥75 expert's response on item ≥4 on 1-5 Likert Scale (1=Not at all important to 5 =Extremely important); a: Kendall's coefficient concordance

Table 48: Governance Sustainability Drivers

S/N	Variables	R1		R2	
		Mean	Consensus (%Agreement)	Mean	Consensus (%Agreement)
	Governance Criteria				
1	Incentive programmes	4.63	≥75(100)	4.42	≥75(100)
2	Performance-based standards	4.62	≥75(100)	4.50	≥75(100)
3	Re-engineering the design process	4.62	≥75(75.0)	4.50	≥75(100)
4	Sustainable construction materials	5.00	≥75(100)	4.75	≥75(100)
5	Re-engineering the design	4.25	≥75(100)	4.42	≥75(100)
6	City planning and innovation (Smart city policy and	5.00	≥75(100)	4.92	≥75(100)
7	development				
8	Integrating agenda 21into urban planning	4.13	≥75(91.6)	4.00	≥75(100)
	Transparency and open Government	5.00	≥75(100)	4.67	≥75(100)
	Number(n) Kendall's W[a] Significance	12 0.298 .000		12 0.383 .000	
	Overall: Number(n) Kendall's W[a] Significance	12 0.369 .000		12 0.511 .000	

In overall, the results from the second (and final) round revealed a high consensus (Kendall's W = .511; p <.001) reached on 63 drivers of sustainable design and construction. The spearman's rank correlation computed to determine the stability of the level of expert ratings between the Delphi rounds reveals strong and positive correlation value (rho = 0.923, $p < .001$), indicating high degree of convergence implying that the stoppage criteria is achieved.

The result of the rounds of the Delphi expert rating of the barriers to sustainable design and construction in FCT Nigeria is presented on Table 5. The result reveals Kendall's W = 0.76 ($p < 0.000$) indicating that the panel's consensus with each other on the items is high. The mean rank of the items indicated that the most rated barrier item among the construction industries in Abuja was the tendency to maintain current practices. Barriers such as Lack of government policy (9.67); Misconception of Construction cost overrun (8.67); Recovery of long-term savings not reflected in service fee structure (8.54); Conflict public policy and/ or regulations(8.46); Lack of awareness from clients (Owner/Developer)(7.50); Limited sustainable knowledge and understanding from customers(7.42); Deployment of resources to back technological changes(6.92); and Lack of knowledge and understanding from design professionals(3.42) were ranked low. However, Tendency to maintain current practices (17.63), Ignorance of life cycle cost (16.29) and Unfamiliarity of sustainable materials and products (15.04) were the highest-ranking barriers.

Table 5: Expert ranks on barriers to sustainable design and construction in Abuja

	Variables	*Mean Rank*
1	Tendency to maintain current practices	17.63
2	Lack of an integrated work environment among all stakeholders	16.29
3	High building cost	15.50
4	Ignorance of life cycle cost	15.50
5	Unfamiliarity of sustainable materials and products	15.04
6	No understanding of the benefits of sustainable construction	15.00
7	Limited sustainable knowledge and understanding from subcontractors	14.58
8	Limited supply of sustainable materials and products	14.33
9	Extension of project schedules	14.25
10	Lack of public awareness	13.67
11	First cost premium of sustainable design and construction	13.63
12	Delay in decision making	13.50
13	Requirement for long payback periods from implementing sustainable practices and technologies	12.71
14	Concerning warranties and risks on non-standard sustainable materials and methods	12.25
15	Initializing sustainability due to lack of building regulations	11.54
16	Lack of government policy	9.67
17	Misconception of Construction cost overrun	8.67
18	Recovery of long-term savings not reflected in service fee structure	8.54
19	Conflict public policy and/or regulations	8.46
20	Lack of awareness from clients (Owner/Developer)	7.50
21	Limited sustainable knowledge and understanding from contractors	7.42
22	Deployment of resources to back technological changes	6.92
23	Lack of knowledge and understanding from design professionals	3.42
	Number(n)	12
	Kendall's W[a]	0.762
	Significance	0.000

The last two factors were awareness-related factors and are consistent with the finding of Marsh, Brent, and de Kock (2020), who found that lack of knowledge is one of highest ranked barriers to implementing sustainable development in South Africa. Again, this finding aligns with the views expressed by Enshassi, Ayash and Sherif (2018) that insufficient capacity to implement sustainable practices is a major barrier. The findings also support earlier findings and conclusions by Daniel, Oshineye and Oshodi (2018) about critical barriers to sustainable construction practices in Nigeria. This suggests the need for context-based strategies that will focus on increasing or improving awareness in sustainable design and construction among stakeholders. Most importantly, the study's findings show the barriers and drivers to sustainable development that the respondents view as important. The study shows that the respondents agreed on many factors; however, this should not be misconstrued as being the correct answer or opinion of judgement rather as stimulation to debate on the issues and an avenue for structuring group discussions (Hasson, Keeney, & McKenna, 2000). However, the method has been criticised for having the potential to produce forced consensus.

Conclusion and Further Research

The study used a two-round Delphi method to identify a set of drivers and barriers that represent consensus-based factors for sustainable design and construction in Abuja. The factors are consistent with previous research. Academics, the government, and professional institutions are encouraged to develop localised strategies to improve stakeholder knowledge of sustainable design.

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Determinants of Smart Technology adoption in the Construction Phase of Projects: A Scoping Study of the United Kingdom

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Abstract:
The slow pace of adoption of smart technology in the construction industry poses a challenge to the industrial revolution. Within the United Kingdom (UK), there is limited understanding of the determinants to innovation in the construction phase of the project lifecycle. This has implications on industry performance. The current scoping study, fills this gap by identifying and assessing determinants to innovation in the construction phase of the project lifecycle. A methodology of unstructured, exploratory interviews followed by a structured survey of construction professionals in the UK was adopted. The study found that client demand heavily dictates the level of innovation and use of technology on a given project. However, industry structure consists of at least 99% small and medium sized enterprises (SMEs), many of whom undertake small-scale operations for clients who have neither the budget nor motivation for driving innovation on a project. SMEs therefore gain little to no exposure to smart technological advancements and as a result they lack the skillset to confidently influence client decisions on innovation. However, large construction companies, such as those who tender for government projects, are making vast advancements in the research and development of smart construction technologies and their implementation in projects. Although limited by the sample size, the implications of the findings include inequality being a key barrier to innovation in the construction phase and addresses the industry skills shortage. Consequently, it is recommended that the UK Government, in conjunction with large construction companies provide financial incentives and training via bodies such as Construction Industry Training Board (CITB) to support the upskilling of the workforce, including those employed by SMEs.

Keywords:
Construction 4.0, construction technology, digital technology, Industry 4.0, innovation, smart technology

1 Introduction

The current industrial revolution coined "Industry 4.0." is recognised as being brought about by the connectivity of current cyber-physical technologies and is already apparent in some industries such as manufacturing, automotive design, data management and communication (Feußner and Park, 2017). The performance of the construction industry remains a concern as covered in literature, for example, Farmer (2018), Rivera et al. (2017) and Pekuri et al. (2014). It there is evidence that Construction 4.0 would contribute to improvement of the poor performance of the industry (Bilal et al. 2016; Muller et al. 2018). Vast developments in construction technology such as the wide-spread adoption and evolution of BIM in the design phase (Bilal et al. 2016), and the development of smart buildings, enabling digitised and automated facilities management in the O&M phase demonstrate a revolution taking place. However, the lack of literature discussing the use of connective technologies available for the construction phase such as those illustrated by Feußner and Park (2017), indicates less technological progress in this area. The advancement of machinery used on site shows that the construction phase remains in the 3rd revolution, defined as automation by combining IT and electronics (Feußner and Park, 2017), however the cyber-physical connectivity, which is missing on site, gives the impression of the industry as a whole being slow to advance or resistant to change. Therefore, the focus of this investigation is specific to the construction phase of the project lifecycle, in particular, using the United Kingdom (UK) construction industry as a case study. The reported study (the undergraduate research project of the lead author (Dixon, 2020) assesses the drivers and barriers to the uptake of “smart technology”, defined as Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI) and Robotics within the construction phase. Following this introduction is the literature review after which the methodology is presented. The findings, discussion, and conclusion with recommendations are then covered.

2 Literature Review

2.1 Industry 4.0: Projections from the Manufacturing Industry

Projections on the future of the construction industry are often drawn from the past of the manufacturing industry. A review by Smith, (2019) of the American economists Jill and Frank Manzo highlights social impacts of automation on the manufacturing industry as a “warning” to the Construction industry, in regard to the industry becoming less reliant on human labour due to automation. According to a PWC (2018) report, 20% of all UK jobs are "at risk" of automation by the mid-2030s, opening opportunities as well as threats. Consultancy roles which remove repetitive tasks such as cost schedules and engineers’ calculations result in creative tasks which require human input to rise in demand. It is possible more jobs could be created than destroyed albeit with the requirement of different skillsets. (Gardiner, 2018, p31). Modern methods of construction (MMC) is a growth area, attracting young people interested in 3D modelling and robotics to the industry (Farmer, 2018). Balfour Beatty (2017) predict that in 2050 “new jobs and industries will be created – and some will disappear, especially low or zero skill roles and those relying on repetition of tasks.” Such reports are examples of the ways in which negative opinions about the use of technology in the construction industry are formed. These conclusions could be flawed, as according to the Smith’s review, infrastructure is an economic growth driver, prompting a rise in demand for labour. Meanwhile, existing skills shortages in the labour market could actually be the driver to roles being filled by robots and drones (Manzo, et al, 2018).

2.2 Client Driven Demand for use of Technology

Evidence that client influence drives and hinders the adoption of construction technology is documented throughout the literature. For example, Aecom found that 36% of the respondents view the lack of client demand for technology use in construction projects as a barrier (Ray 2019). Lindblad & Guerrero (2020) agree that clients are key actors in driving construction innovation but question whether innovation should be supplier-driven as in practice few clients are willing or have the capacity to promote innovation.

2.3 Government Incentivisation

The “Construction sector deal” struck in 2008 (Department for Business, Energy & Industrial Strategy, 2018) brought about the “i3P” initiative, created to “work with construction clients to drive demand for innovative construction materials, technologies and techniques." However, Farmer in 2016 is still calling for tripartite leadership involving, clients, government and industry to spark progress. Lindblad & Guerrero (2020) discuss the dichotomy of government (the client) and the policy maker, as is the case in the largest and most complex infrastructure and development projects in the UK. Governmental power to drive innovation through policy and incentives is evident.

2.4 Education and training for skills in the workforce

Lack of education and training for new digital and automated processes is a topic frequently referred to as a barrier. Ray (2017) and Farmer (2016) demonstrate that development of new enhanced skills amongst the existing workforce is imperative to the industry moving forward. Farmer (2018) recommended reform of the Construction Industry Training Board (CITB) to include an outreach programme to schools, focussing on innovation and technology rather than only focussing on current standards.

2.5 Sustainability

The lack of discussion of sustainability in relation to construction 4.0 was noticeable in the literature. Ray (2017) shows that more communication of the environmental benefits [of BIM] is required, which also applies to the positive environmental impacts of smart technology as a whole, for it to become a driver in industry-wide adoption. Oesterreich and Teuteberg (2016) found that automation reduced labour and material costs. Construction waste minimisation and emissions reduction via strategic project management and digital design was presented as environmental benefits - however these methods are currently used by the industry to improve sustainability. "The high levels of energy required by increased data usage and storage will also begin to have a significant impact on resources within the next decade" (Balfour Beatty, 2017). The industry must mitigate against the projections of the impact of construction 4.0 on the climate.

2.6 Industry Real and Perceived Threats/Opportunities

The opportunities to improve on health and safety management are drivers. Health & safety risk is reduced by use of virtual environments, and wearable safety technology such as smart glasses and helmets (Oesterreich and Teuteberg 2016). Robotic exoskeletons assist in manual handling, reducing the risk of back injury (Theurel and Debrosses, 2018). The project and commercial risk raised in the literature are related to the complexity of revolutionising all stakeholders along the chain of construction processes. This is considered by some an overwhelming task, making avoidance a more convenient option than adoption and adaptation (Oesterreich and Teuteberg (2016). Cyber Security poses a risk to any digitised industry and the need for data security and data protection as discussed by Oesterreich and Teuteberg (2016) and Balfour Beatty (2017), stating national cyber defence programmes should be run by the government. The data acquired and produced must be secured and managed as conscientiously as all assets are.

3 Research Methodology

The literature review informed the development of the data collection instrument which was then validated by pilot interviews of two industry professionals in an unstructured format of open-ended questions. The interviews lasted 40 minutes and explored the barriers and drivers of innovation in the construction phase of construction projects. Following this, the questionnaire survey; the main method of the study, was conducted. The survey was conducted electronically through Google Forms. The survey comprised 4 sections addressing the 4 objectives and a total of 7 questions, a mixture of open and closed format. Closed, multiple choice style questions allow for the clearer categorisation of responses, allowing grouping and quantification. There was the need to gather information about the construction process from construction professionals. Hence, respondents must either work on the construction site, or be privy to the management of construction site activities. Certain criteria such as service department within the organisation were considered critical to qualify as a suitable participant within the sample frame, others, such as company size or sector, hierarchical level within an organisation, gender or educational background were not grounds for exclusion. Using random sampling technique, single stage sampling design was used. To the knowledge of the authors, there is no list of construction professionals working only in the construction phase. Consequently, the list of contacts was drawn up from two of the following accessible populations and sent a survey request: 1) construction professionals on LinkedIn, and 2) apprenticeship degree Kingston University Students, working part-time in the construction industry. Being an undergraduate research project, there was limited time to conduct the research. Of the questionnaires distributed, 30 usable ones were returned. Figure 1 shows the response sample characteristics.

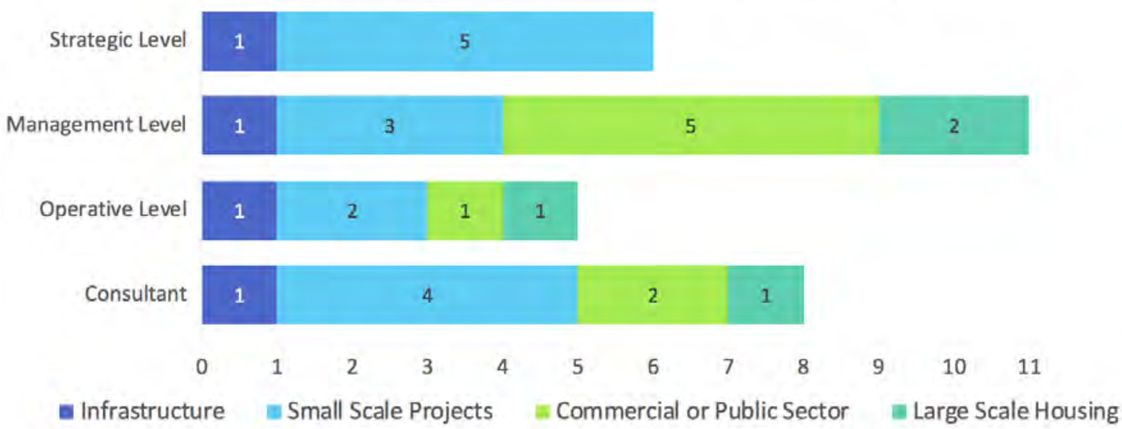

Figure 1: Organisational level profile of the respondents (Dixon, 2020)

4 Findings and Discussion

4.1 Profile of the respondents and discussion

Of the 30 respondents, as seen in Figure 1, over one third, the largest group are of managerial level. This may be explained by the accessible population being LinkedIn members and Kingston University Part-time Students. In construction, employees on this level are likely to have a LinkedIn account and to be supported by their companies to gain a degree via apprenticeship to complement their managerial role. Of the subgroups, the two majorities were 1) Managers of the Commercial and public sector at and 2) Strategic Level of the Small Projects sector, both with 5/30 participants each. Almost half, 14/30 of respondents are from the Small Projects sector, the majority of whom, as stated above selected the "Strategic Level" company position. This also correlates with the accessible population and translates to this group being the owners and directors of SMEs (Small/Medium Enterprises). Taking national statistics into consideration, SMEs make up over 99% of the construction industry. Of those SME's over 138,000 (ONS, 2018) are sole traders or only have 1 director. That translates to 42% of the total of companies in the industry, this is reflected as the largest single sector in the sample. The implication of the small data set is that the findings are indicative hence the interpretation of the data should be with caution. The limitations of the data do not allow for a direct proportionate comparison to the industry to test accuracy. However, sample characteristics are close enough to industry structure to enable theories to be tested for the sake of this study. Scoping studies with small data set is consistent with other research, for example Umeokafor (2016) uses 37 respondents and Yong and Mustaffa (2012), 14 respondents. Both are published in high-ranking journals.

4.2 Findings of Interviews and Survey

4.2.1 – Findings of the exploratory interviews

The exploratory, unstructured interview validated the findings of the literature review which was used to develop the questionnaires. The barriers in literature included lack of awareness of the benefits of the technologies and the high cost of investments in digital technology. Both of which were validated by the interviewees. The interviews confirmed and revealed other barriers such as 'lack of client demand', 'inability to adapt to change', 'inability to procure technology' and 'fear over job security'.The same is applicable to the drivers where 'improvement of processes' and 'client demand' were consistent with literature and the following emerging from literature: 'legislative demands', 'solving real problems', 'available funds to invest', and 'return on investment'. The themes emerging from the 'effects of industry structure' are 'company structure', 'company size' and 'male dominated industry'. The implication of validating the questionnaires is evident as issues explored are not detached from reality. The exploratory interviews, although limited in number, improved the data collection instrument to be as reflective as possible, of what occurs in practice in the industry.

4.2.2 – Findings of the Survey

The survey assessed the smart technologies the respondents had witnessed in use in the construction phase. The answers were multiple choice and allowed a participant to answer "no" if not, or "in another phase" if they had witnessed smart technology in pre/post construction but not within the construction phase. Figure 2 illustrates, more than one third of the respondents answered "yes". These were asked to confirm in what percentage of projects over the last year, they had witnessed any of the named smart technologies in use. Four of the 11 respondents report witnessing smart technology in use in more than half of the projects assessed. The remaining three, stated they could not answer, or did not know the answer.

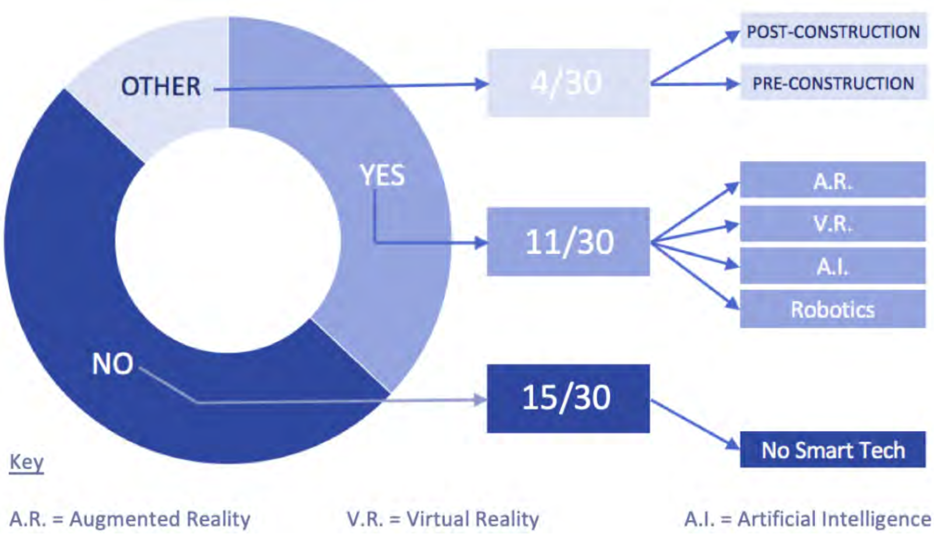

Figure 2: Observation of use of Smart Technology in the Construction Phase (Dixon, 2020)

To better understand the responses in Figure 2, the implications of industry structure on the adoption of smart technology was assessed. Figure 3 suggests that the characteristics of the industry determine whether smart technology will be adopted. In particular, the size of companies and the scope of operation are assessed. The implication is that the smaller the project, the less likely smart technologies will be adopted. However, this should be interpreted with caution due to the scoping nature of the study.

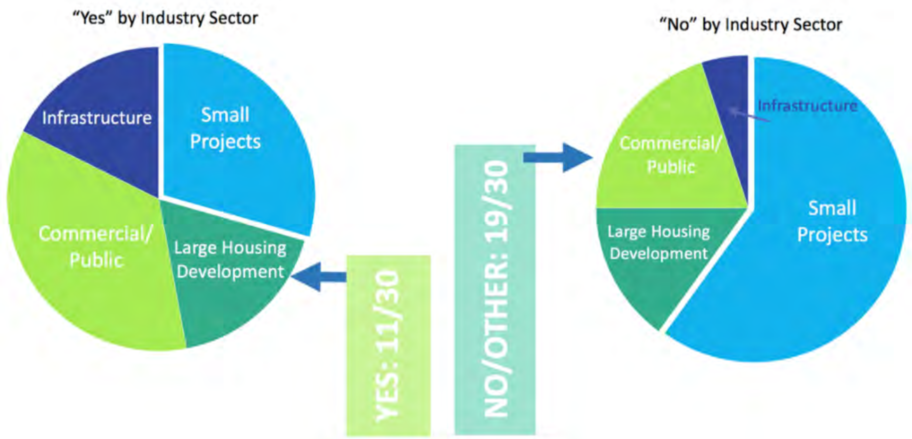

Figure 3. Adoption of smart technology based on industry characteristics (Dixon, 2020)

Figure 4 presents the drivers of smart technology adoption in the construction phase of the project. An open question asked the 11 respondents who answered "yes" to provide views on what the drivers were. The answers totalled 17 (some respondents gave multiple answers) and covered several categories. Indications from Figure 4 are that the main driver is time related, followed by cost related factors.

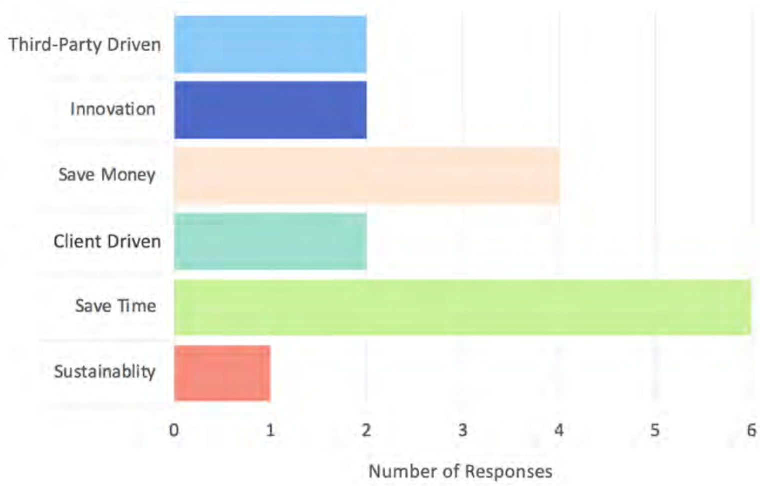

Figure 4: Drivers of smart technology adoption in the construction phase (Dixon, 2020)

Respondents who answered "no" or "other" (nearly two thirds) were subjected to further analysis and asked why those named technologies were not used in the construction phase. Some gave multiple reasons. By implication, the barriers to the adoption of smart technologies were identified and assessed. Figure 5 shows that in the view of the respondents, clients not requiring use of smart technology is the main barrier. Again, cost-related factors in procuring smart technology ranks second, followed by the lack of skills and knowledge required.

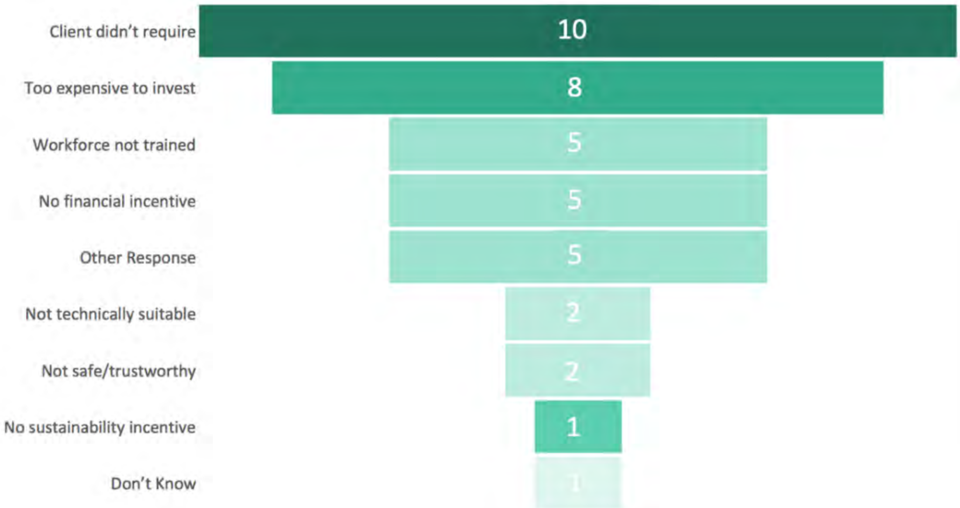

Figure 5: Barriers to smart technology adoption in the construction phase (Dixon, 2020)

4.3 Discussion of Findings

Client demand or lack there-of as a driver and barrier is one major finding of the study. The construction industry is driven to deliver to client demand, which correlates with the 2016 survey by Aecom (Ray, 2019). Akin to Lindblad & Guerrero (2020), the survey also reveals suppliers can be catalysts in the adoption of new, innovative techniques. Respondents revealed that drone technology is used as a survey method due to encouragement by the surveyor engaged on the project. This highlights the nature of the client/contractor/supplier relationship as recommended by Farmer (2016). Subcontractors are the experts in their specialism and qualified to provide guidance on best-practice and techniques.

The survey reveals those contactors operating small projects don't have clients who encourage innovation. A large infrastructure company may absorb the cost of applying a new technology due economy of scale. Costs are more visible on smaller projects therefore the client, who leads on allocation of funds would require encouragement by a confident contractor, to adopt an alternative, disruptive technological method, over a traditional method. There is evidence to suggest that education and training for skills in the workforce is necessary for advancement in the construction phase. Some respondents are concerned the workforce are unfamiliar with the technologies. Both interviewees agreed that there is an unawareness of the existence of beneficial existing technology amongst the workforce. Farmer (2016) suggests addressing through the CITB, the largest education and training provider to the workforce, including SME's. This, in correlation to the last paragraph could lead to SME's being proactive in the use of innovative technologies on projects.

Education and training may improve confidence in connective technology, but for SME's, procurement requires finance. Cost-related factors emerge from the study as barriers and drivers, with over one fifth of the surveyed population claiming cost is the main barrier and reason why they have not used or seen these technologies being used. The expense of investment is strongly connected to innovation in the experience of SME's, hence the need for government incentivisation. As stated by the Farmer Review, government bursaries for innovation, aimed at SME's were largely going untouched. Communication blockages between the government and SME's regarding available incentives must be queried, as more than 99% of the construction industry are classed as SME. Bursaries should not remain untouched.

The survey reveals concerns over risks of technical suitability or safety/security ranked low as a barrier. Logically, these risks would only be of concern to companies in the financial position and with the necessary skills to procure these technologies. In terms of sustainability, there is not enough conversation about the impacts of connected construction technology on global environmental sustainability. The industry urgently require data comparable to that by Balfour Beatty, to communicate and address the benefits or threats to sustainability targets. The lack of conversation in this specific area was proportionally reflected in the survey, where only one participant uses the word "sustainable".

5 Conclusion and Further Research

This scoping study assesses the barriers and drivers to the adoption of smart technology in the construction phase of the project lifecycle. This stems from the limited attention in literature to the implications of barriers and drivers in this specific area. The findings indicate that up to two thirds of respondents claim that smart technology is not adopted in their projects. On further analysis, it was found that the smaller the project, the less likely smart technology will not be adopted in the construction phase, with commercial/public projects most commonly reported to have witnessed the use of smart technology. While major barriers are the lack of client requirement and the high cost involved in acquiring the technologies, the main drivers include the quest to save time and money and the encouragement of third-party construction professionals involved on the project. The implication of the findings include that the SMEs therefore gain little to no exposure to smart technological advancements and as a result they lack the skillset to confidently influence client decisions on innovation. However, large construction companies, such as those who tender for government projects, are making vast advancements in the research and development of smart construction technologies and their implementation in projects. Therefore, inequality is a key barrier to innovation in the construction phase. The vast proportion of the industry are SME's continuing with trusted, traditional methods, albeit whilst improving the specification of their machinery. Hence, there is a requirement for the diversification of (affordable or funded) methods of procuring advanced, connected technology and the training required for these, to SME's. Consequently, it is recommended that the UK Government in conjunction with large construction companies provide financial incentives and training via bodies such as CITB to support the upskilling of the workforce, including SMEs. The interpretation of the data should be with caution given the small data set. However, the study offers insight into discourse and can be used as a framework for further studies. Further study of a larger sample is recommended.

6 Acknowledgement

The research and data presented in this study was carried out as part of another body of work, the lead author's undergraduate dissertation (Dixon, 2020).

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A Systematic Review on Development of a Project Cost Estimation Framework: A Case Study of Nigeria

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Abstract:
In Nigeria, there have been insufficient studies in the field of risk-related cost variability. Due to unreliable cost estimation, variations in cost, length, and quality are the direct implications. Cost estimating is difficult, mainly when dealing with uncertainties. The study aims to develop a construction project estimation framework that will aid accurate cost estimating and address cost variability issues through a systematic review. This is critical because initial estimates provided to clients can demonstrate a certain level of consistency and precision on which the client bases other planning activities. In achieving this, the theoretical concept was validated via a processual lens of a systematic literature review with cost variability and construction projects as search string within three databases: Scopus, Web of science, and EBSCO (BSP) (Business source premium), which were further studied and knowledge or research gaps identified. The review indicated that factors causing deviation between final accounts and contract sum varied from 1 to 40, including Clients change/Changes in owner's requirements, Clients brief, Type of client, Defective design and specification, thus meeting objective 1 of the study. A combination of interview and questionnaire was used to collect data and consider other objectives of peculiarities, severity, effects and ways of mitigating risk, leading to the development of a cost estimating framework that is adjudged a vital tool in risk shedding rather than risk-sharing in project risk management, which would be a panacea to cost estimation problems, leading to cost variability in the Nigerian construction industry.

Keywords: Cost, Construction projects, Future studies, Nigeria, Variability

Introduction
The construction industry in Nigeria contributes 3.21 per cent to the Gross Domestic Product (GDP) as of the third quarter of 2020 (National Bureau of Statistics, 2020), making it a significant driver of economic development. Most risk management studies have gathered data on East Asia, Europe, the Middle East, and the United States (El-Sayegh and Mansour 2015). The main concern is how these risk factors combine to create the differences between the contract sum and the final account sum. As clients become dissatisfied with their projects completed over budget, this study, therefore, seeks to influence government policy to build support mechanisms to promote effective risk management practices in the Nigerian construction industry towards proposing a framework from the perspectives of the different project stakeholders.

Literature Review
Previous researchers like Zakaria et al. (2013); Olatunji, (2008); Ko (2009) have found that the absence of an accurate cost estimation framework leads to cost variability problems in construction, which in turn affects efficiency and effectiveness from the planning stage to the final account stage of the project. Doloi (2011) opined that proper cost estimation is a great concern to project stakeholders. Researchers like Zakaria et al. (2013); Olatunji (2008); Ko

(2009); Doloi (2011); Ameyaw (2015); Salahi and Ali (2018), and several others alluded to the fact that cost variability does exist in the construction industry and accepted that it is a major problem slowing down the construction industry.

Therefore, this study aims to extensively research issues related to cost variability and identify pending research gaps. This study focusses on the following objectives:

(*1*.) To analyse trends in the literature related to cost variability in construction projects as well as their distribution patterns
(*2*.) To propose a classification framework highlighting emerging themes and unaddressed research issues related to cost variability in construction projects.

Research Methodology

This systematic review provides recent insights on the state of research into cost variability in construction projects. The Preferred Reporting Items guide the review for Systematic reviews and Meta-Analyses (PRISMA) framework, which offers a well-established protocol to conduct systematic literature reviews (Azril *et al.*, 2019).

The initial stage of the systematic literature review (SLR) concentrates on searching for relevant papers from relevant and essential databases such as Web of Science (WoS), Scopus and EBSCO Business source premium (BSP). Search string designated as cost variability and construction projects were used for the search over two decades. A total of 443 papers, excluding book reviews, forums, and editorials, were retrieved for further analysis, which was eventually filtered down to 280 papers after excluding papers not written in English language and non-peer-reviewed journals. Repeated entries across individual databases were also removed using the Mendeley reference management platform, thereby retaining 83. Further filtration excluded additional four articles that lacked full details such as author(s) details, year and title, which led to a final population of 79 articles that were then carefully considered and subjected to a detailed review as shown in Figure 1.

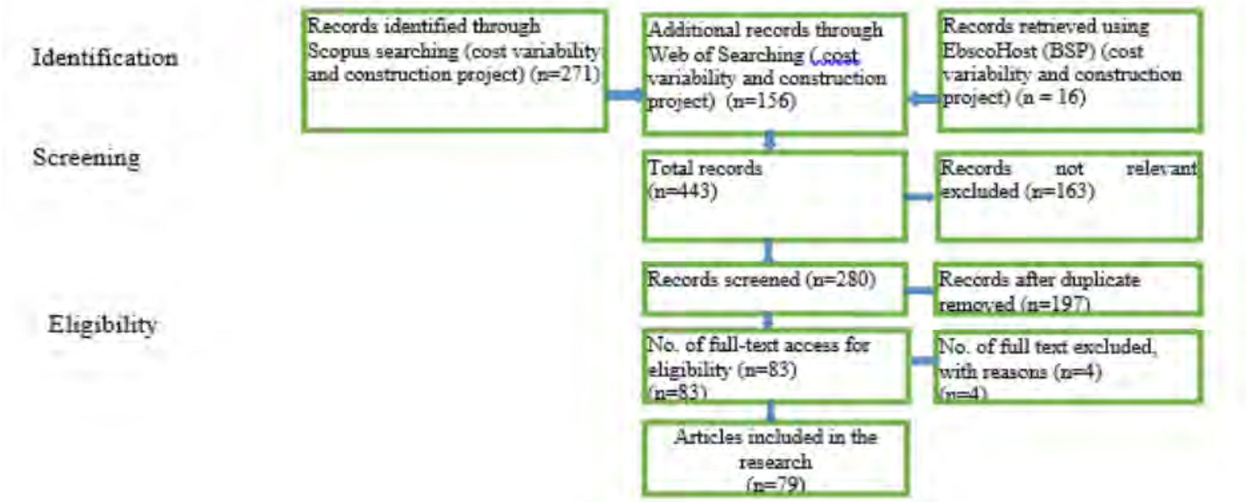

Figure 1. Flow- chart of the methodology

Findings and Discussion

4.1 Content analysis

The frequency of publication was not consistent and could be said to be progressing arithmetically until the year 2000, as seen from Figure 2, when momentum gradually built up till the year 2019. The implication of this is that researchers are showing an increased interest in the field because the issue is now a significant concern. From 2011 up till 2019, the average number of articles per year increased to 4.4. Moreover, the analysis clearly shows the peak (n=19) in the year 2019. However, over the years from the review, the factors causing cost variability ranged between one and forty-five, while their effects can be grouped into four main classes.

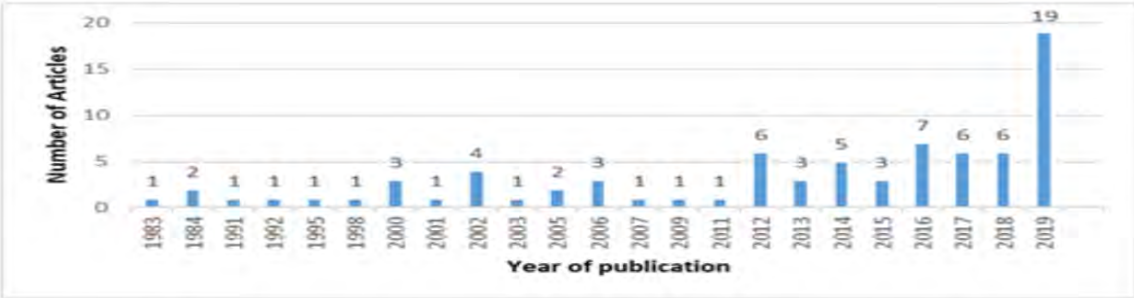

Figure 2. Publication of Articles per year.

4.2 Publication distribution among leading journals

The selected articles belong to 43 journals, as seen in figure.3. The top three journals constitute approximately 34.18% of the total number of journals, and they are the International Journal of Project Management (n=6), the Journal of Construction Engineering and Management (n=13), and the Journal of Construction Management and Economics (n=8). This reflects the degree of importance in cost variability-based publications, which has been handled by core journals closely related to project management and construction.

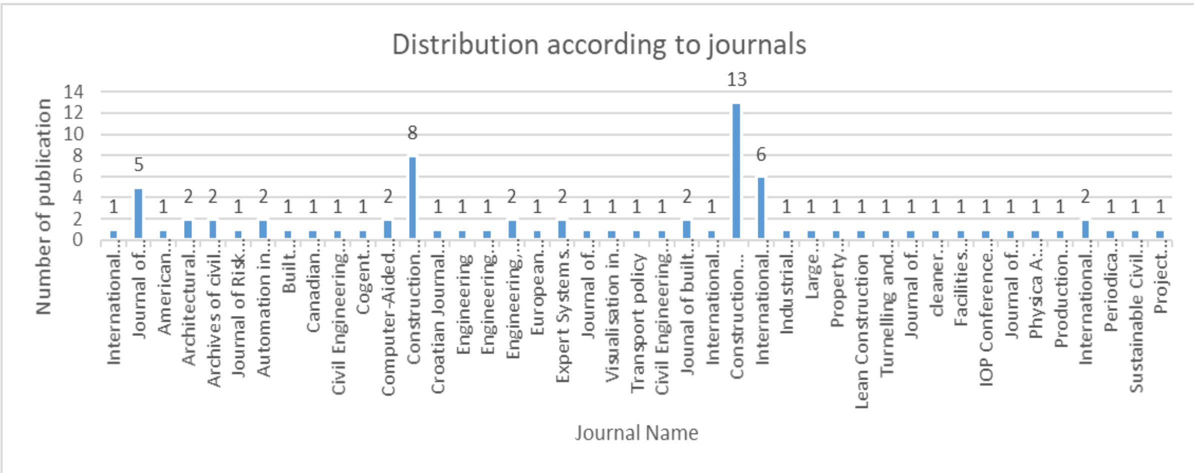

Figure 3. Distribution according to journals from SLR (2020)

4.3 Geographical distribution of the publications

The study shows the spread of publications on the subject matter across different countries, with other parts of the world having 73 (92.41%) while the region being considered (Africa) has (n=6, 7.59%). The existing literature on cost variability is dominated by developed countries, which could indicate advancement in research or researchers in Africa are not yet paying adequate attention in the field of study as realised by the authors.

4.4 Research Gap: Cost Variability

This SLR has revealed that there have been significant advances in cost variability studies in recent years. However, gaps remain in the provision of solid and reliable frameworks capable of providing accurate estimates. A review of related literature gave insights into the critical risk factors influencing variability in construction projects between contract sum and final account sum. Sixty-seven (84.81%) accepted that cost variability is a significant problem, and only 3 (4.48%) is from Nigeria, an indication that the issue needs adequate attention in Nigeria. The same set of reviewed articles established that between 1-40 factors (listed in conclusion) affect cost variability.

4.5 Relative importance or ranking of cost variability factors

Ameyaw (2015) ranked factors causing variability using relative importance index and observed the following: project funding problems with risk impact of 5.91, underestimation of quantities 5.76, variations by the client 5.49, change in scope of works 5.48, inadequate specification 5.37, change in design by client 5.32, defects in design 5.21 and unexpected site (ground) conditions 5.21 are significant causes of cost variability according to relative importance ranking. This may depend on the dynamics of the business environment, which seems to be widely accepted by most other scholars, and this could be embraced for this study.

4.6 Cost variability risk mitigation strategies

Salahi and Ali (2018) suggested that the best way to mitigate issues causing cost variability is through sharing or transferring since risk is considered an umbrella term often associated with opportunities and threats.

4.7 Symptoms*/risks associated with project failure (number of articles = 68)*

From the 79 reviewed articles, 18 authors stated that: Time overrun, cost overrun, Abandonment, and Low-quality jobs were effects of cost variability on construction projects, while 26 said Time overrun, cost overrun, and Disputes. Fifteen (15) asserted that Time overrun, cost overrun, Disputes and Low-quality jobs, while nine claimed that Time overrun, cost overrun, Disputes, Insolvency Bankruptcy; and 11 did not state any effect(s). The publications in this theme investigated the risks associated with cost variability, prediction opportunity and challenges, and the scope for learning from cost variability.

Conclusion and Further Research

The followings are the conclusions drawn:

Researchers have not yet shown the required interest in the field of cost variability, which is becoming an emerging problem within the study area based on the number of outcome from the area. This is an issue that desperately requires attention to curtail the risk across the project life cycle. There is the need to develop a cost estimating framework that will consider the effects of cost variability linked to cost, time, quality, and sustainability aided by location, culture, security, and behavioural attitudes portraying a serious problem in the study area depending on the peculiarities of the area. Further studies in this field might reveal the path to the construction industry's rapid growth and sustainability. This is a clarion call for researchers and practitioners in the construction industry to look deeper into studies that will facilitate the rapid development of the framework to evaluate effective estimation processes, and also give stakeholders a more in-depth understanding of the estimation effectiveness and efficiency to be adopted.

Some papers on cost variability may have been left out of this review because of the inclusion and exclusion criteria in figure 1 that were developed by the researchers to include peer reviewed publications alone, however investigation on risk from the review, shows that 67, (84.81%) of authors stated between 1-40 risk causing cost variability, which includes Complexity of design and construction, changes in owner requirements, client change, expertise of consultants, government legislation, under estimation, project scope and market condition, labor /materials, scope at pre-contract preparation, defective design and specification, changes in estimating or cost planning data, quality of information and flow requirements, availability of design information, projects team experience of the construction type, project location, inadequate cost plan/tender documentation, type and quality of cost planning data, method of construction, site investigation(geological/sub-ground condition), bad weather, site constrain, zonal rates, strikes, politics, procurement system, legal requirements, availability and supply of labor, tender inflation ,planning requirements or restriction, little or no information about mechanical/electrical works, type of project, unforeseeable fluctuation in material prices, availabilities and supplies of materials, security ,client brief, type of client, unforeseeable fluctuation in labor prices, type of bidding, type of structure and contract condition. Six authors came from Africa, and only 3 (4.48%) authors from Nigeria with between1-18 of the identified risk causing cost variability from reviewed literature, indicating that issue of cost variability is presently not adequately explored. Developing a framework to estimate contract sum accurately is considered necessary, as it will be a significant contribution to knowledge when the research work is completed.

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An Evaluation of Planning Techniques Impacting Construction Project Performance in Nigeria

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Abstract:
It has been observed that the planning technique used for project execution determines its performance. Extant literature shows that the five planning techniques mostly used in Nigeria are Gantt/bar chart, linked bar chart, critical path method, project evaluation and review technique and line of balance. However, there are scanty studies on the impact of planning techniques on project cost performance. This study evaluated the usage of these planning techniques in Nigeria to determine their impacts on project cost and duration. A descriptive survey using a structured questionnaire was conducted of medium and large scale contracting firms in Lagos State, Nigeria, using a random sampling technique. One hundred and twenty (120) respondents were sampled out of a population of 159 contracting firms in these categories. The data collected were analysed using mean score and percentage. The results from the study indicated that Gantt/bar chart is the planning technique mostly used in the study area. Moreover, the critical path method and PERT outperformed the other planning techniques in time and cost performance, respectively, while the bar chart performed least in both time and cost. The study concluded that although planning techniques are low in the study area, their time and cost performances are fair. It is recommended that more sophisticated techniques should be used in the study area for enhanced project performance.

Keywords: Construction, evaluation, performance, planning, techniques

1 Introduction

The increasing complexity of construction projects requires proper planning to achieve success (Olateju *et al.,* 2014). Lines *et al*. (2014) defined planning as the procedure of determining what to do and how to do it before it is done. Anyanwu (2013) opined that planning involves making decisions now to influence the future. It sets a roadmap that should be followed to reach a destination. Patankul *et al*. (2010) defined planning techniques as tools used by project managers to orchestrate the activities required in a project life cycle. Idoro (2012) described construction planning techniques as crucial tools that stakeholders use to ensure successful projects. Tesfaye *et al.* (2017) explained that project planning defines the activities required in a project and the resources needed for their accomplishment. Ayodele *et al.* (2015) claimed that planning techniques are needed to implement project activities effectively. Kerzner (2009), Patanakul *et al.* (2010) and Tesfaye *et al.*(2017) observed that there are several planning techniques in use in the construction industry worldwide. Olateju *et al.* (2011), Inuwa *et al.* (2014a), Ayodele *et al.*(2015), Ahmed and Namala (2015) and Ugwu and Attah (2016) have identified the planning techniques mostly used in Nigeria to include Gantt/bar-chart (BC), line of balance (LOB), project evaluation and review technique (PERT), critical path method (CPM), linked bar charts (LBC).

The construction industry has been criticised for being inefficient in its outputs' cost, time, and quality outcomes. In Nigeria, for instance, Ogedengbe and Adesopo (2003) and Zuofa and Ochieng (2014) reported that most projects do not deliver on schedule and budget allocated. However, there is a close nexus between planning and construction projects performance. Ogunde and Fagbenle (2013) posited that proper planning is vital to successful project execution. Omotayo and Kaushal (2014) opined that the level of success of any project executed depends on the planning technique adopted. Ahmad and Namala (2015) affirmed that planning ensures that projects are completed within the specified duration, cost, and quality. In other words, completed projects are a result of careful planning and execution using established techniques.

Similarly, Idoro (2009) claimed that poor project control and planning are major contributors to project delay in Nigeria. Saidu and Shakanta (2017) opined that inadequate project planning and control are major challenges to efficient project performance in developed and developing nations. Daniel and Ibrahim (2019) also found that inadequate planning was a major cause of project failure in Nigeria. Thus, research efforts towards enhancing project efficiency via proper planning should not be underestimated. However, empirical studies on the performance of planning techniques seem scanty in construction literature. Patanakul *et al.* (2010) reported that research on project management tools and techniques had not been adequately investigated regarding their impact on project outcomes. Being a developing country, Nigeria is faced with a lot of infrastructure deficit which will need the deployment of efficient planning techniques in their execution. The preceding necessitates an evaluation of the performance of the construction planning techniques used in Nigeria, hence this study. This study aims to evaluate the impact of planning techniques on the cost of construction projects in Nigeria to enhance project delivery. The specific objectives of this study are to assess the usage of planning techniques in Nigeria and their impact on the cost and time performances of construction projects in the study area.

2 Literature Review

Several empirical studies have been conducted around the world on the usage of planning techniques. Agumba and Fester (2011) investigated construction projects executed by small and medium enterprises in South Africa and reported that bar-chart and networks were used for managing time and cash flow. Deacon and Vander-Lingen (2015) examined the use of critical path and critical chain methods in South Africa to determine which construction sector applies the methods and their usage level. The study concluded that the methods were used mainly by the building sector and that the critical path was more used than the critical chain method.

In Mexico, Carcano *et al.*(2015) investigated the performance of managing 14 public school projects and concluded that the more the schedule management of projects, the more likely timely completion of projects would be. Similarly, in Sweden, Al Nesseri (2015) inquired into the application of project planning and scheduling in construction projects to create an awareness of its understanding. The study, however, found that there is insufficient attention to effective management and definition of project planning. In Ethiopia, Tasfaye *et al.* (2017) assessed the impact of planning on a project using four input factors that affect planning quality: human, organisational, management, and technical factors. The study concluded that project success depended on time, cost and risk. Harun *et al.* (2017) studied the project management practice and its effects on project success in the Malaysian construction industry using interviews and questionnaire administration. The study reported that customer satisfaction, competency of project teams and performance of subcontractors and suppliers are becoming critical success factors of projects in addition to the classic iron triangle's view of cost, time and quality.

Similarly, in Nigeria, several types of research have been undertaken in the area of construction project planning. Olateju *et al.* (2011) studied the management practices adopted for public sector projects in Nigeria using 23 public institutions in the study area. The study found that there is inadequate knowledge of project planning techniques in public institutions in the study area due to the high cost of application. Adebowale and Oluboyede (2011) investigated the cost and minimum expected time required to complete building projects using network analysis to reduce the menace of building collapse in Nigeria. In a related study, Inuwa *et al.* (2014) assessed the project planning techniques used by indigenous contractors in Nigeria using a questionnaire survey and a case study to probe the responses from the questionnaire. The study concluded that most Nigerian indigenous contractors do not apply project planning techniques because of their personnel's incompetence. Ahmad and Namala (2015) investigated the practical application of essential planning tools in the construction process in Nigeria. The study reported that few contractors use planning tools in the study area and that GC is the planning tool mostly used because of its simplicity. The study concluded that the cost of application inhibited the usage of other planning tools. Training on the application was hence recommended for enhanced adoption of planning tools and management of construction projects. Ayodele *et al.* (2015) studied the techniques used for project planning in Nigeria. Umar (2016) appraised construction project planning in Nigerian indigenous construction companies in Northwest Nigeria to ascertain the level of adoption and efficiency of the techniques in use. The study found that the adoption of project planning techniques in the study area was low.

The preceding reviews have chronicled extant literature on construction project planning tools and techniques in country contexts. However, it is pertinent to note that regarding the offshore studies, the emphasis has mostly been on the usage of planning tools or techniques with little emphasis on their impact on project performance. Similarly, most of the studies in Nigeria have been based on the usage of one or two planning techniques with limited coverage of their impact on project cost, time and quality. This study was undertaken to bridge the knowledge gaps in construction project planning techniques in the literature. This study investigated the level of usage of planning techniques and their impacts on cost and time performances of construction projects in Nigeria. The planning techniques investigated are Gantt/bar chart, linked bar chart, line of balance, critical path method and project evaluation and review technique. These planning techniques have been reported in the literature to be the dominant techniques used in Nigeria.

3 Research Methodology

This study assessed construction project planning in the Nigerian construction industry, which is reported to be under-researched. The study was conducted in Lagos State, Nigeria, because it is the commercial nerve centre and its former capital. Moreover, about 70% of construction firms in Nigeria have their offices in Lagos (NIOB, 2005). The objectives of this study are to assess the usage of planning techniques and their impact on the cost and time performances of construction projects in the study area. Cost and time performances were selected because they have been reported to be the measurable indicators of project success (Xiao and Proverbs, 2003). The population for this study comprised all the 159 medium and large contracting companies registered with the Public Procurement Agency of Lagos State (PPA, 2018). These categories of companies were deemed to take project planning more seriously than the small-scale companies. A sample size of 110 contracting firms representing 69.2% of the population was randomly selected for this study. From the 120 copies of questionnaires administered, 98 were retrieved, while 44 (representing 36.7%) were completed correctly and used for analysis. Data collected on respondents' profiles were analysed using frequency counts and percentage, the data on usage of planning techniques were analysed using mean score, while data on the impact of planning techniques on the project performance were analysed using percentage cost and time overruns or savings.

4 Findings and Discussion

4.1 Response Rate

The response rate (36.7%) for this study is considered adequate going by the norm in construction management researches (Takim *et al.*, 2004). Chinowsky and Meredith (2000) reported a 26.5% response rate, while Tam (2007) reported a response rate of 31.2%, indicating that these study outcomes can be used to generalise the study population concerning the usage and impacts of planning techniques on project performance.

4.2 Respondents' Profile

Before presenting the results of the data analysis based on the study objectives, it is necessary to report the respondents' characteristics. Table 1 indicates that 90.9% and 88.6% of the respondents possessed requisite academic and professional qualifications, respectively. Similarly, regarding industry experience, none of the respondents has worked less than seven years. The Table also shows that none of the respondents has handled less than nine projects using planning tools. Thus, the respondents possess sufficient qualifications and experience to provide reliable information upon which valid inferences from this study can be drawn.

Table 1. General Information on Respondents

Category	Frequency	% of Total	Cumulative %
Academic Qualification			
HND	11	25.00	25.00
B.Sc.	20	45.45	70.45
M.Sc.	9	20.45	90.91

PhD.	0	0.00	90.91
Others	4	9.09	100.00
Total	**44**	**100.00**	
Professional Qualification			
MNIQS	23	52.27	52.27
MNIA	9	20.46	72.73
MNSE	4		81.82
Probationer	3	6.82	88.64
Others	5	11.36	100.00
Total	**44**	**100.00**	
Work Experience			
0-5	8	18.18	18.18
5-10	25	56.82	75.00
10-15	6	13.64	88.64
15-20	3	6.82	95.45
>20	0	0.00	95.45
Unspecified	2	4.55	100.00
Total	**44**	**100.00**	
Projects Handled			
1-5	8	18.18	18.18
6-10	21	47.73	65.91
11-15	7	15.91	81.82
16-20	2	4.55	86.36
>20	1	2.27	88.64
Unspecified	5	11.36	100.00
Total	**44**	**100.00**	

Mean = 7 years (Experience) Mean = 9 (Project Handled)

4.3 Usage of Planning Techniques

Data analysis show that Gantt/bar chart with a mean score (MS) of 2.84 is the lead planning technique (Table 2) used in Nigeria. It is closely followed by PERT (MS=2.65) and CPM (MS=2.61), in that order. The least used planning technique is LOB (MS=1.34) followed by LBC (MS=1.74). Overall, BC, PERT, and CPM usage in the study area is high on a Likert-like scale of zero to 4. Similarly, the usage of LBC is low, while the usage of LOB is very low.

Table 2. Usage of Planning Techniques

Planning Techniques	N	TWV	MS	R
Gantt chart/Bar chart	43	122.00	2.84	1
Programme Evaluation and Review Technique	43	114.00	2.65	2
Critical Path Method	43	112.00	2.61	3
Linked Bar chart	42	73.00	1.74	4
Line of Balance	41	55.00	1.34	5

Key: N = Frequency of Responses, TWV = Total Weighted Value, MS = Mean Score, R = Rank

The findings of this study on the usage of planning techniques totally align with Agumba and Festers (2011) and Ahmad and Namala (2015). Agumba and Fester (2011) reported that Gantt/bar chart was the planning technique mostly used in Ghana. Similarly, Ahmad and Namala (2015) concluded that bar chart and networks were mostly used in Nigeria. The findings, however, agree in part with Deacon and Van der Linger (2015), who reported that critical paths were mostly used in South African. Overall, Table 2 shows that the usage of GC, PERT and CPM is high, respectively. This finding does not align with Ahmad and Namala (2015) and Inuwa *et al.* (2014), Al Nesseri (2015) and Umar (2016). Inuwa *et al.* (2014) affirmed that there was inadequate experience and application by Nigerian indigenous contractors of project planning techniques. This study, however, reveals otherwise – that the usage of planning techniques is high on average.

Moreover, Ahmad and Namala (2015) found that few Nigerian contractors use planning tools, contrary to the finding of this study that the usage of planning techniques is high overall. However, a case can be made for the high usage of planning techniques by medium and large scale contractors in Nigeria. The scope of that study probably included small scale contractors who may not pay much premium on project planning. In Al Nesseri (2015) case, the claim that there was inadequate understanding and application of project planning and scheduling in construction projects in Sweden is also not in agreement with the outcome of this study. This study shows a high level of usage of planning techniques in Nigeria contrasts with that study. However, this explanation should not be overemphasised because of the development industry's deferring levels in the two countries.

Generally, the usage of planning techniques in Nigeria seems to be on the increase going by the outcome of this study. This is because their high usage suggests that more competent personnel are now being engaged by Nigerian indigenous contractors contrary to the status quo about a decade ago Olateju *et al.* (2011) and Inuwa *et al.* (, 2014).

4.4 Cost and Time Performance of Planning Techniques

The impact of the usage of planning techniques on project performance is presented in Table 3. The Table presents summaries of appendices 1 to 4 attached to this study, which are percentage time and cost overruns of projects executed using the techniques. They are the archival time and cost data collected on the second objective of this study. Ojo (2009) described project performance as the measurement of achievement against intention. Alqahtani *et al.* (2015) identified cost, time, and quality as the veritable indicators used to measure project performance in the construction industry. Moreover, Atkinson (1999) affirmed that cost, time and quality are the iron triangle of project performance. However, cost and time were used to evaluate project performance in this study because of its ease of collecting data (Xiao and Proverbs, 2003).

Table 3. Time and Cost Performances of Planning Techniques

Planning Techniques	N	Time Performance	Cost Performance
		Mean (%)	Mean (%)
Critical path method	10	10.58	16.03
Programme Evaluation and Review Technique	8	17.61	12.93
Linked Bar chart	8	21.78	14.19
Gantt/Bar chart	16	29.11	16.63
Mean		19.77	14.95

Sixteen time and cost data were collected on projects executed using BC, eight on LBC, ten on CPM, and eight on PERT.If other factors are held constant, the Table shows that CPM is the most efficient technique for planning the duration of construction projects in the study area with an average time overrun (TO) of 10.58%. It is followed by PERT (TO=17.61%) and LBC (TO=21.78%). Gantt/bar chart is the least efficient technique on project duration in the study area. Similarly, PERT outperformed the others in terms of cost with an average cost overrun (CO) of 12.93%. It is followed by LBC (CO=14.19%) and CPM (CO=16.03%).

Moreover, BC performed least on projects cost in the study area with an average cost overrun of 16.63%. Generally, the above performances of the planning techniques investigated can be within acceptable limits compared with previous studies on project time and cost performances. However, the findings of this study align in part with Agumba and Fester (2011) and Deacon and Van der Linger (2015). Agumba and Fester (2011) reported that bar chart and networks are efficient planning techniques for managing time in Ghana. Similarly, Deacon and Vander Linger (2015) also found that CPM was time and cost-efficient in South Africa.

The findings from this study that CPM outperformed the others is not surprising. This is because CPM establishes a project's critical activities, which give the shortest duration of a project. Similarly, the shortest duration will invariably lead to an increase in the cost of a project. Adebowale and Oluboyede (2011) concluded that time reduction increases building cost. This means that as project duration decreases, project cost increases and vice versa, all other things being equal.

5 Conclusion and Recommendations

This study evaluated the planning techniques impacting construction project performance in Nigeria. Five planning techniques reported by extant literature to be mostly used in the study area were investigated. The techniques and their project cost and time performances were investigated using medium and large scale contractors registered with the agency in charge of procurement in the study area. Overall, the study concludes that the usage of construction planning techniques is low in the study area, although their time and cost performances appear fair. Moreover, the usage is limited to simple techniques. It is recommended that more sophisticated planning techniques should be used in the study area for enhanced project cost and time performance.

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Trench excavation health and safety in South African construction

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Abstract:
Construction work is hazardous by nature, and trench excavation collapses contribute to the disproportionate number of fatalities and injuries in construction. A quantitative study was conducted in South Africa to produce a framework of interventions to enhance excavation health and safety (H&S) and mitigate excavation related injuries and fatalities. A self-administered questionnaire was circulated among a sample stratum comprising construction supervisors, H&S Officers, design engineers, and construction managers. The salient findings include: a range of factors that contribute to excavation incidents; excavation hazard identification and risk assessment (HIRA) is important relative to a range of excavation-related hazards; a range of key excavation aspects are not addressed between a near major to major/major extent, and trench collapses impact primarily in the form of fatalities and other injuries, but also impact on performance relative to the other performance parameters. Conclusions include: a cocktail of interventions are necessary to mitigate excavation incidents; there is a need for enhanced supervision during excavations and enhanced excavation H&S knowledge and training; excavation H&S inspections are not effective, and trench collapses have a major as opposed to a minor impact. Recommendations include: an appropriate excavation H&S qualification and training should be developed and registered in terms of the National Qualifications Framework Act, 2000; employer associations should raise the level of awareness concerning excavation H&S; excavation H&S inspections must be comprehensive, and contractors should conduct detailed cost-benefit, and cost of accidents analyses relative to excavations.

Keywords: Construction, Excavation, Health and Safety, Trenches

1 Introduction

Historically, trench collapses have featured in the South African media. Three workers were buried in a five-metre-deep trench collapse near Klein Brak River, near Mossel Bay in the Western Cape Province in March 2005, and four out of the total six workers caught in a six-metre-deep trench collapse in Randburg, Gauteng province, lost their lives in May 2005 (Myer, 2005). Three workers were critically injured after a four-metre-high wall of sand collapsed on them pinning them against a concrete pipe in Mount Moriah, Kwazulu-Natal province in August 2015. The collapse was attributed to heavy rains experienced (Phoenix Tabloid, 2015). A worker was killed, and another injured after a trench they were working in collapsed in Knysna, Western Cape province in March 2016 (Singh, 2016). One of four municipal contract workers repairing a burst pipe, near the outskirts of Despatch, Eastern Cape province, in July 2019, died when one of the pipes they were working on burst filling the excavation with water

(Wilson, 2019). Excavation cave-ins are a major cause of fatalities within the American construction industry, and the fatality rate for excavation work is 112 % higher than the rate for general construction (Druley, 2018).

The Occupational Safety & Health Administration (OSHA) (2015) states that regardless of how many trenching, shoring, and backfilling projects a contractor has undertaken, it is important to approach each new project with care and preparation. OSHA adds that many on-the-job excavation incidents result from inadequate planning and waiting until after the work starts to correct mistakes relative to shoring or sloping, slows down the operation, adds to the project's cost, and makes a cave-in or other excavation failure more likely.

Given the high number of fatalities and injuries resulting from trench excavation collapses in South Africa, a study was conducted, the aim of which was to produce a framework to enhance excavation H&S, the objectives being to determine the: causes of excavation incidents; importance of excavation HIRA relative to a range of hazards; extent to which aspects are addressed during the inspection of excavations, and impact of excavation incidents.

2 Literature Review

2.1 Health and Safety legislation and standards

The Construction Regulations (Republic of South Africa, 2014) require the following relative to excavations:

- Excavations must be inspected periodically by a competent person, namely daily, prior to commencement of each shift, after every blasting operation, after an unexpected fall of ground, after damage to supports, and after rain;
- All excavation work must be undertaken under the supervision of a competent person;
- Excavation supervisors must evaluate the stability of the ground before excavation work begins;
- Shoring or bracing must be designed and constructed in a manner that renders it strong enough to support the sides of the excavation, and
- Excavations must be protected by a barrier or fence of at least one metre in height, and close to the excavation as possible.

According to the South African Bureau of Standards (SABS) 1200 DB-1989 standard (SABS, 1989), pipe trenches should be excavated in lengths approved by the engineer, to widths that, in each case, provide at least the appropriate side allowance such that half of the base width is on either side of the designated centreline of the pipe. Furthermore, the sides of each trench from the bottom up, must be as nearly vertical as possible for at least the height of the bedding. Clearly, SABS 1200 DB-1989 guides concerning the proper construction techniques that need to be implemented during trench excavation works and complements the South African Construction Regulations in terms of promoting proper shoring and bracing.

The issue of a 'competent person' is often the subject of debate in South Africa, primarily due to the broad definition of a competent person as a "person who has the required knowledge, training, and experience, and where applicable, qualifications specific to the work or task." unless there are appropriate qualifications and training registered in terms of the National Qualifications Framework Act, 2000, in which case such qualifications and training are regarded as the required qualifications and training (Republic of South Africa, 2014).

OSHA (2015) defines a competent person as “an individual, designated by the employer, who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to workers, and who is authorised to take prompt corrective measures to eliminate them.”

2.2 Excavation hazards

According to WorkSafe New Zealand (2016), the categories of excavation-related hazards are: excavation hazards per se; falls and falling objects; hazardous atmosphere in an excavation; manual handling tasks; natural hazards and weather; overhead services; site H&S; underground services, and vibration and hazardous noise. The Occupational Safety & Health Administration (OSHA) (2015) states that cave-ins pose the greatest risk during excavations and are more likely to result in fatalities than other excavation-related incidents. They also mention falling loads, hazardous atmospheres, and hazards from mobile equipment.

The Health & Safety Executive (HSE) (2006) recommends that before commencing excavations, the form of temporary support should be decided upon, and the precautions that are going to be taken against the following should be planned: collapse of the sides; people and vehicles falling into the excavation; materials falling onto people working in the excavation; undermining nearby structures; underground and overhead services, and the inflow of ground and surface water.

2.3 Causes of excavation incidents

According to Plog *et al.* (2006) in Ruttenberg *et al.* (2019) an American study determined the main barriers to preventing trench-related incidents were attitude, lack of training, insufficient enforcement, and perceived costs. Smallwood (2010) conducted a study that required respondents to rate the South African construction industry relative to thirteen excavation H&S aspects. 12 / 13 (92.3%) Aspects achieved mean scores (MSs) $> 2.60 \leq 3.40$, which indicates the rating was between poor to average / average. The lower part of the range featured culture, ranked last, preceded by the design of shoring, education, training, and geotechnical reports. These in turn were preceded by the following which featured in the upper part of the range, namely enforcement of legislation, awareness, technology, pre-planning, access, ‘managing’ existing services, and contractor inspections. Only barricading was rated average to good / good.

2.4 Interventions to prevent excavation incidents

OSHA (2015) states that the competent person responsible for excavations should be capable of classifying soil, inspecting protective systems, designing structural ramps, monitoring water removal equipment, and conducting site inspections. Pre-planning is important for addressing factors such as soil, weather, water, traffic, and utilities. Workers also need a safe means of entering and exiting trenches, and any excavation in which workers face a potential cave-in must be equipped with one of the three protective systems in the form of sloping, shoring, or shielding (Johnson, 2011).

2.5 The impact of trench collapses

The outcome of incidents and accidents is fortuitous. However, statistics indicate that construction fatalities are often attributable to such collapses (Druley, 2018). OSHA (2015) mentions delays, and additional costs.

Within the context of South Africa, should a fatality occur, the incident must be reported to the Occupational Health and Safety Inspectorate, Department of Employment and Labour, and to the South African Police Service, and work in the area where the fatality occurred must cease, and the scene of the fatality must remain undisturbed. Furthermore, accident investigations are a requirement, which require management, supervisory, and worker participation, and contributions (Republic of South Africa, 1993). These requirements have obvious implications in the form of distracted management, supervision, and workers; delays; idle workers; decreased productivity; increased costs, and reduced profitability. However, generally, media coverage of such accidents is common as noted in the ‘Introduction’ above, which in turn may result in a tarnished image and reputational damage of the contractors concerned.

3 Research Methodology

The study was conducted on sewer reticulation projects in the Eastern part of the Eastern Cape Province, South Africa, and the sample stratum consisted of construction managers and supervisors, H&S officers, and design engineers. The study entailed a self-administered questionnaire survey, and the questionnaire consisted of nine questions in the form of eight close-ended questions, and one open-ended question. The eight close-ended questions were Likert scale type questions. 27 Responses were received from 38 potential respondents, which equate to a response rate of 71.1%. The analysis of the data entailed the computation of frequencies, and a measure of central tendency in the form of a mean score (MS), to enable the interpretation of percentage responses to the sub-questions, and to rank the variables.

4 Findings and Discussion

Table 1 indicates the extent to which factors contribute to excavation incidents on construction sites regarding percentage responses to a scale of 1 (minor) to 5 (major), and MSs ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint score of 3.00, which indicates that in general, the respondents perceive that these factors contribute to excavation incidents on construction sites to a major as opposed to a minor extent. However, it is notable that 3 / 10 (30 %) of the MSs are > 4.20 ≤ 5.00, which indicates that the contribution is between a near major to major / major extent - inadequate excavation H&S knowledge, poor H&S culture, and inadequate inspections. Furthermore, 7 / 10 (70 %) of the MSs are > 3.40 ≤ 4.20, indicating that the contribution is to a near major / near major extent. However, it should be noted that 6 / 7 factors are in the upper part of the range, namely > 3.80 ≤ 4.20. The Construction Regulations (Republic of South Africa, 2014) emphasise that contractors must appoint competent site management and ensure that adequate inspections are conducted timeously to prevent trench excavation related fatalities and injuries.

Table 2 indicates the extent to which the respondents agree with statements relating to trench excavation projects regarding percentage responses to a scale of 1 (strongly disagree) to 5 (strongly agree), and MSs ranging between 1.00 and 5.00. The results show that all the MSs are above the midpoint score of 3.00, which indicates that in general, the respondents agree with the statements instead of disagree. However, it is notable that 4 / 6 (66.7%) of the MSs are > 3.40 ≤ 4.20, indicating that the concurrence is between neutral to agree / agree. Notably, the statements relate to deficiencies relative to supervision, H&S competencies, HIRA, and toolbox talks. The literature review confirmed that inadequate H&S competencies, HIRA, and toolbox talks leads to trench excavation fatalities and injuries. 2 / 6 (33.3%) MSs are > 2.60 ≤ 3.40, which indicates that the concurrence is between disagree to neutral / neutral. Notably, the two statements relate to SWPs.

Table 1. The extent to which factors contribute to excavation incidents on construction sites

Factor	Response (%)						MS	Rank
	Un-sure	Minor ………………………..… Major						
		1	2	3	4	5		
Inadequate excavation H&S knowledge	3.7	3.7	0.0	14.8	11.1	66.7	4.48	1
Poor H&S culture	0.0	0.0	7.4	3.7	25.9	63.0	4.44	2
Inadequate inspections	0.0	3.7	11.1	3.7	18.5	63.0	4.26	3
Incompetent site management	0.0	0.0	3.7	18.5	33.3	44.4	4.19	4
Inadequate shoring	7.4	3.7	11.1	14.8	14.8	48.2	4.15	5
Inadequate hazard identification and risk assessments	0.0	7.4	7.4	7.4	18.5	59.3	4.15	6
Inadequate supervision	0.0	3.7	7.4	11.1	29.6	48.2	4.11	7
Lack of safe working procedures	0.0	7.7	3.9	15.4	26.9	46.2	4.00	8
Excavated material piled on the edges of the excavation	0.0	3.7	11.1	11.1	29.6	44.4	4.00	9
Poor organisational culture	0.0	7.4	11.1	18.5	25.9	37.0	3.74	10

Table 2. The extent to which the respondents agree with statements relating to trench excavation projects

Statement	Response (%)						MS
	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Supervision during trench excavation operations is inadequate	0.0	3.7	0.0	18.5	37.0	40.7	4.11
Site management lack excavation and H&S competencies	0.0	0.0	8.0	12.0	44.0	36.0	4.08
Employees are not trained to identify the hazards and risks associated with excavation work	0.0	3.7	7.4	0.0	63.0	25.9	4.00
Excavation and H&S toolbox talks are not effectively communicated to all employees	0.0	7.4	14.8	22.2	29.6	25.9	3.52
Excavation safe work procedures are not developed by competent H&S personnel	0.0	11.1	22.2	18.5	25.9	22.2	3.26
Excavation safe work procedures are not communicated to employees	0.0	11.1	29.6	18.5	14.8	25.9	3.15

Table 3 indicates the importance of excavation HIRAs relative to six hazards in terms of percentage responses to a scale of 1 (not) to 5 (very), and MSs ranging between 1.00 and 5.00. Notably, all the MSs are above the midpoint score of 3.00, which indicates that in general, the respondents perceive that excavation HIRAs are more than important instead of less than important in mitigating the hazards. However, it is notable that 5 / 6 (83.3%) of the MSs are >

4.20 ≤ 5.00, which indicates that excavation HIRAs relative to these hazards is between more than important to very / very important - likely adjacent plant and equipment, existing services, access to / exit from the excavation, type of soil, and excavated material. The literature review confirmed that the type of soil, excavated material piled at the edges of the excavation, and excavation method contribute to a high percentage of trench excavation incidents (OSHA, 2015). Only 1 / 6 (16.7%) MS is > 3.40 ≤ 4.20, which indicates that the importance of excavation HIRA relative to groundwater table is between important to more than important / more than important.

Table 3. The importance of excavation hazard identification and risk assessments

Hazard	Response (%)						MS	Rank
	Un-sure	Not …………………………..…… Very						
		1	2	3	4	5		
Likely adjacent plant and equipment	0.0	0.0	0.0	11.1	18.5	70.3	4.59	1
Existing services	0.0	0.0	7.4	3.7	11.1	77.8	4.59	2
Access to / exit from the excavation	0.0	0.0	7.4	3.7	14.8	74.0	4.56	3
Type of soil	0.0	0.0	3.7	11.1	18.5	66.7	4.48	4
Excavated material	0.0	0.0	7.4	7.4	22.2	63.0	4.41	5
Groundwater table	0.0	3.7	11.1	18.5	7.4	59.3	4.07	6

Table 4 indicates the extent to which aspects are addressed during the inspection of excavations in terms of percentage responses to a scale of 1 (minor) to 5 (major), and MSs ranging between 1.00 and 5.00.

Table 4. The extent to which aspects are addressed during the inspection of excavations

Aspect	Response (%)						MS	Rank
	Un-sure	Minor …………………………..… Major						
		1	2	3	4	5		
Existing underground services	3.7	7.4	11.1	11.1	33.3	33.3	3.85	1
Personal protective equipment	0.0	3.7	11.1	18.5	29.6	37.0	3.85	2
Ground stability	3.7	0.0	18.5	18.5	33.3	25.9	3.78	3
Means of access and exit	0.0	7.4	29.6	3.7	25.9	33.3	3.48	4
Excavated material close to the excavation	0.0	7.4	14.8	29.6	22.2	25.9	3.44	5
Weather conditions	3.7	7.4	18.5	22.2	29.6	18.5	3.44	6
Type of soil	3.9	3.9	26.9	19.2	30.8	15.4	3.38	7
Tightness of the bracing and shoring	7.4	18.5	14.8	18.5	18.5	22.2	3.33	8
Equipment moving or standing close to excavations	3.7	3.7	33.3	14.8	25.9	18.5	3.33	9
Protection of the edges of excavations	3.7	11.1	25.9	14.8	22.2	22.2	3.30	10
Presence of soil cracks	3.7	7.4	33.3	7.4	33.3	14.8	3.26	11

Notably, all the MSs are above the midpoint score of 3.00, which indicates that in general the aspects can be deemed addressed during the inspection of excavations. However, it is notable that 6 / 11 (54.5%) MSs are > 3.40 ≤ 4.20, which indicates that aspects can be deemed to be addressed between some extent to a near major / near major extent - existing underground services, personal protective equipment, and ground stability predominate, followed by means of access and exit, excavated material close to the excavation, and weather conditions. The remaining 5 / 11 (45.5%) MSs are > 2.60 ≤ 3.40, which indicates the aspects can be deemed to be addressed between a near minor extent to some extent / some extent - type of soil, tightness of the bracing and shoring, equipment moving or standing close to excavations, protection of the edges of excavations, and presence of soil cracks. These are notable findings as type of soil, bracing and shoring, equipment moving or standing close to excavations, and presence of soil cracks are key issues relative to excavation H&S, especially the latter, presence of soil cracks, which is a key indicator of a pending collapse, and which is ranked last (OSHA, 2015).

Table 5 indicates the impact of trench collapses in the construction industry in terms of percentage responses to a scale of 1 (minor) to 5 (major), and MSs ranging between 1.00 and 5.00. It is notable that all the MSs are above the midpoint score of 3.00, which indicates that in general, the respondents perceive that trench collapses have a major, as opposed to a minor impact in the construction industry. However, it is notable that all six MSs are > 3.40 ≤ 4.20, which indicates that the impact is between some extent to a near major / near major extent.

Table 5. The impact of trench collapses in the construction industry

Impact	**Response (%)**						**MS**	**Rank**
	Un-sure	**Minor …………………………..… Major**						
		1	**2**	**3**	**4**	**5**		
Fatalities	3.7	7.4	7.4	11.1	25.9	44.4	4.04	1
Injuries other than fatalities	3.7	7.4	7.4	11.1	40.7	29.6	3.89	2
Rework	3.7	7.4	7.4	18.5	29.6	33.3	3.85	3
Cost escalation / overruns	3.7	3.7	11.1	25.9	25.9	29.6	3.78	4
Project delays	3.7	7.4	3.7	29.6	29.6	25.9	3.74	5
Poor productivity	3.7	11.1	7.4	11.1	44.4	22.2	3.70	6

Fatalities is ranked first, followed by injuries other than fatalities, which indicates the human impact. This is followed by the opposite of synergy in the form of the negative impact in terms of rework, financial loss, delays, and poor productivity. According to Othman (2012), accidents can marginalise the project team's efforts at achieving the project deliverables on time and within budget, due to the direct and indirect costs associated with accidents.

5 Conclusions

In terms of the extent to which factors contribute to excavation incidents on construction sites, the findings lead to the conclusion that a cocktail of interventions are necessary to mitigate such incidents, namely both optimum organisation and H&S culture; competent site management and supervision, excavation H&S knowledge, optimum excavation HIRA, adequate shoring, safe working procedures and the following thereof, and the positioning of excavated material away from the edges of excavations. Furthermore, the potential exists to reduce the number of excavation-related fatalities and injuries.

Given the extent to which the respondents agree with statements relating to trench excavation projects, it can be concluded that there is a need for: enhanced supervision during trench excavation operations; enhanced site management excavation H&S knowledge; training of supervisors and workers in terms of excavation HIRA; more effective excavation H&S toolbox talks, and development of SWPs by competent people and the communication and implementation thereof to supervisors and workers.

Given the importance of excavation HIRA relative to a range of excavation-related hazards, it can be concluded that excavation HIRA training, excavation H&S toolbox talks, empowerment of workers in terms of excavation H&S, and constant management and supervision of excavations are critical.

Given the extent to which aspects are addressed during the inspection of excavations, and especially the key aspects, it can be concluded that such inspections are not effective, the knowledge of inspectors is inadequate, and the potential of excavation-related incidents is heightened.

In terms of the impact of trench collapses in the construction industry, it can be concluded that trench collapses have a major as opposed to a minor impact in the construction industry. Furthermore, they impact negatively on the other project parameters in the form of cost, productivity, quality, and time, which constitutes a motivator for investing in and realising optimum excavation H&S.

6 Recommendations

An appropriate excavation H&S qualification and training should be developed and registered in terms of the National Qualifications Framework Act, 2000. Furthermore, the term competent person must be elaborated upon relative to activities such as excavation H&S. A national excavation H&S guideline should be developed by the umbrella employer associations, or the Construction Industry Development Board.

Employer associations should raise the level of awareness concerning excavation H&S, especially the hazards, and appropriate interventions. Excavation H&S-related training in the form of induction, toolbox talks, and excavation HIRA are critical. Furthermore, workers must be empowered through HIRA training to be vigilant and to conduct continuous HIRA while working in excavations.

Excavation H&S inspections must be comprehensive, which implies competent management, and supervision.

Financial provision for excavation H&S, in tandem with H&S in general, should be facilitated in contract documentation, and especially in bills of quantities. Contractors should conduct detailed cost-benefit and cost of accidents analyses relative to excavations, which will enable them to motivate appropriate actions by their staff, and which can serve as case studies.

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Integrating Building Information Modelling (BIM) Tools and Techniques in AEC Organisations: Effect on Culture and Structure

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Abstract:
Building Information Modeling (BIM), like all novel concepts, often changes organisational dynamics. Previous studies have lamented the need for the engagement of BIM actors and change in organisational culture and structure for an effective BIM implementation. However, the degree to which adopting BIM affects Nigerian firms' organisational structure and culture is yet to be ascertained. This study filled this gap in the literature through a quantitative research approach. A structured questionnaire was used to collect data from thirty-five (35) Architectural Engineering and Construction (AEC) firms using a snowballing sampling technique. Data collected was analysed using descriptive statistical methods. The study's findings show that BIM adoption has more effect on the organisational culture than the structure. This gives insight into the resilience of AEC firms in Nigeria at the advent of change in operational mode towards adapting to the modern dynamic and highly competitive market. Considering the aparent limitations of this study, it is recommended that longitudinal research studies should be conducted to gain deeper insight on BIM adoption and its effect on organisational dynamics for a clearer and vivid representation.

Keywords: AEC, BIM, Organisational Culture, Organisational Structure

1 Introduction

For centuries, the construction industry was plagued with traditional methods in managing information for project use. Professionals in the construction industry have had at their disposal only a sheet of paper, ink and a simple abacus for project designs and analysis (Yan & Damian, 2008). Professionals were limited to only information within their respective professional boundary. This traditional method of managing information has had a significant effect on the quality of projects as well as the time and cost performance of projects. As a result, the digitalisation of the built environment through various technological developments has been the recent trend worldwide. This is intended to improve information management in the industry as well as improve project performance. With the advances in technology, Yan and Damian (2008) observed that the design process in the global construction industry had experienced a vigorous and theatrical change. Evolving from the use of 2D paper-based drawings, the advancement in technology has led to the shift of design mediums to 2D Computer-Aided Design (CAD) and 3D digital models on the computer screen, which manifested into the modelling of building-related information (Company et al., 2009). East and Smith (2016) defined the basic premise of BIM as the systematic collaboration between project stakeholders at varying phases of the project life cycle, which enables efficient interaction of project information within the BIM process platform across all project participants.

AIA (2007) defines BIM as "a model-based technology linked with a database of project information." Building Information Modelling is viewed as the latest trend of object-oriented computer-aided design (OOCAD) systems (Azhar et al., 2012; Howard & Björk, 2008). Bryde et al. (2013) view BIM as a construction approach that supports the instant provision of reliable and integrated project design scope, schedule, and cost information. It allows all distinct components of Intelligent building object to coexist in a single 'project database' or 'virtual building space' that captures all relevant details about the building. This is much different from the traditional CAD systems with graphic objects in a two-dimensional CAD file, as objects in a BIM model are intelligible to computer programs as representations of real-world building components (Colombo et al., 2007). A building information model provides a single, logical and consistent source for all information associated with the building (Howell & Batcheler, 2015).

Despite the apparent potential of BIM in the construction industry, the effective adoption of BIM in AEC organisations has been seen to be plagued by challenges regarding the displacement of the well-established traditional working process (Hong et al., 2019; Succar & Kassem, 2015). Although most studies focus mainly on technical-related issues of BIM adoption, recent studies have adopted a socio-technical perspective on the digitalisation of business processes and BIM adoption in AEC organisations (Bosch-Sijtsema et al., 2017; Davies & Harty, 2013). Liao and Ai Lin Teo (2018) noted the significance of organisational change attributes in the vision and mission, management support and processes towards successful BIM adoption in organisations. Therefore, as BIM means technological change and change in management processes, the socio-technology informed concept of BIM management is applied (Ning Gu & London, 2010; Luo et al., 2016). The efficient integration of BIM in AEC organisations prompts the need to change almost all aspects of the business process, which requires a thorough understanding before the implementation and transformation (Eastman et al., 2011).

Based on the forgone, it is evident that the development and implementation of BIM in organisations is a change factor that improves organisations' culture and structure (Hartman and Fischer 2017; Kokkonen & Alin, 2016). Thus, adopting BIM manifests into changes. Change in the work process, change in staffing and project organisation and change in how a firm uses information (Zhou et al., 2012; Garwood et al., 2018). However, the extent to which adopting BIM affects AEC firms' organisational culture and structure in Nigeria is relatively not ascertained. This creates a gap in the Nigerian BIM adoption literature which this paper set out to address.

2 Literature Review

2.1 Organisational Culture

Across the literature in diverse contexts, there are numerous classifications of organisational culture which aid in understanding the complexity of the construct. Notably, Hofstede (2011) identified five cultural dimensions, namely; *Power Distance, Uncertainty Avoidance, Individualism and Collectivism, Masculinity versus Femininity, and Long versus Short-term Orientation*. These dimensions offer insight into varying factors of organisational culture. Collectively, the dimensions highlight the divergent traits that instigate diversity in individual and organisational dynamics. Schein (1985) developed a three-level cognitive model that defines organisational culture. The *artefacts* definition of culture focuses on the visible attributes of organisational behaviour that include but not limited to amenities, dress code, work schedule. This differs from the view of culture as a *basic underlying assumption*, with elements that are not visible and mostly unstated such as the rule of thumb, unspoken rules and code of conduct that organisations often adopt. Whereas, from an *espoused value* perspective, culture includes the expression of the organisational vision and mission, and the functioning belief across the organisation.

Overall, organisational culture could be seen to relate to the unique way business organisations conduct business operations, which largely manifests into an overall success or failure of the business (Dartey-Baah, 2013). Culture is central in managing the current global workforce dynamics. According to (Willcoxson & Millett, 2000), cultures are history-based, evolving over time as organisations develop patterns of behaviour and belief that enable effective operations in dynamic business contexts. A change in business operation or circumstance often results in the development of new patterns of behaviour intertwined into existing beliefs and assumptions (Trice & Beyer, 1993).

Hofstede (1998) viewed culture as socially transmitted behaviour patterns, norms, beliefs and values of a given community or organisation that gives it a unique identity. However, Schein (1985) observed that culture is the most difficult organisational element to change, making it very difficult to understand the change fully. Regardless, businesses organisations in the modern global environment face the continuous need to be dynamic to maintain sustainable market relevance and competitive advantage. Certainly, organisational culture plays a significant role in achieving high levels of organisational effectiveness (Waterman & Peters, 1982).

2.2 Organisational Structure

The literature on organisational structure is almost unanimous on the notion that structuring and configuration in business organisations are often dynamic, with a flux relationship between underlying mechanisms (Mintzberg, 1980; Salaman, 1978). Organisational structuring involves the classification of organisational labour into a number of distinct tasks, coupled with a clear definition of how the conduct of the tasks will be coordinated to achieve the organisational objectives (Mintzberg, 1980). Across the breadth of this definition are also the various mechanisms that organisations use in the design of respective structures, which often are the fundamental elements of business organisations. These mechanisms include *job specialisation, behaviour formalisation, training and indoctrination, unit grouping, unit size, planning and control systems, and the liaison devices.* Mintzberg (1980) argued that organisations usually adopt a plausibly unchanging clustering of its elements as it strives for continuous synergy in its internal processes. However, as several internally and externally induced factors define the contemporary workplace, organisations must inevitably be driven to adopt changes in respective structures as they adapt to changing dynamics, evolving from one structure to another.

3 Research Methodology

This paper set out to assess the potential effect of BIM adoption on organisational structure and organisational culture in Architectural, Engineering and Construction firms in Nigeria. The aim of the study was achieved using a quantitative research approach. A structured questionnaire was designed, which was classified into three sections. Section 1 assessed the level of BIM adoption across AEC firms. Section 2 elicited data on the effect of adopting BIM tools and techniques on the existing organisational culture, while section 3 elicited data on the effect of the adoption on the existing organisational structure. Due to the lack of a standardised database for AEC firms using BIM tools and techniques in Nigeria, a snowballing sampling technique was adopted for the study, which resulted in a total study population of 35 AEC firms. All 35 firms fully contributed to the study, with top executive officers of respective firms serving as independent respondents. Data collected were analysed using descriptive statistical techniques that include mean tables and graphical charts.

4 Findings and Discussion

4.1 BIM adoption and performance

Table 1 shows for how long the respective firms have been adopting BIM in their organisation. Considering the low level of awareness on the concept and benefits of BIM in the Nigerian construction industry, as noted by Babatunde, Ekundayo and Adekunle (2019). The majority of the firms, which represents 57.1%, reported adopting BIM for a period between 5-9 years. Firms with a period between 2-4 years represent 20% of the population. In comparison, 14.3% of the firms have been adopting BIM for 10 years or above. Only 8.6% of the studied population started adopting BIM recently within 1-2 years.

Table 1. Years of BIM Adoption

Years	Frequency	Percentage (%)
1-2 years	03	8.6
2-4 years	07	20.0
5-9 years	20	57.1
10years and above	05	14.3
Total	35	100

More so, a Likert scale of 1-5 (1 = Least influence and 5 = Most influence) was presented to the respondents to rate the influence of adopting BIM on delivery performance in their respective organisations. Table 2 shows a significant influence of BIM adoption on accuracy and precision of design and improvement in time and cost performance. The organisations also noted a relative improvement in response to queries. Since its emergence, AEC industry has highlighted BIM as a solution to the pattern of problems and issues of developed countries' construction industries (Gu & London, 2010). Love and Smith (2013) also found a positive influence of BIM on project delivery performance which is not farfetched from the findings of this study.

Table 2: Influence of BIM on Delivery Performance

Measures	Mean	Std. dev.
Accuracy and precision in design/analysis	4.3	0.488
Improvement in cost performance	4.3	0.568
Improvement in time performance	4.2	0.333
Quick response to queries	3.7	0.343

4.2 Effect of BIM on Organizational Culture and Structure

There are different theoretical views on changing or managing organisational culture, which suggest that the culture change process is complex (Pfister, 2009). Arnold et al. (2005) noted the fundamental function of organisational culture as providing a sense of meaning to organisational life by defining how business processes are executed. In this regard, nominal data was collected regarding the change in organisational culture due to BIM adoption in respective firms. A large percentage of the firms reported changing their steering document and creating working templates with 69% and 66% respectively to accommodate BIM implementation. Whereas 57% of the firms noted no significant change in working hours, and only 51% reported ease in getting design/analysis approval. Figure 1 gives a graphical representation of the findings. This finding complements the view of Burgess and Harrison (1998) that organisations undertake conscious culture change only when it is necessary to do so. Cacciattolo (2015) observed that changing organisational culture similar to what is seen from these organisations is usually overwhelming as it often involves the establishment of new systems, rules and procedures to accommodate the changes in business processes.

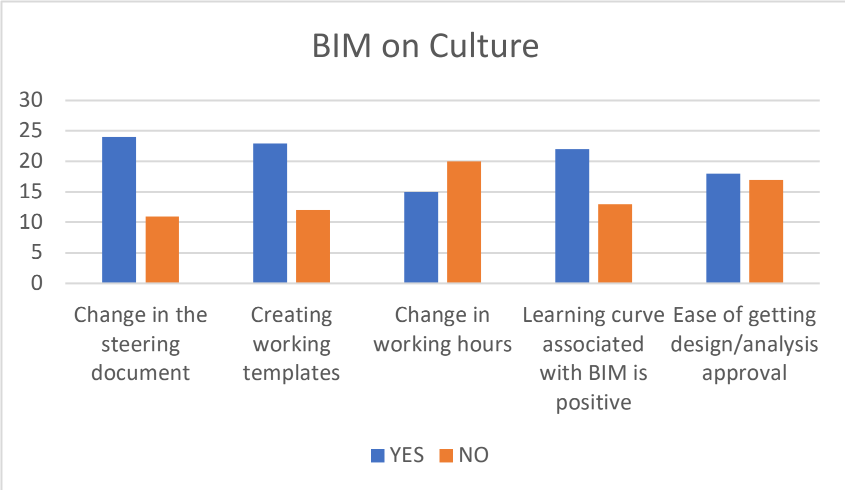

Figure 1: BIM on Culture

Despite the change in the cultural dimensions of the firms, there was no complementing change in the structure of respective organisations. Mintzberg (1980) viewed organisational structure as a set of methods for dividing the task in determining duties and coordinating them. Organisational structure is the framework of the relations between various units of an organisation (people and process) to achieve organisational goals (Lunenburg, 2012). Many firms (80%) reported not establishing an Information Technology (IT) department to manage IT infrastructure for BIM adoption. Furthermore, 63% reported not engaging BIM coordinators to handle the adoption process, while only 29% reported having labour turnover due to BIM adoption in their respective firms. However, only 57% had a change in the medium and channel of communication within and outside the firm, while 60% changed role description. Figure 2 presents the findings with regards to the effect of BIM on organisational structure in this study.

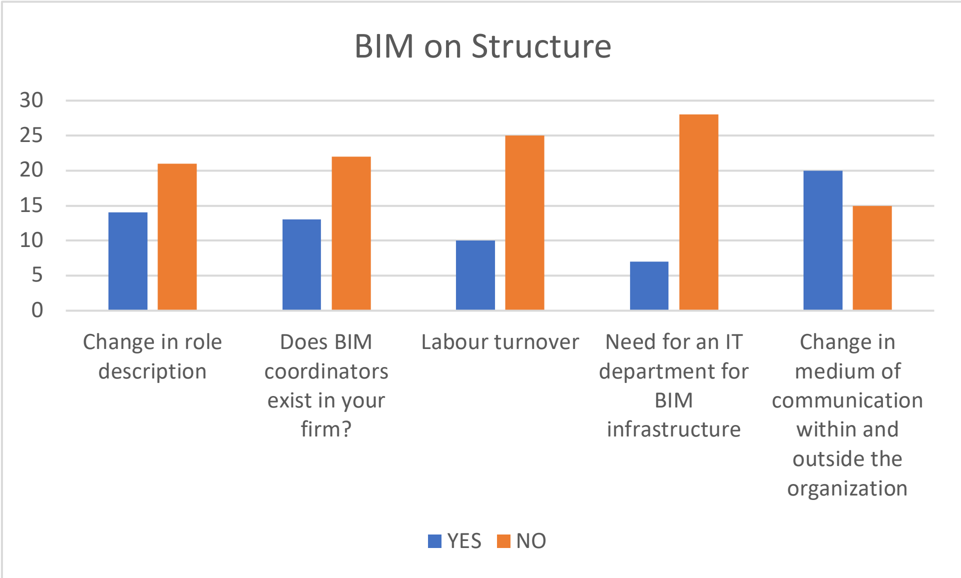

Figure 2: BIM on Structure

5 Discussion

Overall, this study's findings highlight the resilience of business organisations with a specific focus on AEC firms at the advent of changes in business processes. The dynamic nature of the modern construction business environment and the apparent need to adopt trending technologies for improved performance means AEC firms in Nigeria are pushed to evolve to adapt to changes in the global industry. Although the adoption of BIM tools and techniques is still slow in the country, as evident in the data earlier presented, with most of the firms integrating the technologies in their respective business operations over the last decade, there have been signs of improvement in the performance of the firms. There is evidence of improvement in design precision and accuracy, coupled with timely and costly delivery of projects, which undoubtedly sets the precedence for improved efficiency and effectiveness of the industry.

Relatedly, in dealing with the need to meet industry demands and adopting BIM tools and techniques, AEC firms in Nigeria often experience a change in the *operational mode* of business processes, which is a manifestation of change in organisational Behaviour. As BIM tools and techniques are designed to make AEC operations easier and more efficient, it becomes apparent that these tools and techniques will require a change in existing organisational norms to exploit the benefits that come with its integration fully. Although it is widely argued that organisational norms and principles is a manifestation of the underlying configurational mechanism across the organisation, it is seen that adopting BIM and a change in organisational culture does not necessarily result in a change in the organisational structure or configuration. However, it might be due to the level of BIM adoption across the study population, with most firms in their early years of adoption. It could be inferred that culture change is more rapid than a change in structure in AEC organisations as changing culture requires less bureaucratic processes.

6 Conclusion and Further Research

Although the adoption level of BIM in the Nigerian construction industry is relatively low compared to that of developed countries, a few firms have recognised the benefits attached to it and have started adopting the concept. This study assessed the effect of adopting the BIM concept and using BIM tools on organisational culture and structure in respective Nigerian firms. The study found a change in the organisational culture of most firms due to BIM adoption. However, there were no significant changes as it relates to the structure of the firms. As such, it could be concluded that BIM adoption has more effect on organisational culture than structure. However, it is imperative to note that change is gradual and takes time. Considering the period over which the firms have been adopting the concept, it can be deduced that the adoption phase is still ongoing, and therefore the effect might be minimal. Therefore, it is recommended that further longitudinal studies should be carried out to assess the level of BIM adoption and its effect on organisations for a clearer and vivid representation.

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Employee wellbeing factors for improving occupational health and safety performance by small-scale electrical contractors in Zambia

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Abstract:

Small-scale electrical contractors are subjected to a plethora of occupational demands that negatively affect social, psychological, and physical wellbeing, with an adversative influence on employees' and firms' performance. Employee wellbeing is perceived to improve occupational health and safety (OH&S) in various construction projects. However, the literature indicates that limited studies have developed employee wellbeing factors for small-scale electrical contractors that can be used to improve OH&S in Zambia. Therefore, the study sought to assess the factors influencing employee wellbeing for small-scale electrical contractors in Zambia. The study adopted a qualitative research methodology to assess the factors that influence employee wellbeing by using a Delphi study in which 11 experts from the industry were engaged to come up with consensus. Findings indicate that there are twelve employee wellbeing factors essential for OH&S performance. The most highly influential factors are employee work conditions, work relationships, workplace stress management, social support systems, occupational health care, integrating wellness programs with OH&S management. The study recommends that the developed factors for employee wellbeing be adopted to effectively improve OH&S performance management in the Zambian electricity industry, reducing accidents, injuries, diseases, and fatalities.

Keywords: Employee wellbeing, factors, occupational health and safety, small-scale electrical contractors, Zambia

Introduction

The need to promote employee wellbeing and improve occupational health and safety (OH&S) performance at projects is a growing area of research and is critical in reducing the number of accidents, injuries, fatalities, diseases, and damage to property (Manu, 2020). However, the current state of employee wellbeing at projects shows a high risk of contracting diseases, fatalities and injuries (Mwanaumo & Mambwe, 2019). The wellbeing of employees has become one of the socio-determinants of health and if it lacks in employees, it results in harmful lifestyles that affect OH&S performance at workplaces (Downward, et al., 2020). However, Mustapha et al. (2016) and Ofori and Toor (2012) point out that the most affected of the employees with poor health and wellbeing are those employed under small scale contractors (SSCs) who are the bulk of contractors in any industry providing operative flexibility.

In the recent years, employee wellbeing was endorsed to be one of the measures that cross-cuts improving health of employees by the Healthy People 2020 whose goals were to prevent injuries, accidents, diseases, promoting health and improving the quality of life of employees (Kobau, et al., 2013). Also, the 3rd Sustainable Development Goal (SDG 3) on Health and Wellbeing infers that promoting safe and secure working conditions for all employees leads to improved OH&S performance by preventing and controlling certain diseases such as cancer and respiratory diseases project (2019). In addition, an increase in health by employees through the integration of OH&S interventions in employee-centred health care helps in achieving the SDG 3 (United Nations, 2019). When employee wellbeing is promoted, it prevents stress, creates positive and thriving working environments and encourages employee engagement and OH&S performance (CIPD, 2020). At a global level, employee wellbeing has been highly affected especially with regards to employees working with SSCs. The International Labour Organisation (ILO) (2019;1992) noted that most of the SSCs contribute to the strain on employee wellbeing as they fail to provide minimum and acceptable work conditions for the employees.

However, Zambia's wellbeing issues have not been significantly tabled concerning improving OH&S performance at projects, even though employee wellbeing has been brought globally as an important factor in reducing accidents, injuries, and disease (Mwanaumo & Mambwe, 2019). In Zambia, the high rate of accidents at projects, poor wages and salaries for employees, lack of access to proper health care, poor resource levelling, lack of qualified manpower, stressed employee, and burn-out affect the wellbeing of employees in small-scale contracting firms (Mambwe, et al., 2020). According to the International Labour Organisation (ILO) (2021), Mwanaumo et al. (2021) and the National Council for Construction (NCC) (2020), SSCs are plagued with lack of financial resources, staff shortages and competency of employees, including limited awareness of OH&S procedures, lack of equipment to effectively do work, and lack of access to medical care. These negatively affect employee wellbeing and increases physical, mental and social stress on employees. Thus, it is essential that employee wellbeing is integrated in the management and improvement of OH&S performance at all levels of construction in the electricity industry in Zambia.

Poorly rated employee wellbeing and low OH&S performance levels in SSCs are attributed to a failure of recognising the wellbeing factors that improve OH&S performance management that SSCs can use. Adopting employee wellbeing factors by SSCs in improving OH&S performance was significant as a measure; hence, the need to identify factors of employee wellbeing as measures to improve of OH&S performance in the Zambian electrical contractors' context. The purpose of the study was to assess the factors influencing employee wellbeing for small-scale electrical contractors in Zambia. An overview of the literature on the topic of discussion and the adopted methodology are presented. Findings and discussion, and finally the conclusion drawn from the study and recommendations are also shown.

Employee Wellbeing, Occupational Health and Safety and Small-scale Contractors

Various literature describes employee wellbeing differently, attributing to industry and the health context. However, there is no consensus around a single definition of wellbeing. Sniezek et al. (2010) relates wellbeing to include social, mental and physical aspects of a person with provision of quality support systems from family, friends, and workplaces; positive and negative balance of life, optimism, satisfaction, personal growth; and the feeling of being healthy, having vitality and energy. On the contrary, Yaldiz, et al. (2018) and Rongen et al.

(2014) argued that any offering that strives to ensure that employees are safeguarded from physical harm or lower health risk factors, is significant to reach employee wellbeing. This study describes wellbeing, according to Diener et al. (2017), as being psychological and can be subjective, relating to how individuals assess their lives as being good and desirable, or undesirable and negative.

Further, several theories expound employee wellbeing such as Affective Events Theory of 1996 by Weiss and Cropanzano that relates job satisfaction as significant in the emotions, behaviour, attitudes of employees. The theory further states that stress, emotions, frustrations, anger, sadness influence wellbeing at the same time, affecting commitment, job satisfaction and psychological wellbeing. The work demand or stress theory developed by Demerouti et al. (2001) and Karasek (1979) is central to the theoretical approach for this study due to the role it plays on individual with regards to social, financial and personal resources to alleviate the enervating effects of work stressors affecting employee wellbeing. Arguably, Bartholomew et al. (2014) posit that workload and work stress cause poor work outcomes for employees and cross-cuts most wellbeing indicators.

2.1 Factors Leading to Poor Employee Wellbeing

Employee wellbeing is internally and emotionally affected by mental triggers that lead to poor focus, reduced quality of work and sleep, poor co-worker and management interaction, severe health issues, stress by employees. Hence, if not well managed, these aspects can increase the chances of accidents, injuries, diseases, and fatalities, and thus relates well with the need to protect employees at electrical construction projects (Stephenson, 2019). Therefore, since construction projects focus highly on safety issues, the forgoing entails adopting wellbeing as part of improving OH&S at electrical construction projects. According to Mwanaumo et el. (2021), poor employee wellbeing increases the cost on individuals and organisations. Some of the factors they highlighted that cause poor employee wellbeing included long working hours, workloads and volume of work, poor management style, non-work factors such as family and society, job insecurity, and skill variety.

On the contrary, demands at a workplace negatively affect the wellbeing of employees, such as time pressure, how difficult the work is, and empathy, increase stress levels of an employee, affects the mental wellbeing and strains the employees' physical wellbeing (Jennings, 2021; CIPD, 2020; Downward, et al., 2020). There is a strong evidence that increased job demands, poor employee support, working with tight deadlines, working on complex tasks, poor salaries and wages, lack of social support systems at work places, affect the wellbeing of employees especially those employed with SSCs, as indicated by Dolye (2017). Additionally, it was forwarded by Sharratt (2017) that SSCs, most of the time prioritise profits over employee wellbeing. These factors in SSCs firms are attributed to a lack of knowledge of the factors that promote employee wellbeing to positively affect OH&S performance on projects.

2.2 Factors for Employee Wellbeing for Electrical-Construction Employees

Several advances on the factors of employee wellbeing that improve OH&S performance at projects are highly embedded in literature directly related to reducing accident, injuries, and fatalities. When employee wellbeing is applied as one of the constructs of OH&S performance, it should be able to balance the outcomes of economic and social indicators (Diener, et al., 2017). The HSE (2020) forwarded that employee wellbeing as a core factor can be measured by demand (the amount of work, work designs), how work is done, resource support, encouragement, supervision, co-workers, relationships, reduced conflict, understanding roles in the firm, reduced conflict of role, communication, and managing change. However, Arnold and Randall (2016) and Seligman (2011) as employee wellbeing factors include job content, workload, working hours, emotional labour, integrity and fairness, work-life balance (time, strain, and behaviour) control, job support and resources (resources support from colleagues), job role, overtime, and organisational change. Leka and Jain (2013) added that counselling, flexible work, balanced work-life policy, training, job rotation, job matching, and employee assistance programs are vital factors in improving employee wellbeing.

De Silva and Wilmalaratne (2012) in the wellness framework included wellness programs and physical arrangement of work, while Jeebhay and Jacobs (1999) and Kinnunen-Amoroso (2016) posit factors of employee wellbeing as aligning and integrating wellness programs to the strategy of the organisation, sharing responsibilities and accountabilities by the contractor and the client, planning all OH&S activities including wellness programs at the project design stage; procedures and rules to comply with OH&S, and reward and incentives for best wellness programs. Jennings (2021) also forwarded that managing stress and mental health for employees are important, while Dodge et al. (2012) proposed job security and physical arrangement of equipment and the environment. The study adopted seventeen factors from the literature review for further analysis are highlighted in Table 1.

Table 1. Summary of the Factors for Employee Wellbeing from Literature

Driver	Factors	Sources
Employee Wellbeing	Employee work conditions	(HSE) (2020); Diener, et al. (2017)
	Mental Health employees	Jennings (2021); CIPD (2020); Downward, et al. (2020); Keyes (2007)
	Counselling	Leka and Jain (2013)
	Work Relationships	HSE (2020); Seligman (2011)
	Work-life balance	Arnold and Randall (2016); Leka and Jain (2013); Seligman (2011)
	Job security	Dodge et al. (2012); Cooper (2010)
	Workplace stress management	Kinnunen-Amoroso (2016); Leka and Jain (2013)
	Social support systems	Doyle (2017); Sniezek et al. (2010)
	Human resource leveling	Mwanaumo and Mambwe (2019)
	Aligning health with organisational objectives	Jeebhay and Jacobs (1999)
	Integrity and fairness at workplace	Arnold are Randall (2016) and author
	Occupational health care	WHO (2017)
	Welfare provision for employees	Chisumbe and Mwanaumo (2016); Mambwe et al. (2020)
	Physical arrangement of work area	Jeebhay and Jacobs (1999)
	Developed communication channels	HSE (2018), Mwanaumo and Mambwe (2019)
	Integrating wellness programs with OH&S management	De Silva and Wilmalaratne (2012); Jeebhay and Jacobs (1999); Kinnunen-Amoroso (2016)
	Management of overtime and working hours	Arnold and Randall (2016) and Seligman (2011)

Research Methodology

The study assessed employee wellbeing factors that influence and improve OH&S performance for small-scale electrical contractors in Zambia. The study adopted a qualitative approach in which the Delphi study was adopted to collect data by engaging a panel of experts in the field who were asked questions in two different rounds to attain consensus. The Delphi approach was adopted because of its predictive consultative structural qualitative technique, that is intuitive and subjective in nature (Alomari, et al., 2018). The technique was also used as it provides anonymity that reduces the influence of pressure in answering questions in a structured iterative manner, giving essential feedback to the researcher, according to Yousuf (2007). The approach was used because of limited previous research that use the Delphi in assessing the factors influencing employee wellbeing for small-scale contractors in the electricity industry in Zambia. Hence, a set of questions were developed in form of a Delphi questionnaire and grouped into themes based on the factors attained from literature.

The Zambian experts were composed of electrical engineers, construction engineers, public health experts, medical doctors, health and safety experts and wellness experts, practising in the electricity industry. A total number of 11 experts were engaged to take part in the survey. According to Skulmosky et al. (2007), the number of experts adopted for the study was sufficient. The selection of the experts was purposively carried out and a set criterion for selection was set at a cut-off of 50% to be included in the survey (Aigbavboa, 2013). The criteria for selection included professional membership, at least five years' experience in the electricity industry, faculty member, involved in policy formulation, high education background. This is according to Hardison et al. (2014). The 17 factors from literature were used to develop the Delphi questionnaire, which allowed experts to make comments in the second round.

Two iterations of the Delphi survey were carried out using a structured Delphi questionnaire with a 10-point Likert scale of influence that was based on the statistical scale of agreement. The influence scale was 1-2 = strongly disagree, 3-4 = disagree, 5-6 = neutral, 7-8 = agree and 9-10 = strongly agree, to attain the study objectives. The results were analysed using Statistical Package for Social Sciences (SPSS) software. Hence, the second-round questionnaire indicated the group medians of the categorised indicators under key elements. Analysis was done using group median, mean, and interquartile deviation (IQD) between 0 and 1 (Ameyaw & Chan, 2015). Experts were updated with the feedback from each iteration results and could re-rate the indicators. To attain consensus, 60% was used as a cut-off for acceptability of a statement. This means that common consent was achieved on each question with at least 60% agreement by experts (Ameyaw & Chan, 2015).

Findings and Discussion

4.1 Background Information

From the 11 experts only five (5) have had an academic experience while all experts have worked more than five years in the industry with the lowest working for six years and the highest with 27 years of experience. The minimum level of education for the experts was a bachelor degree with the highest being Doctorate level. All the experts had professional membership, and were involved in OH&S activities. The 11 experts responded giving a 100% response rate; otherwise, any reduction to less than 70% would have compromised the validity of the results (Skulmoski, et al., 2007). The Cronbach alpha test was conducted for reliability and validity of the questionnaire and was found to be 0.815. According to Taber (2018), the acceptable Cronbach alpha value should range between 0.70 to 0.95 and indicates a strong interrelatedness.

4.2 Employee Wellbeing Factors

Two Delphi rounds were conducted and the results are presented as follows:

4.2.1 First Round of the Delph Study

The results in Table 2 shows the 17 factors of employee wellbeing as derived from literature were subjected to the Delphi study. However, only 12 factors from the 17 were found to be highly influential in affecting employee wellbeing at the same time improving OH&S performance at projects. Looking at the results, in Table 2, the median ranged from high influence (HI:7 – 8) to very high influence (VHI: 9 – 10) which is highly acceptable. However, the parameter set for the adoption of IQD (≤1) to represent consensus, factors with IQD above one was not subjected to the second round of the Delphi study as they did not reach consensus. The scores revealed that there is a strong consensus attained in the remaining factors whose IQD scores were from 0.00 to 1.00. The five factors that were dropped had IQD above 1.00 which is above the cut-off and could not be accepted according to Ameyaw and Chan (2015). Further evidence showed that the five factors lacked consistency by the SD that was higher than the one (1.00). These results indicate 70.59%, which is above the minimum acceptable threshold of 60% consensus.

Table 2. First Round Results for Employee Wellbeing

Employee Wellbeing	Median	Mean	SD	IQD≤ 1
Employee work conditions	10	9.64	0.64	0.50
Mental Health of employees	**9**	**9.00**	**0.95**	**1.50**
Counselling	9	9.27	0.62	1.00
Work Relationships	9	9.36	0.64	1.00
Work-life balance	8	8.64	0.64	1.00
Job security	9	9.27	0.45	0.50
Workplace stress management	8	8.55	0.66	1.00
Social support systems	9	8.91	0.67	0.50
Human resource levelling	**8**	**7.91**	**1.38**	**2.00**
Aligning health with organisational objectives	**7**	**7.45**	**1.56**	**2.50**
Integrity and fairness at workplace	**8**	**7.91**	**1.56**	**2.00**
Occupational health care	8	8.64	0.77	1.00
Welfare provision for employees	**8**	**7.64**	**1.92**	**2.00**
Physical arrangement of work area	9	9.09	0.79	0.50
Developed communication channels	9	9.36	0.64	1.00
Integrating wellness programs with OH&S management	8	8.27	0.62	1.00
Management of Overtime and number of working hours	9	9.36	0.64	1.00

Note: SD= standard deviation; IQD = Interquartile deviation. Variables in bold did not reach consensus and were not retained for the second round.

4.2.2 Second Round of the Delphi Study

The second round indicated in Table 3, indicate that the retained 12 factors from the first round were maintained and reached consensus. The median attained ranging from very high influence (VHI: 9 – 10) to high influence (HI: 7-8); hence the results were very significant. Nine of the factors gave results ranging in the high-influence threshold. The remaining three (3) factors had the median indicating high influence (HI: 7–8) and hence, significant (7 - 8.99), while the mean range was from (8 -10). All the factors had the IQD ranging within the cut-off score (IQD ≤1); hence there was a strong consensus since the scores were between 0.00 and 1.00 indicating 80%-100% consensus. The SD was within the acceptable consistency range. The experts did not propose including any inclusion, adjustments or comments in the second round; hence, only two rounds were done due to time.

Table 3. Second Round Results for Employee Wellbeing

Employee Wellbeing	Median	Mean	SD	IQD≤ 1
Employee work conditions	10	9.64	0.64	0.50
Counselling	9	9.27	0.62	1.00
Work Relationships	9	9.09	0.64	0.50
Work-life balance	9	9.36	0.64	1.00
Job security	8	8.64	0.64	1.00
Workplace stress management	9	927	0.45	0.50
Social support systems	9	9.00	0.60	0.00
Occupational health care	9	8.91	0.67	0.50
Physical arrangement of work area	8	8.64	0.77	1.00
Developed communication channels	8	7.82	0.72	1.00
Integrating wellness programs with OH&S management	9	9.09	0.79	0.50
Management of overtime and number of working hours	10	9.27	0.86	1.00

Note: SD= standard deviation; IQD = Interquartile deviation.

The study objective of identifying employee wellbeing factors that influence OH&S performance for small-scale electrical contractors in Zambia was met. Employee wellbeing is a vital component according to literature reviewed to improving OH&S performance for SSCs. Limited studies showed that employee wellbeing has not been highly used in relation to OH&S performance improvement at projects yet it is a vital driver according to HSE (2018) and, Leka and Jain (2013). Further, the wellbeing of employees, as asserted by Bergh et al. (2014), is an important elements in meeting sustainable development goal number three, the African Agenda 63(3) on health and the ILO (2001) provisions on OH&S performance management. Therefore, SSCs who are expected to improve the wellbeing of employees by adopting the factors from this study to reduce accidents, injuries, and fatalities simultaneously increase information flow on all aspects of OH&S.

After the second round, the final results show that the factors with the very strong consensus include, employee work conditions, work relationships, workplace stress management, social support systems, occupational health care, integrating wellness programs with OH&S management. The IQD and the mean scores were within the very strong consensus range. This implies that the factors have very high influence in promoting positive employee wellbeing. These factors are influential in creating wellbeing and improving OH&S performance. This agrees with De Silva and Wilmalaratne (2012) who developed a framework for wellbeing through which wellness programs, work relationships and stress management were developed and integrated into the OH&S strategy. Ryan et al. (2019) noted that social support systems promoted communication between employees and employers, which mitigated stressors to counteract poor behaviours at projects. The study agrees with Manu (2020) and the WHO (2018) on the significance of including occupational health care systems from the national level to a firm's level to reduce the gaps related to poor performance of OH&S. Work conditions that include good physical, economic and social are aspects to make employees have a sense of wellbeing, and thus job satisfaction and motivation. These are essential outcomes of improved OH&S performance at workplaces.

Further, the study results show that counselling, work-life balance, job security, physical arrangement of work area, developed communication channels, overtime management, and number of working hours ranged within the strong consensus range. The factors' IQD and mean scores indicate high influence in promoting employee wellbeing. Clear communication channels are one of the vital factors that promote wellbeing at workplaces while counselling by formulating employee assistance programs is essential in combating poor employee wellbeing. These were attributed to reducing stress levels, encouraging open conversations, and promoting support structures (Leka & Jain, 2013). Further, overtime and the number of working hours should be addressed by management to reduce burnout. If employees are expected to work more hours, there is a need for rotation and motivational enticement by paying them for the extra hours only when they are able to work. Electrical contractors are found working long hours to meet deadlines. But this is not encouraged because overworked employees tend to cause accidents and injuries. A balancing up of work and job security are essential for wellbeing and OH&S improvement while workplaces conform to acceptable physical arrangement for employees to work comfortably. This qualifies with Burt's (2019) and Buck's (2014) studies on employee wellbeing and work-related stress.

From the foregoing, it can be noted that the role of employee wellbeing factors cannot be over-emphasised in improving OH&S performance by SSCs in the electricity industry. Therefore, management of these electrical contracting firms should show commitment by enhancing wellbeing of employees at projects to reduce accidents, injuries, diseases and fatalities and reduce indirect costs on the health employees.

Conclusion and Further Research

The study assessed employee wellbeing factors that small-scale electrical contractors can adopt to improve OH&S performance in Zambia. From the findings, it can be concluded that there are twelve employee wellbeing factors essential for OH&S performance. The most highly influential factors are employee work conditions, work relationships, workplace stress management, social support systems, occupational health care, integrating wellness programs with OH&S management. The results contribute to the existing body of knowledge and bring to light the employee wellbeing factors that can be adopted and influence OH&S performance positively. The study recommends that small-scale contractors adopt the findings in the electricity industry to reduce injuries, accidents, fatalities and diseases at projects. On-going research is being conducted by using quantitative approaches to complete the study.

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The effect of unskilled labourers on the construction productivity

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Abstract:
Productivity in the construction industry is a critical factor in project success or failure. However, the construction industry is experiencing productivity challenges emanating from the unskilled worker's usage. This study sought to identify the effects of using unskilled labour on construction output. The study used the qualitative research approach by using semi-structured interview questions to solicit information from 32 construction firms operating from the Northern Cape and Free State Provinces of South Africa. Data received were analyzed through thematic content analysis. Data was collected from the participants in only two provinces in South Africa; however, the findings may be applicable in other provinces. The findings indicate that contractors do not see only the adverse side of utilizing unskilled labour on their projects but only consider its positive aspects. Some of the positive effects identified are low wages paid, financial gain, and training on the job. The adverse effects are reworks, health and safety compliance challenges, poor communication, constant supervision, spending more time on task execution, and training time. Again it was found that, although contractors are aware of the consequences of utilizing unskilled labourers on their projects, they still use them, citing reasons such as the lack of skilled labourers, not all activities required skilled labourers, and being able to achieve project objectives. There is an urgent need to educate contractors on the implications of using unskilled labour on projects. The consequences of using unskilled labour may severely affect the company in the long run compared to the immediate gains experienced. Contractors should regularly improve their workers' skills to enhance their task execution to improve their construction productivity and maximize profits.

Keywords: Contractors, labour, productivity, skilled, unskilled

1 Introduction

Productivity in the construction industry could be portrayed as the amount of competence with which assets are managed to finish a particular project within a cut-off time and a given standard (Loera *et al*., 2013). There are various factors that should be adopted to improve productivity on construction sites. The steps to improve productivity should involve the workers' efficiency and effectiveness because it is not practical to yield an amount of work if it is not completed without any quality standards (Loera *et al.,* 2013). A loss in productivity occurs when a contractor does not achieve its intended production rate (Gibson, 2015). Productivity and effectiveness are of most importance in the framework of the construction industry. Hence, a contractor is expanding extra exertion per unit of production than initially scheduled (Gibson, 2015).
Gibson (2015) states that productivity and effectiveness are of great importance in construction and engineering contracts concerning all sizes. Construction contractors are naturally paid for labour completed with terms that follow the contract. Furthermore, Makhene and Thwala

(2018) added that South Africa only has 10% of the artisans that it had 24 years ago, before Apartheid, and approximations are that South Africa has a 40% shortage of artisans now. This has coerced construction companies working on significant projects to import artisans from Malaysia, Ireland, and India (Matues et al., 2014). South Africa is a developing country, and to attract positive economic growth in terms of infrastructure, skilled artisans will have to be considered. According to Chetty (2017), the deficiency of training, inexperienced administration, lack of planning, unproductive quality management, and the absence of maintenance motivating forces are some of the components that have added to the loss of talented artisans in the construction industry. This is a serious problem because it negatively affects project performances, project time, and maintenance. Makhene and Thwala (2018) have previously stated that one of the most significant challenges facing the construction industry is attracting and retaining skilled labourers within South Africa. The skilled labourers continue to decline whilst project owners pressure the contractors for lower costs and faster schedules through their various build delivery processes. As a result, contractors have increased the use of less-skilled labourers in projects that, in return, costs them money and time (Makhene & Thwala, 2018). What rather lacks from previous studies is how unskilled laborers' use impacts a project's deliverables, hence the need for this study.

2 Literature Review

2.2 The effect of Unskilled labourers on the construction project's output

Labour productivity is probably the best indicator of the efficiency of production. Higher efficiency levels typically convert into superior profitability (Rojas, 2008). A practical improvement in labour efficiency is additionally connected with financial progress, as it creates increments in compensations not caused by inflation and wages (Rojas, 2008). According to Chetty (2017), the absence of training, inexperienced management, lack of planning, inadequate quality management, and the absence of retention motivators are a portion of the elements that have added to the loss of skilled artisans in the construction industry, leaving us with large numbers of unskilled labourers. Unskilled workers negatively affect activities on-site, affecting project performances, project time, and quality of work completed (Zannah, 2017). Non-Productivity in numerous forms hurts construction projects (Alwi *et al.,* 2002). Rework is a part of non-productive activities that negatively affect costs and negatively impact productivity in its entirety (Emuzi & Smallwood, 2011). Emuzi and Smallwood (2011) argue against the fact that as much as 49.6% of construction operative time may be devoted to non-productive activities. Ying (2004) states that low productivity in the construction industry has been a great concern for quite some time, and a few studies have been centered around identifying the productivity's factors.

The construction clients have sometimes been hindrances to construction development efficiency due to their insufficient knowledge of construction procedures, including contractors' work (Ying, 2004). Also, being an outdoor industry, construction execution is typically definitely influenced by the climate conditions, whereby unskilled workers do not have the adequate skill to work under these conditions (Ying, 2004). Notwithstanding the variables depicted above, health and safety legislation, procurement arrangements, and codes of practices are further external elements affecting site practice and productivity, having a terrible impact on the construction industry (Shanmuga, 2017). In the internal classification, the management deficiencies could bring about a misuse of assets with ensuing misfortunes in productivity; adoption of advanced technology and training for the unskilled labourers would improve productivity (Ying, 2004).

2.3 The effect of unskilled labourers on contractors

Labour shortage in the construction industry will cause the construction time frame to be delayed (Essays, 2018). This will cause the construction time frame to be deferred due to the work deficiency in the construction industry. Zannah (2017) states that essentially if all the construction works and progress can run appropriately by complying with the schedule, it will not cause any delay in construction. The construction period is likely to be postponed because of the miscommunications between the contractor and unskilled labourer. The unskilled worker has never got any proper training to experience issues in correspondence between them (Zannah, 2017). Also, the unskilled labourer cannot perform well because of the more complicated project since he works without skills and experience and has never been prepared before. Chetty (2017) reiterates that the unskilled worker cannot finish the works according to the customer's standard requirements; thus, after assessment and inspection, the construction works need to be redone, which negatively affects the project's timeframe. When the project is not completed within the agreed time frame, the contractor needs to pay the penalties to the clients and start the restoration works; therefore, it can directly influence the rate of construction progress (Chetty 2017).

Edum-Fotwe and McCaffer (2000) state that labour shortage will be difficult in controlling and dealing with the time, cost, and quality during the project's execution. In a project, the contractor will invest most of his time finding a skilled labourer, delaying the construction time on site. By utilizing unskilled labourers, the construction time is not under control because of the complications in correspondence with the unskilled labourer (Edum-Fotwe and McCaffer, 2000). They need to take some time and acquaint themselves so that the unskilled labourer can comprehend the best approach to begin the works and finally drag out the construction time frame. When the contractor does not have enough skilled labourers, they will most likely be unable to finish the construction on schedule (Edum-Fotwe and McCaffer, 2000).

3 Research Methodology

A qualitative research approach was chosen for this study. According to Creswell (2007), qualitative research focuses on the presently happening phenomenon or has recently happened in nature. The qualitative method is utilized to uncover patterns in contemplations and assumptions and go further into the research issues. This approach was chosen for this research because the study deals mainly with non-numeric information, which entails a series of interviews to fulfill the research objectives. Thus analyses could be made from individuals who have experienced and witnessed the phenomena and enable the researcher to understand the effects of unskilled labour on contractors and why they use unskilled labours on their projects, despite the foreseeable consequences.

The participants in this study are roleplayers working for construction firms such as firm owners, construction managers, site managers, artisans, sub-contractors, and foremen actively involved and directly linked to the pre and post-construction stages of their projects. This study includes construction firms operating from the Northern Cape and Free State Provinces in South Africa. Convenience sampling, which is a non-probability sampling method, was used for this study. Thus the researcher chose the participants as per accessibility or convenience. Convenience sampling was used for this study because it is the most popular technique, and it is simple, speedy, and the least exorbitant strategy (Lauri, 2011). Therefore, any participant who owns or executes a construction project for a contractor within the research jurisdictions and readily available for the interview was selected. Interviews are usually utilized in qualitative research in a detailed investigation concerning a specific situation or issue.

Due to the current global pandemic, the coronavirus, and associated regulations such as social distancing and travel restrictions, telephone interviews were used to get information from the participants willing to partake in the research. According to Blumberg et al. (2008) telephone interviews are becoming indispensable in modern research as it is relatively cheaper and can reach wider participants, compared to face-to-face interviews. In all, 40 construction firms were contacted for an interview, of which 32 responded. According to Creswell (2014), the first step in qualitative data analysis is reading or listening and memorizing the data by making notes and summarizing what has been gathered. The next step consists of moving from reading and memorizing to describing, classifying, and interpreting the data. Here, the researcher builds detailed descriptions, develops themes, and provides an interpretation in light of their views or the views expressed in the literature (Creswell, 2014). This is done by dividing the research objectives into sections. This makes it easier to interpret the data because each section is thoroughly filled with questions enough to make a concrete conclusion on the research topic's objectives. The researcher linked the interpretation of the research discussed in the literature review. In the final phase, the researcher represents the text's data, tabular or in figure form (Belotto, 2018). The suggestions proposed by Creswell (2014) and Belotto (2018) were adopted in analyzing the data gathered for this study. The features of the participants are indicated in Table 1.

Table 1: Participants demographic features

Respondents	**Frequency**	**Percentage**		**Respondents**	**Frequency**	**Percentage**
Gender				**Work experience**		
Male	29	91%		1 to 5 years	3	9%
Female	3	9%		6 to 10 years	17	53%
Total	**32**	**100%**		11 to 15 years	7	22%
Education				over 15 years	5	16%
None	7	22%		**Total**	**32**	**100%**
Matric	18	56%		**Respondents profession**		
Diploma	4	13%		Contractors	21	66%
Bachelor degree	2	6%		Site managers	2	6%
Honours degree	1	3%		Subcontractors	7	22%
Total	**32**	**100%**		Foremen	2	6%
				Total	**32**	**100%**

From Table 1, the majority (91%) of the participants are males, 56% of them are matric certificate holders, 53% have been working in the construction industry between 6 to 10 years, and 88% are firm owners. The findings portray the notion that the construction industry is male-dominated. Again, since firm owners are in the majority, the findings are more reasonable as they expressed an accurate opinion on the effect of using unskilled labours and why they make use of unskilled on their projects.

4 Findings

4.1 Effects of unskilled labourers on productivity

Participants were asked to express their views on whether the engagement of unskilled labours affects construction productivity. Thirty-two percent (32%) answered negatively whilst 68% answered in affirmative, as shown in Table 2.

Table 2. Unskilled labourer's effect on a project productivity

Yes	No
68%	32%

The researcher then asked a follow-up question for the participants to express their opinions on any effect unskilled labours could have on their projects. The researcher then categorized the responses into positive and negative effects as indicated in Tables 3 and 4.

Table 3. Positive Effects of unskilled labourers

Positive effects	Frequency	Percentages
Low wages paid	16	42%
Financial gain	12	32%
Training on the job	10	26%

As indicated in Table 3, most (42%) believe that unskilled labours are cheaper than skilled labours; thus, it would be advantageous to pay less for task execution. Again, 32% of the participants linked positive effects of using unskilled labour to a firm's financial gain, whilst 28% believe unskilled labour could be trained to execute the assigned task perfectively.

Table 4: Negative Effects of unskilled labourers

Negative effects	Frequency	Percentages
Reworks	15	31%
Health and safety compliance challenges	8	16%
Poor communication	3	6%
Constant supervision	11	22%
Spending more time on task execution	7	14%
Training time	5	10%

On the other hand, some of the adverse effects of using unskilled labours identified from the participant's responses are shown in Table 4. These are reworks (31%), Constant supervision (22%), health and safety compliance challenges (16%), spending more time on task execution (14%), poor communication (6%), and training time needed (10%).

4.2 Engagement of unskilled workers on projects

The participants were then asked whether they had ever used unskilled labours on their projects. As indicated in Table 5, the findings show that 95% of the participants admitted to engaging unskilled workers on their projects, whilst 5% stated otherwise.

Table 5. Engaging unskilled workers

Yes	No
95%	5%

A further question was asked regarding why they use unskilled labour despite its implications on their project's productivity. This question was asked to enable the researcher to understand the underpinning reasons why contractors use unskilled workers as they are aware of its negative consequence when it comes to construction productivity. The responses received were then categorized into three main themes, as shown in Table 6. From Table 6, 41% of the participants believe that it is not all project activities that required skilled workers to be executed, 35% believe they employ unskilled workers because of lack of skilled labourers, and 24% mentioned the ability of unskilled workers to achieve project objectives as reasons.

Table 6: Motivating factors for using unskilled workers

Motivating factors	Frequency	Percentages
Lack of skilled labourers	13	35%
Not all activities required skilled labourers	15	41%
Achievement of the project objectives	9	24%

5 Discussion

5.1 Effect of unskilled labourers on productivity

5.1.1 Positive effects

Theme 1: Low wages
Participants believe that unskilled workers provide a cheap source of labour; therefore, engaging them would be wise as they execute the work with proper supervision. Participants 4 and 8, who are subcontractors, indicated unskilled worker's engagement could be a good thing because they could be paid as low as half of the amount that skilled workers would charge. As participant 4 narrates;

> *"I think it is not a bad idea for using unskilled workers because they charge a low amount as compared to skilled workers."*

Them 2: Financial gain
On the other hand, some participants mentioned the firm's potential financial gain when unskilled workers are used. Participants 12, 14, and 21 opined that if you pay workers less, your expenses in terms of worker's compensation would be reduced, leading to extra savings for the firm. In support of these assertions, participants 24 noted that using unskilled workers reduces their expenditure. As participant 24, a contractor narrates;

> *"I believe if you make use of unskilled workers in a combination of skilled workers reduces your financial burden and increases your profit in some cases."*

Them 3: Training on the job
Again it was revealed that one of the positive effects of using unskilled workers is their ability to learn on the job and gradually become perfect in task execution. Looking at the relatively cheaper expense, it worth engaging them and train them to execute the task. Participant 6 stated that training them would let them know what is expected of them and how the work should be done. As participants 6 (foreman) narrates;

> *"if we can all do our part, we will be able to mitigate the situation of unskilled labourers. With training, skill development, and good management, we can get there."*

Participant 2 (contractor) responded that as a company, they wanted to ensure that they trained the workers so that they maintained the company reputation by providing good quality of work to the clients. Again participant 8 (contractor) stated that they source external firms for training their workers, such as safety officers and foremen who were employed as unskilled workers. Others agreed to this, saying that they (the foremen) and the site officers were mainly involved in providing training to unskilled labourers. Participants 13 stated that skilled workers could be trained by engaging them in a combination of skilled workers. In this way, unskilled workers gained knowledge through observing the skilled workers and implementing the work physically. Training these workers would have a positive effect on productivity and quality, which instigates a positive, vibrant atmosphere on-site. These findings imply that contractors consider financial gains as one of the main reasons they use unskilled workers, neglecting the future consequences they may experience on their project's output. It has been suggested by Makhene and Thwala (2018) that as a result of low wages paid to unskilled workers, contractors in South Africa make use of them intending to maximize profits; however, it rather costs contractors money and time in the long run. Again Ofori (2015) suggests that although less-skilled workers may come as cheap to contractors, they may also cause additional financial expenses.

5.1.2. Negative effects

Theme 1: Reworks

Reworks was the significant negative effect of unskilled workers on project productivity mentioned by the participants. Some participants stated that unskilled workers usually make huge mistakes initially, affecting project quality due to a lack of task execution skills. Since the firms want to produce good quality, they are forced to redo some of the works to achieve the quality standard. Participants 3, 7, 9, and 10 stated that they had experienced these in some of their projects, where newly recruited less skilled tillers made mistakes, and they had to remove all the floor tiles and redo them, causing them a substantial amount. As describe by Participants 9 (a contractor);

> *"In one of my projects, I engaged tillers whose rates per square meter were low but less experienced. Unfortunately they made mistakes and I had to replace the floor tiles in some of the rooms. It was very difficult for me but I had to do it since the project manager rejected the work."*

The above findings support Gibson's (2015) finding that contractors struggle to control the low quality of work produced by unskilled workers making them lose money in the process through reworks. Rojas (2008) suggests that there is no assurance regarding the quality of work executed by unskilled workers complying with standard requirements because they are not specialists, which often raises problems for the contractors. Utilizing unskilled creates more problems for a company because an additional cost would be incurred during construction as defective works may become rampant, leading to late project completion (Das, 2015). Rework is a part of non-productive activities which affect project costs negatively (Emuzi & Smallwood, 2011).

Theme 2: Constant supervision

Constant supervision of unskilled workers at the site to enable execution of tasks to befit the project quality requirement is also a problem identified. Participants stated that unskilled workers need to be monitored to ensure they comply with the requirements. Participants 7 gave an example of a situation where the foreman needs to be at the site to ensure workers are doing what is right, which may not be necessary if workers have the skills and experience to do the work. As she narrates;

> *"At times some the workers who are not familiar with the work after completing an assigned work have to sit and wait for the supervisor to show them what to do next, which sometimes lead to time wastage in project execution."*

This problem was also raised by participant 20, in that there is a waste of time on unskilled laborers' supervision as one has to monitor whether they are doing the right thing constantly.

When the supervisors do not ensure that the workers are productive, they spend time idling and becoming tired easily and feel entitled to take more breaks than others. Any process that incurs cost but does not add any value to the construction project, such as unnecessary supervision, can be defined as waste, which is known as a non-productive activity (Castillo *et al.,* 2018). Unskilled workers spend too much time on non-productive activities, and they ended-up not keeping up with the program as required. Hickson and Ellis (2013) stated that as much as 49.6% of construction operative time is devoted to non-productive activities such as wasting time supervising workers and time used for task execution.

Theme 3: Poor communication
Other participants identified poor communication as a feature of unskilled workers. Because they are untrained in project communication, they might have finished activities or require materials for task execution but may not communicate this to the appropriate authorities and wander around doing unnecessary activities. As commented by Respondent 11;

> *"If there is no clear instruction from the foreman, it results in inactivity with labourers having to wait around and argue unnecessarily."*

Participants 12 and 16 also asserted that most unskilled workers do not understand the essence of timely communication in project environments and delay activities due to delayed communication regarding tools or materials they need to execute tasks. Ying (2004) suggests that construction productivity is negatively affected through waiting for feedback on changes requested due to poor communication channels. Construction projects often delay because of miscommunication between contractors and unskilled laborers because unskilled workers are rarely trained or lack experience in issuing correspondences (Zannah, 2017).

Theme 4: Health and safety compliance challenges
Participants mentioned that when labourers are not complying with health and safety regulations, the Municipality could suspend construction; due to non-compliance. This would have a direct effect on the contractor and productivity. Participants 3, 8, and 12 stated that most unskilled workers do not understand the implications of not complying with the safety regulations. Thus, they may have been supplied with safety gadgets yet would not use them. Participants 8 narrates;

> *"One of the problems is that these unskilled workers have no knowledge about safety regulations, so even give them the PPEs but they do not use them, especially when the site supervisor is not around."*

Shanmuga (2017) states that lack of health and safety legislation compliance affects site productivity as workers may be injured and thus delay task execution. In some extreme cases, the entire site would be shut down due to a lack of health and safety compliance.

Theme 5: Spending more time on task execution
According to the interviewees, unskilled labourers spend more working hours on task execution as they did not understand the work situation and that it had to be explained to them. Participants 11 and 13 responded that the loss of time influenced the production of the project very badly. The influence of lost time on a project makes it difficult, as you have to increase resources, labourers have to work overtime to catch up with time. Thus, more money would be spent to catch up with time. Participant 17 said that the loss of production time on the site affects the project's financial projections because you have to hire more people to cover the lost

time. Again, participants 21 and 24 said that; poor management of unskilled workers results in time lost on the project; thus, it is important to make sure that as a contractor, you do not employ unskilled labourers without employing skilled labourers. Skoyles (1987) suggests that a skilled worker's technique is more powerful than an unskilled worker; thus, a skilled labourer can execute tasks quicker than an unskilled laborer and shortens project duration. Skoyles (1987) further suggests that while a skilled labourer can lay 900 bricks a day, an unskilled labourer will just lay 700 bricks, given the same timeframe. Edum-Fotwe and McCaffer (2000) found out that unskilled workers usually take time to finish activities because they need time to find the best approach to begin the work, causing the project schedule to delay.

Theme 6: Training time

Again participants cited the time frame needed to train unskilled labourers as a concern as the training time further delay project execution. However, respondent 11 opined that although time is required to train unskilled workers, they eventually get the work done. As participant eleven (11) states;

> *"There would be inactivity while training occurred, but that productivity would be higher than before after they had accrued the necessary knowledge."*

Other participants, including 4, 7, and 10, agreed that it did not help with production when more unskilled labourers were deployed due to the time needed for training; thus, they should instead be working alongside the skilled labourers to increase the unskilled labourer's knowledge. According to Chetty (2017), the lack of training and inexperienced management caused unskilled labourers to spend too much time on productive activities. The purpose of the Construction Management Training Program is to increase contractor's capacity and ensure that they are genuinely competent in understanding the requirements and the construction activities of a project to lead the skilled and unskilled workers in completing their tasks adequately (Rui *et al.,* 2015). Contractors are affected negatively due to delays and lost time they need to train unskilled workers, making them incur unnecessary costs.

5.2 Reason for using unskilled labours on construction projects

The majority (95%) of the participants believe that they use unskilled labourers because not all activities required skilled labourers. Participants 4, 8, 11, and 15 stated that unskilled workers could perform labour intensive work. As suggested by Participant 15;

> *"They perform the "difficult" part where you need to rely on them to complete the work because it requires physical attention*."

Other participants (14, 18, and 19) indicated that even though unskilled workers tend to be less productive, they do get the job done, and thus, in the long run, the project objective is achieved. As participants indicated

> *"The unskilled labourers' usages do not prevent the achievement of their main project objective because, at the end of the day, the job gets done."*

Other participants indicated a lack of skilled labour in the South African construction industry as the main reason they engage unskilled workers on their projects. For instance, participants 3 and 7 indicated in most of their projects, they are required to use local labours who are mostly unskilled as skilled workers are hardly found in those localities. This means they are forced to use local people and train them on the job. Again, participant 12 indicated that they normally engage the unskilled labourer to execute tasks requiring highly skilled workers and stated examples as site security, site cleaning, and material arrangement. However, participants 18 indicated that they try to engage people who have experience since it is best to do the right thing initially, but due to their inability to get skilled workers, they fall on unskilled workers to do the job. Makhene and Thwala (2018) also suggest that one of the main challenges facing the South African construction industry is attracting and retaining skilled workers. The continued decrease in skilled workers forces contractors to increase the usage of less-skilled workers in projects, with the consequences of increased cost and time. Again Chetty (2017) opines that lack of motivating factors has propounded the loss of talented artisans in the construction industry, leaving no option for the contractors to rely on unskilled workers.

6 Conclusion and Recommendations

Productivity in the construction industry is paramount for efficient project completion. Lack of productivity affects the project, contractors, clients, and end-users because it brings additional costs to the client and contractors and deprives them of utilizing the facilities. To ensure effective project execution that meets all the stakeholders' requirements, the people engaged in the project should be knowledgeable and experienced in executing the assigned tasks. This study sought to understand the effect of using unskilled works by contractors on project output. The findings indicate that contractors do not see only the adverse effects of using unskilled workers on their projects; but also positive effects. Some of the positive effects identified are low wages paid, financial gain, and training on the job. The adverse effects are reworks, health and safety compliance challenges, poor communication, constant supervision, spending more time on task execution, and training time. Although contractors are aware of the consequences of using unskilled labourers on their projects, they cited reasons such as the lack of skilled labourers, not all activities required skilled labourers, and achieving project objectives as motivation factors. Therefore, it is recommended that the construction industry roleplayers intensify awareness creation on the negative impact of unskilled labourers on the construction industry. The construction industry and the government sector may combine with higher education institutions to implement more short courses and training for all construction workers to improve their skills. Again, construction vocational training institutions should be established to train workers to increase skilled workers employed by contractors.

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Unethical behaviour in construction industry- the South African construction professionals' views

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Abstract:
Ethics is an important issue in any profession and business organisations. Due to its importance, many organisations and professional bodies' usually have ethical guidelines and principles available in the form of a code of conduct to guide key stakeholders within their organisations and professions to operate with integrity, fairness and accountability. Notwithstanding these provisions, previous studies have shown that the South African construction industry professionals possess "a reputation for unethical practice." This unethical conduct has become a cause for serious concern in the industry and has negatively impacted the industry image, integrity, and reputation. Consequently, this study investigates factors facilitating unethical practices and effective disciplinary measures to curb unethical behaviour for better performance and productivity of the construction industry. A quantitative research approach was adopted using a well-designed questionnaire. The target population were various experienced construction professionals in the South African construction industry. A total of 110 questionnaires were distributed, out of which fifty completed questionnaire were received and found to be useful. There were six disciplinary actions against unethical practices, which were presented and rated by respondents. The data obtained were analysed using SPSS. Mean item score was derived for each disciplinary measure. From the analysis, the most rated measure among all the identified disciplinary measures was the dismissal of an individual caught in any unethical acts. Other measures include termination of contracts by clients and disqualification of tender. Adopting these measures will help reduce unethical practices in the industry and promote transparency and accountability within the construction industry in South Africa.

Keywords: Construction Industry, contracts management, ethics, South Africa, unethical practices

Introduction

The construction industry as a sector employs large numbers of professionals to execute its projects. These professionals are expected to discharge their duties in accordance with the industry codes and standards. Consequently, several professional bodies have developed ethical guidelines and principles as a code of conduct for their professionals to act with good morals, integrity, fairness, accountability, and an acceptable manner. Unfortunately, despite these ethical guidelines, previous studies revealed that unethical conduct among various construction stakeholders had impaired the industry's integrity, thereby affecting the growth and economic development of the industry and the nation at large. Globally, the professional, ethical code of conducts is very vital to professional bodies. It contains moral principles within which all professionals should operate. The word "professional" is often associated with service because professionals in the built environment provide various services to clients. These professionals are expected to satisfy clients' needs by delivering quality services (Aluko and Mewomo, 2020).

Consequently, their obligations and responsibilities towards the general public, their clients and peers are detailed in the professional code of conducts (Bowen *et al*. 2007). According to Abdul-Rahman (2014), Construction professionals are answerable to their clients and compelled to work within the limit of their professional code of ethics. Similarly, Construction Industry Development Board (CIDB) Act No.38 of 2000 stated that codes of conducts are good ethics or conducts established to “guide and regulate the behaviour of parties engaged in construction-related procurement and the standards of behaviour that industry participants may expect from each other against which their behaviour can be measured."

These codes of conducts include “honesty and transparency; timeous discharging of duties with integrity; adherence to applicable legislation and associated regulations; compliance to relevant requirements established in procurement documents; avoidance of conflicts of interest and malicious or reckless act that may injure or attempt to injure the reputation of another party” (CIBD, Act No.38 of 2000). Bowen *et al*. (2007) have suggested that certain ethical practices contribute to organisational success and economic efficiency. This conduct includes integrity, respect, good reputation, honesty, transparency, honouring commitment, work ethics, teamwork, and accountability (Hutchings and Christofferson, 2005; Bowen et al., 2007b). Therefore, professional, ethical behaviour in construction means practising in the right and acceptable moral standards and principles of the construction profession.

The construction industry plays a vital role in the growth and development of any country. The SA construction industry is not excluded. Reports have indicated that the SA construction industry is one of the industries creating employment opportunities and contributing to the nation’s Gross Domestic Product (GDP) to the tune of about 6% (Aigbavboa *et al*., 2016). Apart from these contributions, other sectors in a country, such as mining, manufacturing, health, education, religious transportation, depending on construction product to execute their services. Unethical behaviour had greatly affected the integrity of the construction industry in both developed and developing countries (Bowen *et al*., 2007). South African industry contractors are no exception to ethical issues, including collusion, dishonesty, bribery, fraud, negligence, and unfair practices. This behaviour is unacceptable and has drawn public disapproval, criticism and decreased faith from the citizens (Adnan *et al.,* 2012). Over the past four decades, there has been increased emphasis on ethics within industry and business. Managers and researchers monitor the development and effects of corporate ethical performance with keen interest (Bowen et al., 2007).

Notwithstanding, the "Transparency International Report" noted in Bowen *et al*. (2007) revealed that the scale of corruption is greater in construction than in any other sector. The issue of unethical practices within the construction industry in South Africa is a major concern as the industry's growth and standard construction works depend on the industry's good ethical conduct. Therefore, this paper investigates factors contributing to unethical practices in the South African construction industry, their effects and disciplinary measures to curb these unethical acts to promote ethical principles and standards among professionals in the SA construction industry.

Literature Review: Unethical Behaviour in Construction Industries

Motzko *et al.* (2013) identified ethical principles as an action involving honesty, fair reward, integrity, objectivity, fairness, reliability and accountability. Accordingly, any intentional or reckless disregard for ethical principles is referred to as unethical practice or behaviour. Unethical conduct is increasing in and out of the construction industry in many countries, and this has led to survey by many researchers in identifying such unethical acts in the industry. Researchers such as Bowen *et al*. (2007a), Bowen *et al*. (2007b), Aigbavboa *et al.* (2016), among others, have surveyed the ethical conducts of different categories of professionals in the South African construction industry. The results revealed the variety of ethical issues causing unethical behaviour among construction professionals and the prevalent unethical conduct among the industry stakeholders in South Africa. In addition, various ethical issues associated with customer needs, conflicts of interest, customer services, fair competition, and professional responsibilities and integrity were noted to face the construction industry.

Moreover, globalisation, technology, competition, law, and public perceptions have brought ethical issues to a critical focus. Unfortunately, these ethical issues have the potential to stimulate unethical behaviour. There is, therefore, a need for professional organisations to carefully provide means of preventing unethical acts and measures to curb their spread in the industry.

Bowen *et al*. (2007) study on professional, ethical issues in South Africa revealed a spectrum of unethical practices among professionals, namely fraud, negligence, dishonesty, collusion, bribery in the form of gifts or payments, among others, of which contractors are most reputed. Clients and various levels of government are also noted to be involved. According to their report, unethical behaviours that are mostly connected with clients and multiple levels of government include nepotism, awarding contracts to acquaintances, abuse of the tendering process, and clients taking advantage of construction professionals. The construction professions are not altogether cleared of unethical behaviours. On the part of professional construction consultants, violation of statutory requirement where a professional practice without being registered with the relevant professional bodies, conflicts of interest and doctoring of contract documentation to cover professional incompetence have been recorded. Adnan *et al.* (2012) studied the ethical issues focusing on the contractor's perspective. Their findings revealed that cover pricing, poor documentation, delayed payments, falsification of experience, bid cutting are common unethical acts among contractors.

Vee and Skitmore (2003) researched professional ethics, focusing on the Australian construction industry. The study's findings revealed that all professions had experienced a certain degree of unethical practice in the form of negligence, fraud and bribery, collusion (collusive tendering), and conflict of interest. The results also indicated contractors as being the most unethical in all areas. In his survey, Abdul-Rahman (2014) also reported five most occurring unethical conduct, namely: "underbidding, bid shopping, and bid cutting; bribery and corruption; negligence; front loading and claims game; and payment game". Finally, Jackson (2005) investigated unethical conducts in construction from contractors' point of view. The study noted the four most occurring unethical behaviours: misrepresentation of completed work, improper bidding practices, misrepresentation of competence, and poor quality control. Based on various literature, it is evident that bribery, dishonesty, unfair practices, fraud, collusion and negligence are common unethical behaviours in the construction industry.

Factors facilitating unethical behaviour in the construction industry

The uniqueness of the construction industry in terms of the complexity and size of the industry being executed by the industry gives room for unethical practices to grow. Several factors trigger unethical acts. For instance, leadership failure to vigorously promote ethical practice has resulted in ethical failure in organisations (Bowen, 2007). The study of Shah and Alotaibi (2018) on unethical practices classified the factors that engender unethical practices into three areas, namely: contractor related, owner related and consultant related factors. The analyses identified the factors responsible for owner-related factors, including delayed/default payment and the illegal award of the tender to a contractor. The contractor related factors identified were overbilling, collusive bidding, bid-rigging and bid cutting, among others. At the consultant level, lack of supervision and lack of experience were identified. From owners' perspectives, illegal action and mounting pressure on the project manager and payment delay processes were mostly occurring. Aigbavboa *et al*. (2016) identified 13 unethical issues, with the three most critical cause arising from greed, favouritism and political influence.

Effects of Unethical Practices in the Construction Industry

There are serious consequences associated with unethical conducts. Previous studies have indicated that the professional ethics issue in the construction industry affects a broad spectrum of population: the suppliers, the home buyers, local authorities, contractors, consultants, client organisations, public works department and users of public infrastructure are all within the scope of professional ethics (Al-sweity, 2013). The consequences of unethical behaviours are many. It can lead to a diminishing market for organisation services, tarnished reputation, loss of income by governments and clients, and cause avoidable expenditures that can reduce the quality of life (Shah and Alotaibi, 2018). In a survey conducted by Abdul-Rahman *et al*. (2014) on construction industries in Malaysia, most respondents agreed that unethical conduct contributes to quality-related problems and can cause poor-quality projects. Also, poor standards of ethics can birth opportunities for corruption to arise, as found out by a survey carried out by Bowen *et al.* (2012), where several participants pointed unethical acts as a root cause of high levels of corruption in the industry. In addition, unethical practices lead to increased customer dissatisfaction, distrust and fear, and decreased productivity and profitability. Unethical practices have been illustrated to produce additional negative cost at different levels: personal, group and organisation (Bowen, 2007a), the quality of projects is another important aspect affected by unethical behaviour in the industry (Al-sweity, 2013). Therefore, organisations, professions, and businesses must understand the wide-ranging consequences of unethical practices and avoid them like the plague.

Control and disciplinary action against Unethical Practices in Construction industries

The construction industry productivity in terms of timely delivery, project quality and safety is a function of the people involved in the construction project from inception to completion. Awareness of the required professional ethics to display during construction will reduce unethical practice in the building industry. According to the study of Al-sweity (2013), the best way to enhance ethics is to create ethical awareness to various construction stakeholders and apply heavier penalties on the offenders. This suggestion is in line with the recommendation proposed by Bangani and Mewomo (2019). Their study indicated lack of accountability, unethical practices and corruption as serious challenges in South African state-owned construction project and suggested serious penalty on collusive bidders. Abdul-Rahman et al. (2014) also indicated that all construction players must be monitored strictly to follow and generate a standard scheme to measure the quality of work achieved by contractors. A survey by Shah and Alotaibi (2018) revealed factors such as employee benefits, strict monitoring, adequate supervision, and punishment for unethical activities at different stages of the construction activities as effective ways to discourage and minimise unethical practices among the stakeholders in the construction industry.

Ameh and Odusami. (2010) suggested establishing an ethical facilitator group separate from professional bodies who will act as ethical facilitators, investigate and sanction individuals and organisations that breach ethical principles and rules in the construction industry. Bowen *et al.* (2007) noted the importance of educating clients and the need for policy related to ethics issues. Such policy is needed to safeguard stakeholder trust and confidence in the professional practices of the construction industry. In a survey to seek practitioners' views on ethical practices in the Malaysian construction industry, the Majority of the respondents (97%) believed that the leaders are the main catalyst of the organisation and should serve as role models to act ethically. Furthermore, it is believed that ethical behaviour should be a prerequisite for determining an individual's competence. Also, better remunerations, incentives, and a working environment should be provided for employees to reduce or curb bribery or corruption. Further, some respondents suggested that all construction-related organisations should develop a formal Code of Ethics, including specific anti-corruption provisions. These provisions should be detailed in contracts and apply to anyone involved at any stage of construction projects. (Mohamad and Abdul Aziz, 2009).

Ehsan *et al.* (2009) categorised the suggested solutions to unethical behaviour into short, medium and long term bases. The short-term measures include serious punishments such as cancellation of license on repetitive violations and penalty to the offenders. For the medium-term measures, regularisation of consultant and architect organisations through laws were proposed. Long term measures are; proper training of tradesmen/technical manpower through recognised training institution before executing projects, the creation of public awareness and debating on ethical issues; allowing people with good knowledge and training on professional ethics to be in charge of civic bodies.

Research Methodology

This study employed a quantitative research approach. The research instrument used for the collection of data was a questionnaire. The target population were the experienced professionals comprising of quantity surveyors, architect, engineers and project managers. The study utilised convenience sampling and a total of 110 questionnaires distributed out of which fifty completed questionnaires were received and found to be useful. The questionnaire was divided into two sections; the first section looks at the demographics of the personnel, while the second section consists of study variables regarding the ethical issues faced by stakeholders in the construction industry. The questionnaire content was developed from existing literature on the topic and distributed to professionals in both the public and private sector construction industries in Kwazulu-Natal province of South Africa. The questionnaires include several factors which were ranked as having a minor or major effect using a scale of 1 to 5 with "unsure" and "do not know" option. These factors were discussed concerning professionals' common unethical behaviour in the South African construction industry. A mean score (MS) was calculated for each statement to interpret the percentages relative to each point on the response scale. The following are the scale range and their definition: $> 4.20 \leq 5.00$ major influence; $> 3.40 \leq 4.20$ near major influence; $> 2.60 \leq 3.40$ moderate influence, $> 1.80 \leq 2.60$ near minor influence and $> 1.00 \leq 1.08$ between a minor to near minor influence. A total of 50 responses were received.

Furthermore, from the respondents' profession analysis, 12% were Architects, 18% were Builders, 10% were Engineers, 20% were Quantity Surveyors, 6% were Construction Managers, 14% were Project managers, and 20% were Clients. Also, the position held by each respondent in their place of work varies; 2% were managing director, 2% were Director/ senior executive, 12% were managers, 32% were senior staffs, 36% were supervisors, and others were 16%. The demographic information implies that the respondents are mature experienced professionals who have a key position in the construction industry in South Africa, indicating that the data provided are reliable.

Findings and Discussion

As previously indicated, the study investigates the factors facilitating unethical practices, their effects and measures to prevent such practices in the construction industry. The second part of the questionnaire has several factors addressing the study focus areas. Seven unethical facilitating factors were presented to the respondents for rating. Seven factors were also identified as possible effects of unethical practices and were presented to the respondents for ranking, while five possible curbing factors were also identified and presented for scoring. The identified factors were ranked as having a minor or major effect using a scale of 1 to 5 with "unsure" and "do not know" option used to determine whether the respondents considered a particular factor.

Table 1 Indicates factors facilitating unethical practices in the South Africa construction industry. Poor ethical management, greed and lack of training and professionalism have the same mean score of $> 3.40 \leq 4.20$, representing a near major influence among all the other unethical behaviour or practice were rated by the respondents as the major factors facilitating unethical behaviours in the industry.

Table 1. Rate the contribution of each of the below-mentioned factors to unethical practice

Factor	Mean	Standard Deviation	Rank
Poor ethical management	4.40	4.07	1
Greed	3.72	2.79	2
Lack of training and professionalism	3.42	3.43	3
Increased competition	2.98	2.78	4
Inability to meet project constraints	2.94	1.91	5
Economic recession	2.74	2.44	6
Poor company income	2.40	2.10	7

Table 2 presents the factors that are negatively affected by unethical behaviour in the construction industry. Respondents indicate that unethical behaviour has a major influence on Company reputation, with a mean score between $> 4.20 \leq 5.00$. Followed by time, quality and cost having a mean score between $> 3.40 \leq 4.20$. This implies that the unethical behaviour of the contractor may affect the quality of work, project delivery time, and cost, thereby affecting the industry's growth.

Table 2. Rate the factors that are negatively affected by unethical behaviour in the construction industry

Factor	Mean	Standard Deviation	Rank
Company reputation	4.28	4.00	1
Time	4.08	3.19	2
Quality	4.00	3.12	3
Cost	3.47	2.41	4
Reduction of Profit	2.69	1.97	5
Compromising of safety	2.58	1.82	6
Shareholder value decreases	2.37	2.55	7

From Table 3, rating of the effectiveness of the disciplinary action against the unethical practice, dismissal of individuals was highly rated by the respondents; a mean score of 3.66 ($> 3.40 \leq 4.20$ near major influence), the respondents strongly believe that the dismissal of individuals followed by termination of contracts by clients with mean score 3.66 and disqualification of tender having a mean score of 3.12. This shows that the respondents believe that ethics issues are more personal and that individual caught in such activities should be disqualified.

Table 3: Rate the effectiveness of the disciplinary action against unethical practice

Factor	Mean	Standard Deviation	Rank
Dismissals of individuals	3.66	2.88	1
Termination of contracts by clients	3.34	4.14	2
Disqualification of tender	3.12	2.32	3
Lawsuits	2.84	2.31	4
Abandonment of projects	2.72	2.49	5

Implications of research findings

This study shows results that are similar to previous studies conducted locally and internationally on ethical issues in the construction industry. For instance, the studies of Hamimah *et al*. (2012), Bowen *et al*. (2007a), Bowen *et al*. (2007b) all indicated the presence of unethical practices among construction professionals. Moreover, all these studies proposed several means of curbing unethical practices. Notwithstanding, the current research specifically indicates that the factors causing unethical behaviour have remained unchanged. Moreover, unethical practices show that most of the previous suggestions to curb unethical practices seem not to have been meticulously employed in the industry. This study, therefore, suggests a serious need to consider a more proactive means of curbing unethical practices in the construction industry.

Limitation of research findings

This study utilised convenience sampling. Also, only the professionals from KwaZulu-Natal Province of South Africa participated in the study. Consequently, the 50 responses cannot be regarded as representing all professionals in the South African Construction industry.

Conclusion and Further Research

This study revealed that poor ethical management, greed, lack of training, and professionalism are the major factors facilitating unethical behaviour in construction. It has a negative effect on the industry's productivity in terms of quality, cost, and project delivery time. The measures identified to minimise the effects of these ethical issues are dismissal of an unethical individual, termination of contracts by clients and disqualification of tender as they were highly rated by the respondents. In conclusion, this study has shown that the factors causing unethical behaviour has remained unchanged. Therefore, it is important that various professional bodies employ more stringent strategies that can support strict compliance to ethical code of conduct.

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Assessment of the role of institutionalised self-help housing in achieving the United Nations Sustainable Development Goals in Post-Apartheid South Africa

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Abstract:
This paper assesses the role of institutionalised self-help housing as postulated by John Turner in achieving the United Nations Sustainable Development Goals (SDG's) in post-apartheid South Africa. This study problematises how the two are interlinked, the challenges and opportunities that self-help housing presents in realising sustainable development goals. This study adopts a systematic literature review approach to critique the self-help housing policy i.e. enhanced peoples housing process whose objectives emerged out of the broader housing policy of Breaking New Ground (BNG). The study adopts a qualitative research approach and uses secondary data sources, which is presented thematically. This study is limited because it does not use primary data from self-help organised groups and beneficiaries of housing provision to understand the limitations of neoliberal agenda in achieving SDGs in the Global South. This study found that Turner's ideas were heavily disputed by Marxist scholars, who argued that self-help leads to the commodification of housing. There are practical implications of Turner's work in that governments should not have to provide aspects of housing, which people can provide for themselves. This study concludes that Turner was in favour of dweller-control, whereas the World Bank's neoliberal approach was based on the economics of housing and that, self-help is influenced by neoliberalism, where the market, individualism and commodification of a house reinforces poverty. As a result, institutionalised self-help has advantages in delivering sustainable human settlements but has limitations in achieving sustainable development goals.

Keywords:
Breaking New Ground, Instititionalised Self-help Housing, Neoliberalism, Self-help Housing, Sustainable Development Goals

Introduction

The dawn of democracy in South Africa in 1994 has exposed the existence of housing backlog, which tested the government's capacity for housing delivery to the majority of the poor households in both urban and rural areas. Over time from Nelson Mandela to Cyril Ramaphosa's administration, the South African government has been actively engaged in addressing the huge housing challenges, which includes reducing the housing backlog and improving the low quality of living conditions. The first administration of Nelson Mandela, which was forged through Government of National Unity (GNU) focused institutional reforms to address the injustices of the past and on building a non-racial, inclusive democratic society. Through the Department of Human Settlements, the government introduced a national housing programme that targeted low-income households through subsidy that aimed to provide a piece of land, building a basic house with the installation of basic services such as water, sanitation, and refuse removal and electricity. This means the South African government intervened to address the problem of housing the poor people. Moreover, South Africa made significant progress in building structures for a democratic state partly for the purpose of implementing housing development. The historically fragmented housing delivery governance structures were consolidated into a system designed to serve developmental objectives, which was concretised through the promulgation of the White Paper on Housing in 1994 and the National Housing Act in 1997 and later Breaking New Ground in 2004. This served as the basis for implementing self-help housing to citizens in South Africa.

Evidence and practices in different countries show that self-help housing has been adopted as a housing option. Evidence also indicates that self-help was successful in several countries because poor people have the freedom to make their own housing decisions (Ward, 1981). Self-help housing in the context of developing countries is commonly associated with the ideas of JFC Turner (Turner, 1976). From his experience working as an architect in Peru and as a consultant for the World Bank, Turner argues that the role of the government in self-help housing is to “create an enabling environment for housing delivery through legislation and the provision of subsidies to poor and low-income households.”

According to Harms (1992), self-help housing delivery should be taken as "a form of community-based housing delivery [mechanism] whereby individual households are responsible for provision of their own housing". It was observed that "self-help housing can take various forms ranging from self-build (individual households or group self-help), which relates more to technical aspects of house building. Collective actions around housing relate more strongly to organisational and political actions to improve living conditions beyond housing". Existing evidence suggests that a local builder's hiring of and supervision in building a home is commonly known as the local contractor option, where the household is responsible for decision making, site layout, house design, materials procurement, and financial management. The definition is relevant to the self-help housing approach applicable in the context of in-situ upgrading of informal settlements and site and services projects implemented in different parts of South Africa.

Self-help housing is one of the most prevalent housing options globally (Ward, 1982; Harris, 1998; Dingle, 1999), and researchers have formulated ideas on the topic (Harris, 2003). The notion of self-help in developing countries is commonly (rightfully or wrongly) attributed to JFC Turner (Turner, 1976). Drawing from the evolution and the practice of self-help housing around the world, it has become apparent that there are contestations taking place amongst different researchers. Still, due to limited space in this study and the guiding theme, the contestations will not be engaged as it is discussed somewhere (Sithole, 2015). Therefore, the purpose of this study is to assess the role of institutionalised self-help housing as postulated by John Turner in achieving SDGs in the post-apartheid South Africa. This study intends to problematise how the two are interlinked and the challenges and opportunities that self-help housing presents to realise sustainable development.

This study will firstly engage with the origins and a broader conceptual debate of self-help housing. Secondly, it provides the role of institutionalised self-help housing soon after different types of self-help housing are discussed, and its legislative framework in South Africa. The findings section, thematically analyses concepts from the literature review. The themes of interest are; i) SDGs, BNG and Institutionalised Self-Help Housing, ii) Enabling a Neoliberal Approach to Housing Provision and power dynamics, iii) Institutionalising Housing for poverty alleviation and iv) SDGs, BNG and Institutionalised Self-Help Housing towards poverty alleviation.

Literature Review

This section covers the origins of self-help housing. It engages different debates about self-help housing which aims to demonstrate that John Turner popularised this housing solution but the concept did not originate from him. Furthermore, it covers different types of self-help housing. Lastly, it focuses on one type of self-help housing which is institutionalised self-help housing.

Origin of Self-Help Housing

Self-help housing has a long history in housing studies. Pugh (2001) traces the origins of self-help in the housing environment and found that it became an important paradigm in housing delivery since the 1960s but did consider that it has been with humankind for centuries. The reason provided on why it dominated in the 1960s was that there was a failure of government-driven housing development. Harris (1998) avers that self-help housing was commonly practised prior to the introduction of formal town planning. Harris gave a geo-spatial evidence which affirmed that self-help housing started to be practiced in urban areas from the 1900s even prior to the commonly accepted notion in the 1960s that John Turner spurred self-help housing. Other scholars also traced the history of self-help housing schemes, particularly in developing countries, and revealed that self-help housing dates back from the 1930s and 1940s when US-agencies like the ‘Housing and Home Finance Administration’ and later the ‘International Cooperation Administration’ introduced pilot projects to specific Latin American countries such as Columbia, Puerto Rico, and Chile (Mathey, 1992; Tait, 1997).

In Africa, Keivani and Werna (2001) found that poor people living in urban areas had always been housed under conditions, which today are referred to as self-help housing schemes. These findings agree with Harris (1998) that the use of self-help housing as a solution in the developing world was initiated in the 1930s. This challenges the commonly held views that self-help housing originated from Turner ideas in the 1960s. Harris (1998) further supported this historical view through scholarly evidence that during the pre-Second World War period, the most pronounced advocate of the theory and practice of self-help housing was Jacob L. Crane. Harris (1998) observed that through his writings on self-help housing, Crane elaborated on the logic behind the theory of self-help housing and further helped to initiate certain self-help housing projects. Harris further concluded that Crane published extensively (Crane, 1944; 1949; Crane & Foster, 1953; Crane & McCabe, 1950 as cited in Harris, 1998) but his works were soon overlooked and forgotten. A conclusion reached by scholars has been that Turner succeeded in changing the world's perception about self-help housing programmes as an alternative means of low-income housing provision, even though these ideas never originated from him (Harris, 2003).

Different Types of Self-Help Housing

The existing literature distinguishes between three types of self-help housing, namely laissez-faire self-help, aided self-help and institutionalised self-help. The primary focus of this study is on the low-income housing programmes. Therefore the focus is on institutionalised self-help, but other types are also briefly discussed in this study.

There are three types of self-housing practices. Writers note that the first form of self-help is effectuated without any aid or assistance from government. Scholars support this view that self-help without government assistance was practised worldwide for centuries by low and high-income households (Hardy & Ward, 1984; Harris, 1991; Jenkins et al., 2001). Rodell and Skinner (1983) note that the second form of self-help housing is termed "aided self-help", which comprises an approach in which site-and-service schemes have played a crucial role. This type of self-help housing creates an environment in which people could build for themselves Ward and Macolloo (1992) maintain that these two forms of self-help housing were motivated by a range of political-economic arguments, which were about reducing the costs for governments, and transfer costs to the individual, while at the same time making housing more affordable to the individual households.

The third self-help housing practice is implemented through institutions or organisations, which involves the establishment of housing cooperatives. Scholars observed that self-help housing cooperatives were largely used in India, Jordan, Bangladesh, Indonesia, Malaysia, Pakistan, Thailand, Iran, Cuba, Egypt, Botswana, Zimbabwe and Zambia (Khurana, 2001; Kerr & Kwele, 1998; Midgley et al., 1986; Harris, 1997; Sukumar, 2000; Keivani & Werna, 2001; Gough, 1996). Scholars also argue that self-help housing was commonly associated with neo-liberalism, and was also implemented in countries with socialist policies. This third form of self-help housing is called institutionalised self-help housing which is the focus of this study and is discussed separately below.

Institutionalised Self-Help Housing

International literature shows that self-help housing has been implemented through institutional organisations, and this involved the establishment of self-help groups often called 'housing cooperatives' (Mathey, 1992; Keivani & Werna, 2001). In co-operative housing, a group of households provide their own housing and there is an element of a contribution of collective labour and the group of households receives advice, support and/or training from an external agency. According to Khurana (2001), housing cooperatives can be described as a legally incorporated group of persons of limited means pursuing the same cause of meeting the common need for housing or its improvement based on mutual assistance. Keivana and Werna (2001) argue that groups are able to negotiate on behalf of its members to acquire land from the government or on the private market, apply for and receive credit or mortgage loans from the government and from formal-sector institutions, receiving building materials and commissioning contractors to build the housing units. Moreover, in housing cooperatives membership is voluntary, control is democratic, and members make an equal contribution to the capital required (Khurana, 2001).

However, government's role, either directly or indirectly, in the activities of these institutions remains the main concern. This is further analysed in the next sections of this study. It would thus be well within the scope of this study, in the next section, to give an overview of countries in the developing world that have used institutionalised self-help (housing cooperatives) as an alternative mechanism for the provision of low-income housing. Furthermore, the role of different stakeholders in the operationalisation of these institutions is also analysed. That is finally followed by a discussion of the successes and challenges faced by the housing cooperatives.

Legislative Framework for Self-Help Housing in South Africa

The Peoples Housing Policy of 1997 which was later revised to an Enhanced Peoples Housing Process was designed as a policy instrument to allow people build for themselves and not wait for government to do things for them. The assumption of the policy was that people have resources i.e. money, time and labour. Therefore, the rational of the self -help housing policy in the South African policy was that individuals, communities could bring their resources together to help themselves improve their living standards and environment by themselves and for themselves.

The self-help housing policy was also influenced by the UN -HABITAT's Peoples Partnership Trust initiative that was established to support self-help policy in South Africa. This structure was later absorbed into the National Department of Housing. Omenya (2006) notes that most self-help housing policies internationally, have been influenced by neoliberal policy positions of the World Bank and UN-Habitat as well as by other international, bilateral and regional development agencies and donors.

Lessons learnt from this structure influenced the peoples housing process. A number of NGO's lobbied for the policy to provide an options for people to build for themselves as this could provide a better outcome than what government was able to provide. The Peoples Housing Policy was revised and enhanced to bring support organisations and structures such as cooperatives for different purposes i.e. building cooperatives, savings cooperatives for employment creation etc.

The Enhanced People's Housing Process Guidelines of 2009 (EPHP) provided a process where beneficiary participation, individuals and communities are empowered to take control of their housing process themselves. This includes identifying the land, planning the settlement, getting approvals and resources to begin the development, contracting out or building their houses and providing the services, living in and up-grading their homes, and continually improving their lives as community members. Further outcomes stipulated in the self-help policy includes supporting partnerships for social capital, building livelihood, creating poverty-alleviation opportunities for the communities, using a house as an asset, far beyond its monetary value for all the value-added components it provides for individual household members, and for the family as a whole, stimulates local economic development is promoted and increase the local multiplier effect of the self-help process.

At the centre of the self-help housing policy, i.e. Enhanced Peoples Housing Process is the principle of partnerships between government, cooperatives and civil society. These actors assume different roles in delivering housing as a basic need that enables the realisation of other socio-economic rights and benefits such as security, income and access to basic services such as water, electricity and sanitation. The principle of partnership between government and civil society is self-help policies is a key principle that could encourage the involvement and a collective effort of community-based self-help initiatives to realise the Sustainable Development Goals.

Self-Help Housing and SDGs

SDG's and Institutionalised Self-Help Housing

In 2015, the United Nations General Assembly presented the Sustainable Development Goals as a blueprint to be used to achieve a better life for all world citizens by 2030. During the Sustainable Development Summit in September 2015, a total of 193 countries adopted these goals as a 'guide' to improve the well-being of the human race and the planet by tackling social, environmental, political and economical issues globally, South Africa being one of the member states (General Assembly, 2015; McCloskey, 2019).
The ultimate aim of the SDGs is to end world poverty without compromising the earth's life-supporting systems and ensuring that in so doing, no one is left behind. Underlying the SDG's is a somewhat moral obligation to the less privileged, the environment and to future generations (Gert and Kharas, 2018). These moral obligation undertones have been greatly debated by some scholars (Beckerman, 1994; Daly, 1995). Affordable housing is one way to attack the plight of poverty. The relationship between housing and sustainable development drives the ideas behind the Sustainable Housing concept. There is extensive literature on this concept, and it acknowledges the centrality of housing to achieving SDGs (Golubchikov & Badyina, 2012). Further to this, the concept advocates for affordable housing as a condition that is necessary for transformation.

SDG 11 is about realising sustainable, safe, resilient and inclusive cities and communities. One of its seven outcome targets addresses safe and affordable housing. This goal is the only target where housing is explicitly articulated. According to Winston and Eastaway (2008), housing is an essential part of the overall quality of life, if sustainably realised 14 of the 17 SDG targets would be achieved (Winston and Eastaway, 2008). Rust (2020) explains that, once housing is established, access to basic services can be achieved (SDG 2,3,4,6 and 9), inclusive growth promoted (SDG 1, 5, 8, 10, 12 and 17) and a contribution made towards a sustainable future (SDG 7 and 13).

BNG and Institutionalised Self-Help Housing

The South African Breaking New Ground (BNG) policy is rooted in the principles of Sustainable Development. It is a comprehensive plan seeking to refocus policy attention from the delivery of just subsidised houses as 'units' to ensuring the development of Sustainable Human Settlements from a holistic perspective. Additional to this, BNG corrects the top-down supply driven approach of its predecessor policy, the White Paper on Housing, with a bottom-up demand-driven delivery approach (Department of Housing, 2004). The BNG policy has 7 objectives all with an ultimate goal of poverty alleviation as also seen with the SDGs.

Self-Help principles find expression in the BNG policy (Ntema, 2011). The policy allows members to have dweller control as well as to exercise power to build dwellings responding to their cultural habits, economic and social context as also advocated by Turner (1976).

Research Methodology

This study adopted a qualitative research design informed by an interpretivist paradigm. A qualitative approach can be defined as a descriptive approach to collect and interpret information to understand a social phenomenon and develop an in-depth understanding of individual views, attitudes, and behaviour (Moore, 2000: 121). In essence, this study used secondary data sources to gather information that helped inform the study based on the research topic. The nature of information reviewed was theories and approaches that explain the role of self-help housing approach in achieving SDG's. The researcher reviewed information obtained from a variety of written material: government policy documents, books, journal articles, published and unpublished articles, internet and other publications, to inform the study based on what had been written before on the subject of self-help housing delivery and Sustainable Development Goals. The review of documents was necessary to draw from the sources on international and local experience in the context of self-help housing delivery in general and specifically the role of institutionalised self-help housing delivery in the context of Breaking New Ground (BNG) policy.

Neoliberalism is necessary for this study because it has influenced the current housing policy in South Africa and the role government plays in housing delivery. The study also made use of references from international agencies involved in housing, namely the World Bank and the United Nations Centre for Human Settlements (UNCHS) also known as UN-Habitat (UN-Habitat, 2000:185). Existing studies showed that the World Bank was the first institution to come up with the concept of site and services and has had an influence on National Housing and Urban Policies. The World Bank argued that the role of the government is to support the beneficiaries' efforts to build their housing on a progressive basis. The thematic analysis and interpretation of data was conducted following a qualitative approach. The thematic analysis of data is conducted according to the origin of self-help housing and post-apartheid planning for housing development in South Africa and the possible contribution this approach has or may have in achieving SDG's.

Findings and Discussion

This section presents a thematic analysis and interpretation of the literature review.

1.8.1 SDGs, BNG and Institutionalised Self-Help Housing

In an analysis where the BNG objectives to the SDGs it seeks to address (Table 1) are contrasted, linkages and contradictions are observed. At face value, both have a moral drive towards alleviating poverty and improving the lives of the impoverished. They both acknowledge the centrality of housing to basic service delivery, improved health and an overall improved quality of life. Institutionalised Self-Help Housing, however, in its traditional untailored form, is neoliberal. Neoliberalism is innately driven by exploitation, privatisation and commodification, it promotes individuality and is anti-static (Peck and Tickell, 2002). The moral drive for Self-Help then becomes questionable. These contradictions run deep in the South African state.

Table 1. Linkages between BNG objectives and SDGs

BNG objectives	SDGs addressed
Accelerate the delivery of housing as a key strategy for poverty alleviation.	1, 2, 3, 6,7, and 11
Utilise the provision of housing as a major job creation strategy.	1,2,3,5,8,and 9
Ensure that property can be accessed by all as an asset for wealth creation and empowerment.	5, and 10
Leverage growth in the economy.	8
Combat crime, promote social cohesion and improve quality of life for the poor.	1,2,3,10 and 16,
Support the functioning of the entire single residential property boom and the second economy slump.	1, 8, 9, and 16
Utilise housing as an instrument for the development of sustainable human settlements, in support of spatial restructuring.	9 and 16

Source: adapted from Department of Housing (2004) and United Nations (2020)

1.8.2 *Enabling a Neoliberal Approach to Housing Provision and power dynamics*

To understand or craft the nature of the state, we would have to historicise it. Understanding the economic devastation of its people, the Freedom Charter envisioned a state-centric developmental project. In other words, a developmental state where government's intervention is vital for the empowerment of a previously oppressed group (Stagar, 2008). The South African Institutionalised Self-Help Housing model assumes that its target group has the financial resources; it could be contradictory for the targeted group in the South African context. It could be excluding and disempowering the poorest of the poor. It appears to be applying neoliberal strategies to a group that perhaps requires a more morally driven developmental approach.

The formation of institutions for the housing delivery process needs to consider power dynamics and vested interests from multiple stakeholders, rendering the process counterintuitive. The rights and interests of the impoverished can easily be overpowered in such cases. Ntema (2011) advises that the involvement of the state to ensure the successful delivery of houses would remain key. The statement that 'people doing it by themselves and for themselves' could thus be an overambitious one in such a context.

1.8.3 Institutionalising the Provision of Housing for poverty alleviation

The BNG policy has an objective of using housing to create job opportunities but, outside of supporting local businesses, the policy is not clear on how an opportunity to be a member of the cooperation would be regarded as a job, as far as remuneration is concerned. Burgess' argument is that this approach assists government to achieve some of their fundamental responsibilities for housing delivery at the expense of the poor (Stein, 1991). Therefore, as much as the Institutionalised Self-Help approach can address some of the SDGs, the manner in which it is delivered can be seen as exploitive with little to no outcomes for the alleviation of extreme poverty. It can also be interpreted as the enablement of a markets approach to the delivery of SDGs, which can yield the developmental results. It also socially rises from a neoliberal, capitalist ideology, an approach known to reinforce poverty. One would want to recall that, the ultimate goal of the SDGs, just as the BNG, is to alleviate poverty (Gert and Kharas, 2018).

1.8.4 SDGs, BNG and Institutionalised Self-Help Housing towards poverty alleviation

As Institutionalised Self-Help Housing principles and the BNG are also orientated towards national economic goals where housing is a means to achieve neoliberal goals as well as the SDGs. This can be argued to present itself as a double standard as the moral drive of the SDG's is not the same calibre as the capitalist and developmental nature of neoliberalism.

Self-Help policies promote unpaid labour by the poor in the delivery of houses. According to Burgess (1977), this approach is an inhumane strategy by the state to achieve national housing delivery targets at the expense of the poor. SDGs advocate for sharing the wealth with the poor, not for further exploitation or to share wealth amongst themselves. According to Velencian analysts observing through a neoliberal lens, the concern with SDGs is that they reproduce the same status quo. This is because they employ a managerialist and technical approach without addressing the root causes of impoverishment which are created by neoliberalism itself (Belda-Miguel et al., 2019). According to McCloskey (2019), SDGs are toothless in the face of neoliberalism.

Harris et al., (2008) explains that South Africa's institutionalised approach to Self-Help policies is inherently contradictory. It is hedged between the boarders of neoliberalism and is a strategy for the state to maintain control over housing delivery. Harris et al., (2008) agrees with Bauman (2003) that the South African model to housing delivery has households who are in actual sense beneficiaries of a house that they built through a controlled and designed process. Within the South African context, which considers itself a hybrid developmental state, perhaps a more morally driven approach is necessary (Satgar, 2012).

Lessons can be drawn from countries like Cuba which upon its economy collapse in 1990, employed the Self-Help approach to housing delivery in a cautious way. Cuba managed the clash of its socialist nature to that of the neoliberal Self-Help policy by tailoring the Self-Help policy and contextualising it to their Socialist tradition by plucking out some exploitive neoliberal tendencies. Cuba used co-operatives but without the state's constant intervention as in South Africa (Harris et al., 2008).

Even with efforts where affordable/Self-Help housing is placed at the center of meeting the SDGs, self-help policies have not contributed significantly in the fight against the plight of poverty. The SDG 2020 report confirmed that the world is not on track to meeting the SDGs by 2030 (United Nations, 2020). To McCloskey (2019), the elephant in the room, is Neoliberalism.

Conclusion and Further Research

In conclusion, we can use the Institutionalised Self-Help approach to deliver a house in a settlement for those in need. It can ensure the delivery of basic services such as sanitation, improved safety and health, as well as an improved overall quality of life. Concurrently, as encouraged by the BNG policy, the procurement of building materials from local businesses is a way to support the local economy and improve the lives of the business owners. In this way, the neoliberal approach to housing, would have addressed a majority of the SDGs. This approach, however, is contradictory with many gaps and as far as the ultimate goal of the SDG's is concerned, the approach is likely to reinforce poverty, instead of 'leaving no one behind'.

Self-help would have been an ideal approach for the realisation of SDGs but it is influenced by vested interests, neoliberal tendencies, market forces, capitalist views that have commodified the house. Therefore, in the South African context, self-help housing as a process and an approach for collective effort and individual effort may have limited impact because of its neoliberal origins and influence. The paper's findings thus suggest that government in the delivery of housing through the application of the Institutionalised Self-Help Housing approach should consider the revision of policy to ensure the alignment of housing delivery to SDGs and inclusion of the moral obligations in this approach.

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Rethinking Resilience: Review of the Impact of Capability Maturity Models (CMM) on selected South African Category B4 Municipalities

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Abstract:
Category B4 municipalities in South Africa perform poorly in managing their infrastructure prompting a probe on the utilization of capability maturity models (CMM). The mismanagement is due to skills deficiencies occasioned by their inability to retain capable, and matured engineers and related construction professionals. CMM are structured improvement levels previously used in software engineering to develop employee skills in executing daily responsibilities, from impulsive and inconsistent, to mature and seasoned. This ongoing study seeks a rethinking of resilence on the skills programmes and explore the use of CMM in developing resilient employee infrastructure (IM) skills. Seemingly the current municipal engineering skills (ES) improvement programmes undermine the resilience component and ultimately service provision outcomes. The study aims at reviewing current infrastructure management capability maturity levels in selected category B4 municipalities. The study methodology will assume a qualitative case study approach involving the use of interviews and thematic analysis of data obtained. Conclusions will be drawn based on the selected case study municipalities. Interim finding is that, current capability maturity models (CMM) are devoid of the resilience element and are inappropriate for the category B4 municipalities. The study recommends a radical rethinking of resilience and how ES improvement programmes in the the local government sector are conceptualised. Founded on the existing 5-stage Organizational Project Management Maturity Model (OPM3) maturity model, the study seeks to review and to promote resilience in CMM for infrastructure management in category B4 municipalities.

Keywords: Category B4 Municipalities, Capability Maturity levels, Rethinking, Resilience, Skills programmes

Introduction

In South Africa there are 257 municipalities set out in various categories (A, B, and Cs) (RSA, 1996). Municipalities are allocated powers and service provision functions in terms of Section 155 of the Constitution, as well as the Municipal Structures Act No. 117 (MSA, 1998). Primarily, the constitutional powers and functions of municipalities are related to the provision and maintenance of services to their communities, which include water services, municipal roads and stormwater, solid waste collection, electricity, and firefighting services.

Table 1. Descriptions of municipal categories in South Africa

Classification of Municipalities	Number of Municipalities	Description of the Municipal Categories
A	8	Metropolitan municipality with select executive and legislative authority
B1	19	Local municipality with largest budget and secondary cities
B2	26	A municipality with a central large town
B3	101	A municipality with a relatively small population, mainly urban, and having no large town as a core. Rural areas in this category are characterized by the presence of commercial farms
B4	59	Mainly rural municipality with at most, one or two small towns
C1	23	District municipality with few service delivery functions, not a water service authority
C2	21	District municipality that is a water services authority and often with sizeable obligations

(Source: MDB, 2018)

The National Treasury (2018) framework for infrastructure delivery and procurement management (IDPM) revealed that category B4 municipalities are the worst-performing municipalities on service delivery indicators. Likewise, the Municipal Demarcation Board (MDB) demonstrates that category B4 municipalities are devoid of infrastructure management resilience to address service provision challenges (MDB, 2018). According to Khatleli (2017) despite the government investment in the construction of new infrastructure, obsolescence is a major challenge in South Africa. Category B4 municipalities perform poorly in managing their infrastructure prompting a probe on the utilization of Capability maturity models (CMM) which are structured improvement levels previously used in software engineering to develop employee skills in executing daily responsibilities.

Engineering organizations with the quest to promote systematic processes for employee skills and knowledge improvement, used CMM to respond to the dynamics of technological innovations (Nenni, et al., 2014). Employee adaptable maturity levels are therefore key in assessing organizational resilience and the resilience of the employees upon which the organization is dependent. Joseph (2013) avers that in order to maintain resilient competitive advantage, organizations must aim to cultivate specific employee capabilities in the medium to long-term. This ongoing study advocates for a continuous capability improvement pathway, to address the non-resilient, impromptu, incoherently executed practices. Wendler (2012) advocates for a mature, methodical improvement process of employee's infrastructure management skills and capabilities.

The research aim is to probe the utilization of capability maturity models (CMM) in selected category B4 municipalities. Furthermore, the study aim is to review current infrastructure management capability maturity levels in category B4 municipalities. The 5-stage epistemology will be used to heighten weak infrastructure management capabilities particularly, in this municipal category (PMI, 2013). Founded on the existing 5-stage OPM3 maturity model, the study encourages a radical rethinking of resilience in conceptualizing ES support programmes in the local government sector, particularly in category B4 municipalities. In order to satisfy the research objectives, a case study qualitative research design will be utilized using one-on-one semi- structured interviews. Thematic data analysis will be conducted in this research. Given that a case study will be the basis of this research therefore not representative of the category B4 municipalities in South Africa, and the fact that the study was thus narrowed in scope could be viewed as a delimitation.

Practically, it is anticipated that the identified maturity levels will be useful in refining a systematic improvement path for infrastructure management (IM) capabilities for category B4 municipalities. The expectation is that new emergent qualitative data from the capability maturity assessments will help confirm the maturity levels in the case study municipalities. Anticipated study findings will be a recommended systematic capability maturity framework incorporating resilience element, which will be developed to address IM deficits and maintain service provision normalcy in the category B4 municipalities, that are currently performing poorly in managing their infrastructure. In terms of policy contribution, it is hoped that this study would most probably be useful to the policymakers in changing the ways public infrastructure delivery is implemented.

Literature Review

Previous Engineering Support Programmes

Legoabe & Ngozwana (2012) posit that the Siyenza Manje technical and ES transfer programme aimed at transferring ES to candidate young professionals, has not yielded the desired results. The study findings further cited the downside of significant limited engineering activities in the category B4 municipalities, occasioned by lack of capacity and expertise. (Ibid). These findings are consistent with this study assumption that previous ES support programmes to improve infrastructure management capabilities in category B4 municipalities were not effective.

Lephotho & Khatleli (2019) have also commented on the limited effectiveness of expatriate professionals in transferring ES to candidate engineers in South African mega construction projects (MCPs). Using mixed-method data collection methods, this study found that there is no systematic transfer of ES during the implementation of MCPs. These findings are consistent with study assumptions that previous ES support programmes to improve construction management capabilities lacked the resilience component.

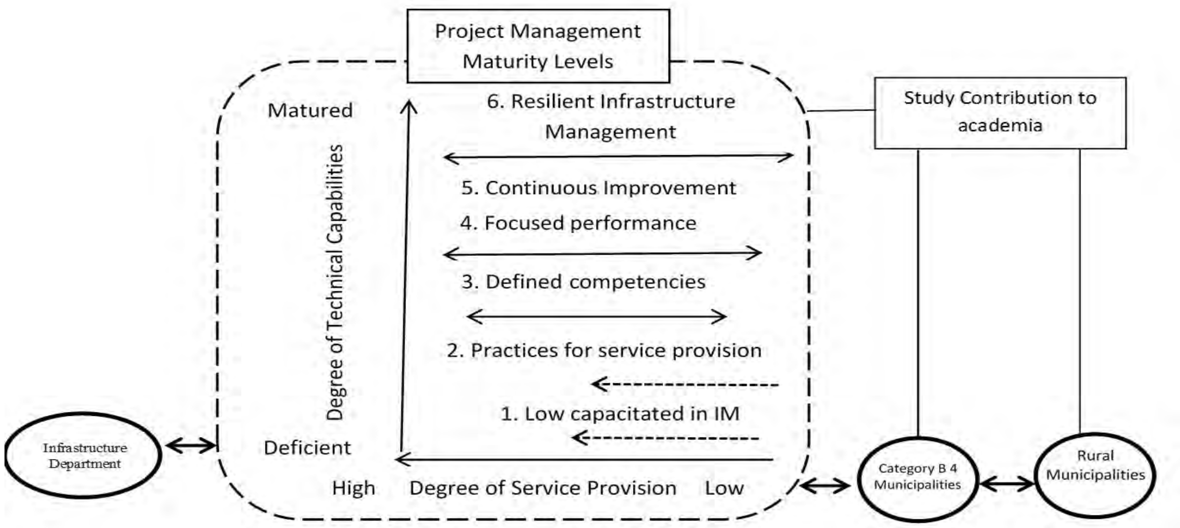
Further studies that employ qualitative approach to assessing the effectiveness of Section 139 of the Constitution as a viable instrument to deal with dysfunctional municipalities, as opposed to Section 154 which advocates for strengthening and supporting municipalities. Njikelana (2016) contends that these regulatory-support instruments were not achieving their objectives. Confirming these study findings is the trend wherein municipalities remain dysfunctional despite provincial interventions invoked through Section 139 or support programmes through Section 154 of the Constitution (COGTA, 2018).

It is for these reasons that this study aims to review current infrastructure capability maturity levels and, rethink resilience on the skills programmes that currently have little consideration of capability maturity, ultimately undermining resilience and therefore service provision outcomes. Likewise, Lephotho & Khatleli (2019) argue that the improvement of the engineering skills throughput in South Africa remains a national priority, which is essential for long-term socio-economic transformation. This study situates resilience as a context within which the design parameters of the capability maturity framework should be considered to model the capability improvement process, for application in under-capacitated municipalities.

Theoretical Framework

The theoretical framework for this study originated from the Organizational Project Management Maturity Model (OPM3) maturity model. The OPM3 model is defined by Project Management Institute (PMI) as the organizational project maturity model based on managing portfolios, programmes, and projects methodically towards achieving service provision objectives (PMI, 2013). The central notion of CMM is the continuous improvement process of key capacities at different levels (PMI, 2013). The conceptual thought is that actors will interactively produce their reality by assessing the level of IM capability maturity in category B4 municipalities using the OPM3 model. Maturity levels are accomplished when specified key capacities progression levels are concluded. The conceptual framework design process will assume the 5-stage epistemology underlying the OPM3 maturity model as depicted in figure 2.2 (PMI, 2013).

Figure 2. Suggested study Conceptual Framework



Source: Adapted from (PMI,2013)

The study will first review the current infrastructure capability maturity levels in the selected municipalities using the existing Project Management Maturity Model (OPM3). Project maturity assessments would be conducted to review the current levels of maturity in the implementation and management of infrastructure in the case study municipalities. It is anticipated that accomplishing the optimal level–5 would help category B4 municipalities to eventually move closer to addressing the resilience gap in infrastructure management capabilities. By introducing the six-level of resilience, this on-going study posits that resilience can only be built where there has been an appreciable investment in employee capabilities. In a nutshell, the study seeks to close the resilience gap in infrastructure management in category B4 municipalities. Interviews would be conducted with the technical employees in the infrastructure department. The OPM3 project management capability model entails charting key capability areas to maturity levels. The capability maturity assessment will assume the 5-stage principles underlying the OPM3 maturity model, using a pre- set excel worksheet (PMI,2013).

Level 1- Measuring the IM capabilities against the Project Management Body of Knowledge (PMBOK) knowledge Areas

The PMBOK project management knowledge areas will be used to benchmark and measure the current infrastructure management capabilities in category B4 municipalities against maturity levels. These requisite capabilities for resilient IM capabilities in the case study municipalities would be measured covering all 3-project management domains PMI (2013) project, programmes and portfolios.

Level 2: The Repeatable level of the CMM

Thus, the primary focus of this level "Repeatable level" is to instil discipline, deploying common processes to monitor project budgets, schedules and quality (SEI, 2009). Discipline on this level is about avoiding impulsive construction decisions, circumventing construction slipups due to hasty work, and firefighting, but building resilient capabilities to perform regular and repeatable basic project management practices.

Level 3: Defined level

This is the level where the experts are invited to help standardise the critical practices, infrastructure management processes, developing effective contingency approach for category B4 municipalities; define and collect and analysis to determine best practice.

Level 4: Managed level

Workforce competencies are integrated through mentoring, workgroups. documented combination of knowledge, skills, and process abilities to be imparted. At Maturity Level 4, mentoring activities are organized around the knowledge, skills, and process abilities to be imparted.

Level 5: Optimizing level

In applying the OPM3 organizational project management capability the organization will continue on its improvement path, using the percentage of fully achieved capabilities and capability outcomes, relative to the number that would be assessed for scoring. An alternative scoring provides a more quantitative assessment of maturity by measuring the extent to which capabilities are present in the organization. Results from the first scoring will represent the maturity level, that is, the degree to which the OPM3 methodology is implemented, which is comparable across all organizations. The second scoring, based on capabilities, gives a more detailed picture of the ability of an organization to "do right things well" (PMI, 2013). Reaching the optimal level would hopefully assist in closing the resilience gap in the infrastructure management capabilities.

Research Methodology

A case study qualitative research design will be utilized as an investigation strategy, using one-on-one semi- structured interviews to answer the research problem statement. The nature of this case study design will be both descriptive and exploratory (Creswell,2014). This study assumes the classical pragmatists' understanding that reality is continually in the making (Schwandt, 2003). The study will adopt a pragmatist approach with more practical outcomes, which is the interest of this ongoing study.

1.9 Case Study Municipalities

According to the MDB (2018), there are precise attributes of category B4 municipalities in the Eastern Cape Province. The Province is among the most burdened province of municipal technical services (MDB, 2019). This has resulted in service provision deficiencies in the category B4 municipalities, which still struggle to attract the requisite mature engineering skills (ES) to perform the municipal functions (National Treasury, 2019). The study resolved to select three municipal cases Nyandeni, Port St Johns and Mhlontlo as the units of exploration. These municipalities are situated within the OR Tambo District of the Eastern Cape. These rural towns remain the centre where goods and services can be accessed by the surrounding rural settlements of the municipality (IDP, 2018).

Figure: 3.1 Map of the Selected Municipalities
(Source: MDB,2018)

Two respondents who is the technical director and one technical employee in the infrastructure department would be selected in each municipality. These municipalities have been chosen due to their strategic geographic location. Subsequent to the data collection phase, the interview data will be thematically analysed and linked to the intended study objectives. Review of performance reports on previous engineering municipal support models including the Development Bank of Southern Africa (DBSA) Siyenza Manje programme will be used as an additional data collection tool to corroborate the results. This will hopefully enhance the credibility of this ongoing study findings. Content analysis will be used to analyse the data coming from the document review. The study scope is limited to the case study municipalities identified.

Findings and Discussion

Despite the on-going research on the ES deficit in local government, there has been no empirical study proffering a Capability Maturity Model (CMM) for resilient infrastructure management in dysfunctional category B4 municipalities. Given that this is an on-going study; data has not yet been collected. It is anticipated that findings from the qualitative interviews will be used to elicit pertinent views that could inform new resilience thoughts and innovations. This study will use a purposive sampling technique, wherein selected cases and research participants with a specific purpose in mind will be identified, as opposed to a random sampling approach which is not suitable for exploring the study's central phenomenon (Guthrie, 2010). The expectation is that new emergent qualitative data from the capability maturity assessments to be conducted will help confirm the maturity levels in the case study municipalities. It is envisaged that the study findings will assist in providing meaningful recommendations on a methodical continuous capability improvement pathway incorporating the resilience component, for infrastructure management resilience in category B4 municipalities. The study findings will eventually inform the design of a Capability Maturity Framework (CMM) for resilient infrastructure management in category B4 municipalities.

Conclusion and Further Research

The local government sector is in a continual search for research studies that can aid resilient employee capability reclamation endeavours. To date, there has been no recommended systematic capability maturity model developed to address IM deficits and maintain service provision normalcy in dysfunctional category B4 municipalities. The expectation is that the study recommendations would solicit new resilience thoughts and innovations in deploying Capability Maturity Models (CMM). It is anticipated that the study would yield the same results as it was the case with software engineering sector that achieved employee improved capabilities by employing CMM. Inspired by the existing OPM3 capability maturity template, the current identified maturity levels will help structure and develop employee skills improvement pathway. It is further envisaged that the recommendations will help improve technical employee skills in executing daily infrastructure management responsibilities in the case study municipalities. Thus, replicating what the software engineering sector achieved by employing CMM.

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Effects of combustion generated pollutants on the indoor air quality of university laboratories

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Abstract:
Health threats in a learning environment can jeopardize the entire effort of teaching and learning. One of such health threats is the presence of hazardous gaseous elements within the building interior due to learning processes such as combustion activities, especially in laboratories or from the external environment. This paper assessed the perception of laboratory users on the effect of combustion generated pollutants on the indoor air quality of a typical university laboratory using some selected laboratories in Ahmadu Bello University Zaria as a case study. A well-structured questionnaire was designed and administered to a hundred and twenty-seven laboratory users randomly selected. Data collected were analyzed using a computer-based software SPSS version 16.0. The results revealed among others that combustion processes in laboratories is a major contributor to poor indoor air quality compared with other learning processes; fatigue (RII: 0.81) was identified as the most prominent symptom of poor indoor air quality during combustion among other symptoms like; coughing and sneezing; dryness and irritation of eyes and throat; sinus congestion; shortness of breath and headache, arranged in the order of intensity. The absence of functional fume hoods, congestion in laboratories and inadequate ventilation system intensify the discomforting effect of combustion generated pollutants in laboratories. Hence, provision, where there are none and adequate maintenance of fume hoods for functionality, is recommended. Consequently, the construction of new laboratories to accommodate the students enrolled to avoid congestion in the laboratories is highly recommended.

Keywords: combustion generated pollutant, indoor air quality, sustainability

1 Introduction

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

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

IAQ as the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants (USEPA, 2020)

In developing countries like Nigeria, the main source of indoor air pollution is biomass which contains suspended particulate matter like nitrogen oxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO) formaldehyde and polycyclic aromatic hydrocarbons (PAHs). However, in industrialized countries and NO2, CO and formaldehyde, radon, asbestos, mercury, human-made mineral fibers, volatile organic compounds, allergens, tobacco smoke, bacteria and viruses are the main contributors to indoor air pollution (David, 2010).

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

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

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

This paper examines the perception of the laboratory users on the impact of combustion generated pollutants on the indoor air quality of the laboratories considering the users' lengthy exposure during research activities.

2 Literature review

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

i) The nature of outdoor air quality around the building
ii) The ventilation rate of the building
iii) The materials used in the construction of the building (presence of chemicals)
iv) The activities that go on inside the interior (cleaning, cooking, heating etc.)
v) The use of household chemicals

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

Smith and Zhang (2005) studied the indoor air pollution from household fuel combustion, and estimated that air pollution from solid waste in China is responsible for 420,000 premature deaths annually with more than 300,000 attributed to the pollution of the urban outdoor environment. To help elucidate more fully the extent of hazard caused by combustion of pollutants in China, Smith and Zhang (2005) reviewed nearly 200 publications in china reporting health effects, emission characteristics and/or indoor air pollutants concentrations associated with solid fuels. Smith and Zhang (2005), also took measurements in 122 individual studies, from which they concluded that indoor air pollutant concentrations exceeded health standards in many of the households.

In like manner, Stanley (2010) assessed the environmental suitability of electric power generators for power supply to buildings with a view to devising appropriate control measures for a cleaner environment. The assessment was for buildings within Kaduna metropolis and the approach adopted was the use of both a well-structured questionnaire and an IMR 1400C combustion gas analyzer. The research results showed that the level of awareness of health hazards caused by generators was high and that the mean concentration of SO_2 and NO_x indoor was higher than the FEPA limits (0.01ppm and 0.04-0.06ppm), respectively. The research also revealed that none of the ambient pollutants met the WHO and FEPA limits at the point source.

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

2.1 HVAC requirements for a laboratory

Several write-ups have been done regarding the heating, ventilation and air conditioning (HVAC) requirements for a laboratory; with the emphasis being on the energy usage common to laboratories and the comfort requirements. According to Lindsay (2010), an HVAC engineer’s prime concern when planning or constructing any laboratory building is the safety of the building’s occupants. The system must operate to specification and meet appropriate regulations. To this end, many older laboratories were designed with little regard to energy efficiency. That’s no longer true, and designers must account for operating costs as well as functionality (Lindsay, 2010).

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

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

3 Methodology

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

3.1 Data analysis procedure

Most of the questions in the questionnaire involved assessing some indices of utilization on a five (5) point Likert's scale. The data analysis, therefore, employed the following steps.

a. Computation of the mean using the weighted average formula

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

Where,

$\sum fx$ = is the total weight given to each attribute by the respondents.

$\sum f$ = is the total number or respondents in the sample.

K = is the highest weight on the Likert scale.

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

RII<0.60 -it indicates low frequency in use

0.60≤RII<0.80 -it indicates high frequency in use.

RII≥0.80 – it indicates very high frequency in use.

4 Data presentation, analysis and discussion

Data from the expert opinion survey are presented in Table 1.

Table 1. Laboratory combustion activities

S/N	Variable	Option	Frequency	Percentage (%)
1	Combustion in laboratories:	a) Yes	94	74.0
		b) No	33	26.0

		Total	**127**	**100**
2	Heat generating device frequently used :	a) Stove	16	12.3
		b) Gas burner	89	70.1
		c) Hot plates	22	17.3
		d) Candle	0	0
		Total	**127**	**100**
3	Presence of functional fume hood:	a) Yes	40	31.5
		b) No	27	21.3
		c) Not Aware	60	47.2
		Total	**127**	**100**

Source: Field survey, (2020)

From Table 1, it is observed that the majority of the respondents opined that their work entails combustion (74.0%). Also, the major heat-generating device frequently used in the laboratories as opined by the respondents is the gas burner (70.1%). Concerning the presence of a functional fume hood installed in the laboratory, most respondents (with frequency of 47.2%) were not aware of its presence and its functional status; this corresponds to 47.2% of the respondents.

4.1 Combustion and ventilation in laboratories

The perceptions of the respondents with regards to the impact of combustion activities in the laboratory as well as the evaluation of the adequacy of the ventilation system were also assessed. Table 2 below, presents the results of the assessment.

Table 2. Combustion and ventilation in laboratories

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

Source: Field survey, (2020)

It can be observed from Table 2, that combustion is a source of discomfort, as observed by 92.1%. Also, it can be observed that of all the processes identified combustion was more discomforting (54.3%). With regards to the ventilation system, it is obvious that the ventilation is not adequate as 79.5% of the respondent attested to it.

4.2 Health symptoms of poor indoor air quality

Several health symptoms of poor indoor air quality were assessed and the respondents ranked these symptoms. Table 3, presents the ranking of the various health symptoms that serve as indicators to poor indoor air quality. From Table 3, it is observed that the respondents ranked fatigue (with RII= 0.81) as the most reoccurring health symptom. Also, it is observed that only symptoms like fainting and nausea had a relative importance index less than 0.6, indicating that they are not a commonly observed symptom. Also from the mean values, it can be deduced that the values were closer to the Likert weighting of four (4) an indication that the respondents' general opinion was that the symptoms were truly an indication to poor indoor air.

Table 3: Ranking of the health symptoms of poor indoor air quality

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

Source: Field Survey, (2020)

Where: 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

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

The questionnaire also sought the respondents' opinion regarding how the heating ventilation and air conditioning (HVAC) system and combustion contribute to the poor indoor air quality of laboratories. The respondents' opinions and ranking thereof are presented in Table 4.

Table 4: HVAC and Combustion Related Activities that Affect Indoor Air Quality in Lab.

	WEIGHTNG/RESPONSE FREQUENCY									
CAUSES	**1**	**2**	**3**	**4**	**5**	**(∑f)**	**∑fx**	**MEAN**	**RII**	**RANK**

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

Source: Field survey, (2020)

Where: 1= not a cause, 2 = not a major cause, 3 = barely a cause, 4 = a cause, 5 = always a cause

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

4.4 Remedial action to poor indoor air quality in laboratories

Table 5 gives the respondents ranking of the various remedial measures to poor indoor air quality identified. It also gives the percentage response per option as well as the mean.

Table 5: Remedies of poor indoor air quality

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

Source: Field Survey, (2020)

Where: 1 = not Effective, 2 = no effect, 3 = slightly effective, 4 = Effective, 5 = very effective

From the Table 5, it can be observed that the highest ranked remedy to the poor indoor air quality by the respondents is the provision of adequate heating ventilation and air conditioning system (RII= 0.87). Also from the mean values, it can be established that in general the respondents opined that the identified remedy were all feasible options as the value of the mean is closer to the Likert weighting of four (4).

5 Conclusion and Recommendation

Combustion activities are practically unavoidable in teaching and learning of practical science courses. The major source of heat for the combustion activities is the gas burner except in few cases of limited gas supply, when the water bath is used as an alternative heat generating source.

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

As a matter of urgency, the school authority should try and construct new laboratories to address the overcrowding challenges in the laboratories that have intensified the effect of combustion activities, which in turn affect the indoor air quality. This would also help in accommodating the teaching and learning of the students enrolled.
Proper attention should be paid to maintaining the heating ventilation and air conditioning (HVAC) systems of the laboratories, particularly the fume hoods.

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Artificial Neural Network Models: Conceptualized and Improved Method of Contingency Assessment for Nigerian Building Projects

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Abstract:
Precision in estimating the contingencies in project parameters has been difficult in Nigeria despite the numerous available computational techniques. This study aims at exploring the predictive ability of artificial neural network with a view of designing prediction models and ascertaining efficiencies. Secondary data from a recently completed research based on projects in the North Eastern Nigeria were analyzed. Their surveyed construction cost ranged between ₦103.80 million and ₦303 billion, while delivery periods were between 20 and 192 weeks. Others are high cost and duration drivers, which formed the artificial neural network (ANN) models input variables, 210 cost and 199-time data sets formed the output variables. Mean contingencies of 6.46% and 7.06% for cost and duration were established from the developed models. The study concludes that the developed ANN forecasting models can aid the construction contractor in estimating project contingency of higher precisions. It, therefore, recommends the conversion of the developed models into Dashboards for contractors' use.

Keywords: Artificial neural network, contingency, cost and time modelling, estimating, North-East Nigeria

1 Introduction

Determining the comprehensive budget and duration of proposed construction projects have been difficult. This is because of the difficulty in ascertaining the contingencies that are inevitable while constructions are in progress. Contingencies are extra funds and time included within the budgets and construction programmes so that total finances and schedules can be committed. In other words, contingencies are provisions for absorbing the increments in funds and schedules that are unavoidable in managing the risk of overruns on project goals (AACE, 2010). Accurate estimations of contingencies are, therefore, of critical importance to construction project success. Such reserves in funds and time can significantly impact when the estimates are higher than the optimum, thereby encouraging untidy project cost and schedule control. Invariably, the completed buildings become costly and unprofitable and deprive the company of monies that could have been invested elsewhere. If the contingencies are underestimated and rigid, they could set unrealistic financial and duration issues, and the consequences are usually unsatisfactory performance. Questions this study intends to answers are how effective have been the contingency sums hitherto included in the building construction projects vis-a-vice the methods used in the derivations? Can the current methods previously used in the provisions of contingency sums in Nigeria be described as satisfactory? Can a more scientific method of contingency computation for building construction projects be explored?

This study aims at exploring the forecasting power of ANN with a view of designing building construction project cost and time prediction models and ascertaining the efficiencies. The objectives are to (i) investigate the current estimating techniques used for deriving the contingency sums for building project budget and schedule (ii) develop ANN models for project cost and schedule estimation (iii) establish building project budget and schedule contingencies from the developed ANN models. The scope is limited to 246 completed government-owned buildings in the North-East geopolitical zone of Nigeria. Results of this study shall have a significant impact on future building construction project economic management.

2 Contingency Sums Estimating Techniques

A set of techniques for construction resources estimation exist for computing the budget and time contingencies. These are Analytical Hierarchy Process, Fuzzy Sets, Influence Diagrams, Individual Risks – Expected Value, Factor Rating, Methods of Moments, Monte Carlo Simulation, Range Estimating, Regression Analysis, Theory of constraints, Traditional (Customary) Percentage, and recently ANN. The customary percentage method is the most used; however, Monte Carlo Simulation, Regression Analysis have become famous while ANN modelling technique is increasingly being embraced in the advanced economies. The customary method of contingency sum determination has continued among estimators for the past years. It is a general percentage increment of the basic quantity of cost or schedule, usually recalled instinctively or obtained from records and knowledge from past projects. For instance, an addition of about 10 – 20 per cent of the basic, to determine a working estimate. This is common to firms in the construction industry.

According to Otali & Odesola (2014), the customary method is arbitrary, subjective, unreliable, grossly inadequate, and it is not easy to defend or justify as it is unscientific and helps in over budgeting. This research investigates Ameh *et al.*'s (2010) suggestion of a thing that should evolve with scientific management principles. Its results hopefully will replace the general and unscientifically related addition to the basic sum.

Recently, the weakness of the general addition approach has led to research into more robust methods of contingency funds and extra time determination as artificial neural network. The use of ANNs for project parameters estimation has grown such that the models can now be used to predict project cost and time overruns that are needed as precautions right from project onset. When adequately computed, they become management tools and contingency approaches of higher precision than current methods.

2.1 The ANN Models

Some construction industry researchers had ventured into ANN with recorded success because of the numerous advantages. These include (i) ability to appropriate, expressing, and mapping facts involving two or more variable quantities to an additional set of details, (ii) information processing in a pattern like the human brain, (iii) power of deriving sense from sophisticated, random, and inexact statistics, (iv) detecting inclinations that are compounded and certainly not done by alternative problem-solving devices (v) it is used for projections where new situations of interest arise, and (vi) ability to answer hypothetical questions. A good number of problems that have defiled rule-based programming in different fields have been solved with ANN, because the model works on a training and learning concept. Like the stochastic relationships between the multivariate construction cost and time drivers and the associated impacts on the initial targets, the desired models should be most suitable.

In the network architecture, the value of all weighted inputs impels the degree of the level of inducement that is further altered by a triggering function to produce the output signal, summarized in an output represented by 0. The output is denoted by $f\ (\sum_i WiXi)$. X_i and W_i *are* the ith input and matching weight. The stimulation can be a threshold function, or a smooth function like a sigmoid or hyperbolic tangent function and is represented by f. Neural network representations in machine learning or artificial intelligence (AI) are commonly referred to as ANNs; which are in essence simple computative equations defining a function $f: X \rightarrow Y$ or a spread on X or both X and Y.

2.2 Contingency computations for construction projects using ANN

Chen & Hartman (2000) is one of the past studies that utilized ANN to forecast the final amount of a concluded construction project. The authors found that 75% of the predicted final figure aligned with the real deviations, pointing to the fact that variabilities indeed happened as predicted by the network. This meant that if the part left out of 100 (100 – 75) i.e., 25 % were to be provided as extra fund as contingent sum, there could have been nothing left to call overrun or underrun. Oboirien (2019) computed sums complementary to the efficiencies of twelve ANN construction parameters estimating models and found an average of 10.21% herein called contingency sum.

2.3 The research concept

The persistent occurrence of budget and schedule slippages in building work globally indicates that more research effort is required if the outcomes are to be kept close to the set objectives. The evidence is found in the works of Flyvbjerg (2005), Edwards & Kaeding (2015), Idiake *et al.* (2015), Amusan *et al.* (2017), where projects overran their initial cost and time parameters by over 50 to 100%. In Nigeria, the slippages are up to 500%. For example, Oraegbune (2008) found 683.33% time overrun on NIPOST Headquarter buildings, 400% cost overrun on Upper Benue River Basin Development Authority Dam, all in Yola, Adamawa State capital. Since, estimators normally allow for budget and programme risk mitigations (contingencies) at planning stage, the current high variability between the initial and final project outcomes supports the argument that an innovative and more robust technique over the orthodox and popular ones is now needed in the industry.

Mean contingency allowance 10.21% common to projects estimated with ANN models is very well lower than the overruns recorded globally, ranging between 36.02 to 138%. Obviously, if all construction project parameters were forecast with ANN, the current unbearable slippages in the global construction industry would obviously be minimal and manageable. Currently, only about 7 % of research on budget and schedule assessments that applied ANN forecasting technique are based on the African context (Oboirien, 2019). More effort is still required in conceptualizing solutions to the current high construction cost and time slippages via a more precise contingency estimation method in developing economies like Nigeria. This research is therefore focusing on addressing the knowledge space (gap) articulated in the preceding section.

3 Research Methodology

The study centre was North Eastern Nigeria which comprised six states but excluded two: Borno and Yobe, due to the intense insurgency activities of an Islamic sect (Boko Haram). The study sample was 246 public building projects spread across Adamawa North, Adamawa South, Bauchi State, Gombe and Taraba States. Adamawa was divided into two to ensure a reasonable project spread. While the construction cost ranged between ₦303 billion and ₦103.80 million, the shortest construction duration of the project studied was 20 weeks; the longest was 192 weeks.

3.1 The study's ANN models development steps

Five steps were involved: data gathering, examinations and presentation, followed by network layout definition, the learning step, training and testing of the model and lastly, establishing the models' efficiency levels (validations).

3.2 Determining the ANN input and output variables

Oboirien (2019) identified the main driving factors on 210 and 199 completed buildings in the study area that formed the ANN models' input (influence) and output (impact) variables. The cost and duration factors' influence were computed from research participants' responses from the administered questionnaire. The performance impacts (model outputs Z_c and Z_t) on the project and planned durations were calculated with the following equations (1) and (2). The values were fed into the ANN software.

$$\text{Output variables } Z_c = \frac{\textit{Final cost} - \textit{Initial contract sum}}{\textit{initial contract sum}} \quad (1)$$

$$\text{Output variables } Z_t = \frac{\textit{Actual construction duration} - \textit{Estimated construction duration}}{\textit{Estimated construction duration}} \quad (2)$$

3.4 Division of data into training, learning and validation sets

The cleansed input and output data sets were divided into two in a ratio of 80% to 20% (Gunaydin & Dogan, 2004). The divided data are 209 for cost and 198 for the time. Though there are not yet acceptable generalized rules for deciding the size of suitable training data; Setyawati *et al.* (2002) advised for training samples that should cover all sections of the available statistics.

3.5 Data mining for pattern learning

The larger of the two divided data sets was used for detecting inhibited patterns in the collected data (data mining). In this step, any patterns or relationships in the variables found to be continuously uniform are used on new data sets for purposes of checking or proving acceptability. This step aims to search for relationships that have predictive potentials for improving an existing system. For instance, a mechanism for forecasting project parameters in which differences between the initial and outcomes can be consistent in various data sets, which are acceptable differentials (contingency) that construction project planners need the awareness and factored-in at the pre-contract stage. This dimension is yet to gain popularity in construction research, but Yang *et al.* (2003) found its use in construction equipment productivity estimating. Other studies that have benefited from data mining are Yu and Lin (2006), and Cheng *et al.* (2012). The studies are respectively in construction management knowledge refinement, workplace accidents and concrete strength forecasting.

This is the model teaching stage that needs the sourced data prepared and acquire the model learning principles. Backpropagation (backward propagation of errors) is the intrinsic nature of neural net training. It is the method of fine-tuning the weights of a neural net based on the prevailing rate of error in the preceding epoch (i.e., iteration). Backpropagation is an accepted mode of nurturing ANNs. It aids in computing the slope of a loss function regarding all the weights in the network. Appropriate tuning of the weights allows for reducing error rates and makes the network well-grounded since it increases its judgement. It is classified as supervised machine learning because it requires a known output for each input value. It computes the loss function gradient to determine the unknown relationship in a repeated data feeding.

Model training is stopped when a stated number of iterations is reached. Performance measures are applied to pick the best network configuration, the training rules, and the criteria. These are Root Mean Squared Error (RMSE) given in equation (3).

RMSE is expressed as: $\frac{\sqrt{\sum_{i=1}^{n}(t_i - o_i)^2}}{n}$ (3)

Number of projects in the sample is represented by n, t_i actual impacts computed from survey data, and O_i is model's predicted impacts.

4 Findings and Discussions

4.1 Details of research participants

246 respondents from the study centre each supplied data on a project. Details of professions, membership of professional associations, stakeholder category and years of industrial experience are shown in Figures, 1, 2, 3 and 4. Participants were built-environment professionals i.e., registered builders (45.53%,) while mechanical, electrical, civil, and structural engineers combined (25%). Others were architects (21%), and quantity surveyors (8%) depicted in Figure 1. A breakdown of participants' corporate membership of professional association indicates that all were in the full membership grades, except the builders, quantity surveyors, and engineers with a small percentage on graduate membership grades (Figure 2).

A large portion was in the employment of main and subcontractors, while others worked in corporate clients and consultancy firms (Figure 3). In terms of years of experience, there were five classes. Between 11-15 years fell into the modal class of 19 %. The lowest and largest classes of 16-20 and 6-10 years are 9% and 33 %, respectively (Figure 4). The supplied data are, therefore, adjured fit for use in the analysis.

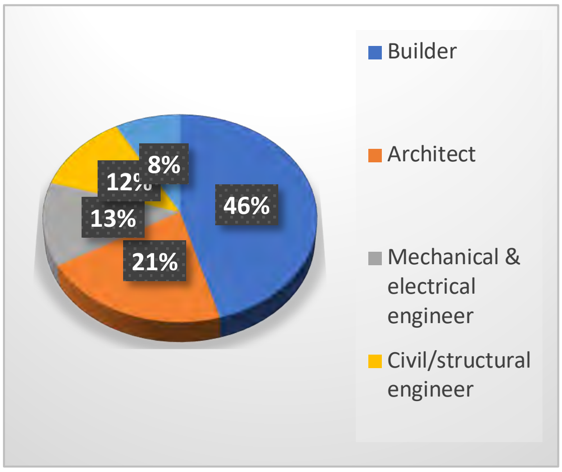

Figure 1. Respondents' professional background details

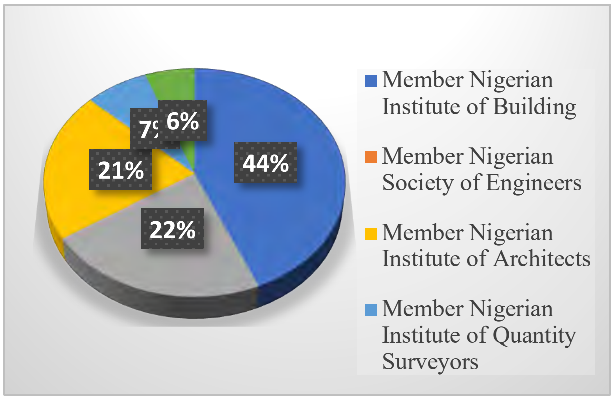

Figure 2. Respondents' membership of professional association

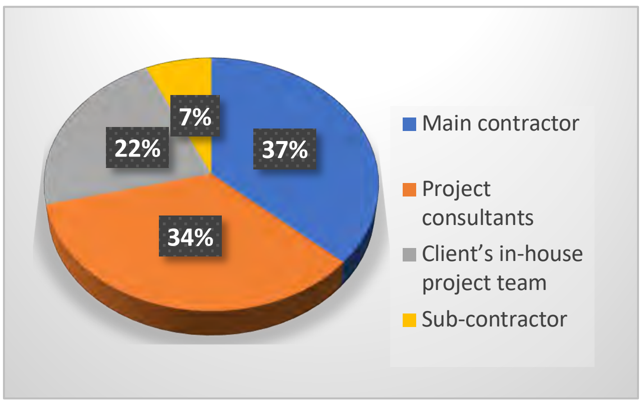

Figure 3. Respondents' stakeholder category

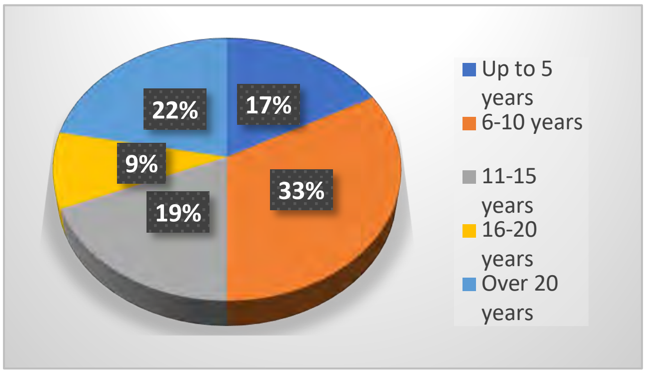

Figure 4. Respondents' professional experience

4.2 The ANN building construction project cost and time contingency estimation models

Pairs of the processed independent and dependent data sets were trained using Smart Lab, an ANN software. To understand the pattern of association between the inputs and output data, 294 cases were reduced to 209 datasets, due to incorrect filling of questionnaire by the research participants and a sieve from outlying data. These were used in the analysis. Using the 80: 20 % data ratio as stated earlier, 168 datasets which were 80% were used in training the cost influence and impact prediction network. The other 41 datasets were used in confirming if the outputs of model are acceptable (validation).

Model training began with the data divided into 70:30 ratio, and sample adjustments till it had a good performance at 80:20 division. Trials' RMSE of the trained model was computed using equation (3). This good performance is an indication that the interconnection is now reasonably knowledgeable about the association between the inputs and outputs and could effectively generalize from fresh data sets. The iterations resulted in 18 hidden nodes of two layers. Normally enough processing elements are based on hidden layer trials as there are yet to be the authoritative rule for determination. The model after many iterations, went through a gradual transformation process in a backpropagation that resulted to 9-9-9-1 layout. 0.75, with 5288 training cycles was found as best network from the series of trials, with the set error in training reduced to 0.001. The stabilized and final model becomes a prediction model for construction cost forecasting. The subtraction of the model efficiency determined using the reserved validation data, from one hundred gave the desired cost contingency estimate, by the ANN construction cost forecasting model.

In similar trials, network model training for the construction factors' influence and impact on planned duration stabilised at the 80:20 data division. 159 datasets represented 80% of the survey figures were used for the duration impact network training, while 39 raw data were reserved for use in confirming the model's level of training. The resultant network configuration was 10-6-6-1. In this case, the impact training cycles (epochs) read 1534 while the learning error was 0.80. Training inaccuracy was configured to gradually decrease and get as small as one-thousandth (0.001).

4.3 ANN models validations and construction project cost and time contingencies

The validation tests conducted on the developed network models were comparable between the predicted and real values, using the reserved raw information. The computed RMSE statistic enabled validation of the trained models. The forecasting efficacy of the developed cost impact network is 93.54%. This implies a contingency of 6.46% when 93.54 is subtracted from 100.

In a similar process, the models' development process evaluation conducted were considerations of similarities between the predicted and the true impacts from the designed duration model and those computed from the reserved sourced data. Again, the statistical verification technique used here is RMSE. The 39 datasets representing 20% of the survey data reserved for testing the forecasting precision of the duration network were used. Input variables that influence the driving factors, and output variables which were the duration impacts or extra times over the planned were entered into the model. The ANN network was asked to forecast the duration impacts (ratios of the difference between estimated and actual construction times on the originals). The RMSE statistic of the developed duration impact forecasting model represents the required construction programme contingency. This was determined when the validated construction duration impact estimating model efficiency is subtracted from a hundred (100 – 92.94). Therefore, construction programme contingency found in this study is 7.06%. The study results compare favourably with related research outside Nigeria. For instance, Gunaydin and Dogan (2004) made use of eight design criteria to estimate the price per unit area of a reinforced concrete structural complex in low-rise private homes; the network produced a budget precision of 93%. The remaining 7% serves as a needed contingent sum. Similarly, the work of Aibinu, Dissanayaka, Chan, and Thangaraj (2015) on cost estimation for electric and power elements during building design, using a neural network approach, resulted in forecasted contingency sums of 6.4, 4.5 and 4.5% for cable pathway, light wiring, and power wiring, respectively.

Since Chen and Hartman (2000) revealed the predicted values same as actual project values, it can be concluded that ANN models for construction project parameter estimating have higher prediction accuracies than the traditional methods still popular among Nigerian estimators. The network prediction models are, therefore, better. Since, construction project planners normally allow for budget and programme risks mitigation from onset using at least one convention technique. The current industrial status in Nigeria (where budget and schedule slippages in multiples of hundreds are still prevalent) beckons on the researcher to explore further into improved construction resources estimation technique like the ANN prediction models, designed in this study.

5 Conclusions and Recommendations

Ascertaining the inevitable project contingencies with precision has been difficult, and not much has been achieved in Nigeria with current methods. The study explored the predictive ability of ANN with a view of designing building project budget and construction duration prediction models as well as ascertaining their efficiencies. The objectives were, (i) investigate the estimating techniques used for computing project cost and time contingencies (ii) develop

ANN estimating models for construction project cost and time (iii) establish building construction project budget and schedule contingencies from the developed ANN models.

Twelve forecasting methods for budget and activities programme contingencies were found in the existing literature. They are Analytical Hierarchy Process, Fuzzy Sets, Influence Diagrams, Individual Risks – Expected Value, Factor Rating, Methods of Moments, Monte Carlo Simulation, Range Estimating, Regression Analysis, Theory of constraints, and Traditional Percentage. Their use, however, are yet to meet the desired industrial satisfaction in terms of zeroing out project overruns via a highly efficient contingency forecasting technique.

This research developed ANN cost and time prediction models that validated efficiencies 93.54% and 92.94%. These translate to 6.46% and 7.06% cost, and duration percentage complements, herein referred as estimated contingencies using the data sourced from government-owned buildings in Nigeria's North East geopolitical zone. The implications are ANN model-based project budget and duration predicted, can assist the constructor in estimating contingencies of higher precision than the methods hitherto used in the industry. It, therefore, recommends the conversion of the developed models into Dashboards for use by building project designers and managers.

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Frameworks for remuneration of construction consultants during unwarranted project time overrun in Nigeria

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Abstract:
This study postulates frameworks for remuneration of consultants in the event of construction project unwarranted time overrun. Compensation clauses in Nigeria, standard bidding documents (SBD) for procurement of works 2011 version for clients, contractors, and consultants were examined and compensation frameworks for consultants were postulated in case of unwarranted time overrun. The target population constituted Architect, Quantity Surveyors, Structural Engineers, and Mechanical cum Electrical Engineers. Primary data were obtained through a structured questionnaire by random sampling technique. Secondary data were obtained from conditions of contract and extant literature. Primary data were analyzed using frequency distributions aided by Microsoft excel 2016 version and results presented in tables. The study is limited to building projects funded with Tertiary Education Trust Fund (Tetfund) in Nigeria. Liquidated and ascertained damage (LAD) and interest on delayed payment calculated after the statutory 28 days duration for payment are all covers for the contracting parties. However, there is no provision in the standard bidding documents for compensating consultants in the event of unwarranted time overrun. The study thereby postulates measures for compensating consultants during unwarranted time-overrun. These include payments to consultants by the defaulter through 10% of the cost of works yet to be executed at the expiration of the contract period Man-Month approach and agreement between the consultants and the culprit.

Keywords: Construction, consultants, time overrun, remuneration

1 Introduction

Project time overrun is inimical to the performance of construction projects in Nigeria and the world over (Ade-Ojo and Babalola, 2013; Nasser, 2013). This results in adverse multiplier outcomes both to the client and the contractor. Ade-Ojo *et al.* (2013) identified a decline in the anticipated profit of the contractor and delay in the client taking custody of the project as a product of time overrun. Odeh and Battaineh (2001) adjudged 28 factors that necessitate time overrun and concluded that the most outstanding factors responsible for time overrun were the contractor's inexperience and the client's shillyshally attitude in decision making. Kadiri and Shittu (2015) cited Ameh and Osegbo (2011) and observed that time overrun in Nigeria construction sites could allude to the client, contractor, and external factors, which include; a glitch in the client's ability to honour payments certificate, contractor's ineffective project implementation. Majid (2006) also identified 16 significant proponents of time overrun, which clients and contractors cause. Kadiri *et al.* (2015) opined that both the positions of contractors and consultants (client's agent) agreed that time overrun mostly occurred due to financial hitches, inadequate project details, and clients' intrusion. From the foregoing, it stands out that time overrun as pitching a tent, so to speak, with construction projects in Nigeria. It appears that Nigeria standard bidding document for procurement of works (SBD), (2011) edition provides a cover for both the client and contractor in the event of defaulting in payment and unwarranted time overrun, but with no known cover for the consultants who are essential to the entire procurement process.

This study thereby postulates frameworks for remuneration of consultants in the event of construction project unwarranted time overrun in Nigeria. The aim of the study was achieved by examining the compensation clauses in the standard bidding documents for procurement of works 2011 version for client, contractor, and consultants, examining time performance of Tetfund sponsored projects in Nigeria and assessing suggestive compensation module for compensation of consultants during time overrun. Based on these, frameworks were postulated.

2 Review of Nigerian Standard Bidding Document (SBD) for Procurement of Works - 2011 Version

2.1 Unwarranted Time Overrun (UTO) Defined

For this study, unwarranted time overrun refers to any period after a justifiable extension of time was/were granted during construction wherein liquidated, and ascertained damage is deemed to apply.

2.2 Tertiary Education Trust Fund (Tetfund) Sponsored Projects

Tetfund sponsored projects are construction projects supported by the dedicated fund by the federal government of Nigeria. The beneficiaries include mainly tertiary institutions (universities, polytechnics, monotechnic, colleges of education) and other government parastatals.

2.3 Compensation Plan for Client during (UTO) in Nigeria

Three unavoidable factors moderate construction works; time, cost, and quality (SBD, 2011). If the contractor's actions or inactions result in unwarranted extended time, the conditions of the contract provide a compensation plan for the client. SBD (2011) *sections 46.1,*

> *"States that except in case of Force Majeure, as provided under GCC Clause 41, a delay by the Contractor in the performance of its Completion obligations shall render the Contractor liable to the imposition of liquidated damages under GCC Clause 68, unless an extension of time is agreed upon, according to GCC Sub-Clause 46.2."*
>
> *"If the Contractor fails to complete the Works by the Intended Completion Date, as extended by the Engineer as the case may be, the Contractor shall be liable to pay liquidated damages to the Employer, under GCC, Sub-Clause 68.1."*

2.4 Compensation Plan for Contractor during (UTO) in Nigeria – Delayed Payment by Client

SBD (2011) provides a compensation plan for delayed payment outside the conventional twenty-eight days (28) of honoring payment requests submitted by the contractor. According to SBD (2011) section 63.1, *"If the employer makes a late payment, the contractor shall be paid interest on the late payment in the next payment. Interest shall be calculated from the date by which the payment should have been made up to the date when the late payment is made at the prevailing interest rate for commercial borrowing established in Nigeria".*

3 Research Methodology

The study adopts positivists' position. The target population constitutes relevant Consultants (predominantly engaging in consultancy) in the Nigerian construction industry: Architect, Quantity Surveyors, Structural Engineer, Mechanical cum Electrical Engineers. Primary data were obtained through a structured questionnaire by random sampling technique using online google form due to covid-19 pandemic protocols that limit person-to-person contacts. Secondary data were obtained from standard bidding documents to procure works 2011 version and other relevant extant literature. Primary data were analyzed using frequency distributions aided by Microsoft excel 2016 version, and results presented in tables. The major setback in ascertaining the sample size for the study is that the exact number of the consultants was challenging to obtain. This is because the professional bodies do not have accurate statistics of professionals engaged by contracting firms. This study depended on the number of respondents as the sample size is 46.

3.1 Validation of the Questionnaire

The survey instrument was validated by sending the draft to three (3) seasoned relevant consultants to ascertain the relevancy of each of the enlisted questions and how these built up to the formulation of the frameworks for compensation of consultants during unwarranted time overrun for Tetfund sponsored projects in Nigeria.

4 Findings and Discussion

Questionnaires were administered to relevant professionals in the Nigerian construction industry through an online google form because accessibility to some of the respondents was limited due to the Covid-19 pandemic. These include Architects, Quantity Surveyors, Mechanical Engineers, Electrical Engineers, and Structural Engineers in no other of importance. Out of the administered questionnaire, 46 were retrieved, which constituted a 66% retrieval rate. The percentage recovered is substantial, and the information provided by the respondents are deemed to be reliable and can be generalized as the average submission of the concerned professionals in the built industry on the subject under discourse, and the findings are presented as follows.

Table 1 shows that 82.6% of the respondents were Quantity Surveyors, 10.8% were Architects, while Mechanical Engineers, Structural Engineers and Electrical Engineer were 2.2% each in the distribution. The role of Quantity Surveyor in the subject under discourse is central. They manage all aspects of construction projects' contractual and financial side; estimate and monitor costs from concept design to completion. Therefore, the table indicates that the relevant respondents were sought after and the quality of information gotten from the survey adequately addressed the topic.

The result could be easily generalized for built industry professionals affected by time overrun in projects. Respondents from academics and consulting firms were 32.6% each, 21.7% were from the contracting firm, while 4.4% and 8.7% were from government parastatal and multiple practices, respectively. These imply that opinions were collected from different sectors of engagement for a more robust and inclusive analysis. Academics and consultants that constituted 65% of the respondents are versed in the subject matter. Therefore, their experience is not in doubt, hence, the confidence that the data provided by them and other respondents are reliable.

Table 1. Background Information of the Respondents

Background of Respondents	Frequency	Percentage
Professions		
Architect	05	10.8
Quantity Surveyor	38	82.6
Structural Engineer	01	2.2
Mechanical Engineer	01	2.2
Electrical Engineer	01	2.2
Sector of Engagement		
Academics	15	32.6
Consultancy	15	32.6
Contracting	10	21.7
Government Parastatals	02	4.4
Multiple-Practice	04	6.7

Table 2 reveals that 84.8% of the respondents were not aware of any compensation plan for construction consultants when there is an unwarranted time overrun; whereas, 15.2% said they were aware. These positions posit that it is not common in Nigeria for construction consultants to be compensated for time overrun if the agreed project completion period is exceeded. This in all cases, increases the running cost of the consultants at the supervision stage, reducing their income.

Table 2. Awareness of Compensation Plan for Consultants during *(UTO)* in Nigeria

Awareness of Compensation Plan	Frequency	Percentage
YES	07	15.2
NO	39	84.8

In Table 3, enquiry was made to know if the respondents have ever been involved in Tetfund sponsored project(s) before and the results indicate that 47.8% have been involved while a little above half (52.2%) said they have never been involved. Usually, Tetfund project is one of such building contracts that often experience (UTO) due to bureaucratic bottlenecks that often characterize project fund disbursement and monitoring process. The results, therefore, imply that a good number of the respondents had been involved in Tetfund sponsored projects. Despite its characteristics of time overrun, there is hardly a consideration for compensation to consultants that the respondents are aware of, as can be inferred from results in Table 2.

Table 3. Involvement of Respondents in Tetfund Sponsored Projects

Involvement in Tetfund Projects	Frequency	Percentage
YES	22	47.8
NO	24	52.2

Table 4 presents a multi-choice question that permitted respondents to choose more than one option from the list provided. 36.1% prefer the person-month rate, 54.1% favors that agreement between the consultants and the culprit (consultant or client) should be the module for compensation. In comparison, 9.8% suggest that 10% of the unexecuted work as the yardstick for compensation. This implies that the majority support that agreement between the consultant and the culprit as the most appropriate yardstick for compensation in the event of unwanted time overrun.

Table 4. Module for Compensating Consultants during (UTO) in Nigeria

Module	Frequency	Percentage
Man-Month Rate	22	36.1
10% of Cost of Un-Executed Works	06	9.8
Agreement between Consultants and the Culprit	33	54.1

From Table 5, 65.2% of the respondents believe that the method for assessing unwarranted time overrun should be included in the letter of commissioning and award of contract. 15.2% refute the idea, while 19.6% are indifferent. This implies that most consultants prefer the method of assessing compensation to be spelt out on the letter of commission given to them. This will enable the parties to know in advance what obtains in the event of unwarranted time overrun. Where such applies, the parties will be guided appropriately as the implication for delay on the part of the parties to the contract is already known.

Table 5. Inclusion of Compensation Module in Letter of Commissioning and Award

Respondents Positions	Frequency	Percentage
YES	30	65.2
NO	07	15.2
NOT SURE	09	19.6

In Table 6, 78.3% of the respondents opine that Tetfund sponsored projects often result in time overrun. In comparison, 15.2% posit that they were not sure if the project often experience time overrun. Perhaps the indifferent respondents were part of the people who have not been involved in such projects before. 6.5% assert that Tetfund projects are constructed to time. This implies that unwarranted time overrun is a problem peculiar to Tetfund projects in Nigeria.

Table 6. Assessment of Construction Period for Tetfund Sponsored Projects

Assessment of Construction Period	Frequency	Percentage
Often Experience Time-Overrun	36	78.3
Projects are Constructed to Time	03	6.5
Not Sure	07	15.2

From Table 7, 17 respondents posit that the module for remuneration of consultants be implemented by professional bodies, 19 responses supported that BPP should undertake the implementation while 10 responses opted for sponsored bill in the National Assembly. Judging from the responses, Bureau of public procurement was chosen by majority of respondents to implement the module for remuneration of consultants in the event of unwarranted time overrun.

Table 7. Implementation of Module for Remuneration of Consultants during (UTO)

Implementation	Frequency	Percentage
Through Professional Bodies (PB)	17	37
Bureau of Public Procurement (BPP)	19	41
Sponsored Bill in the National Assembly (NA)	10	22

4.1 Conceptual Framework for Compensation of Consultants During (UTO) for Tetfund Projects in Nigeria

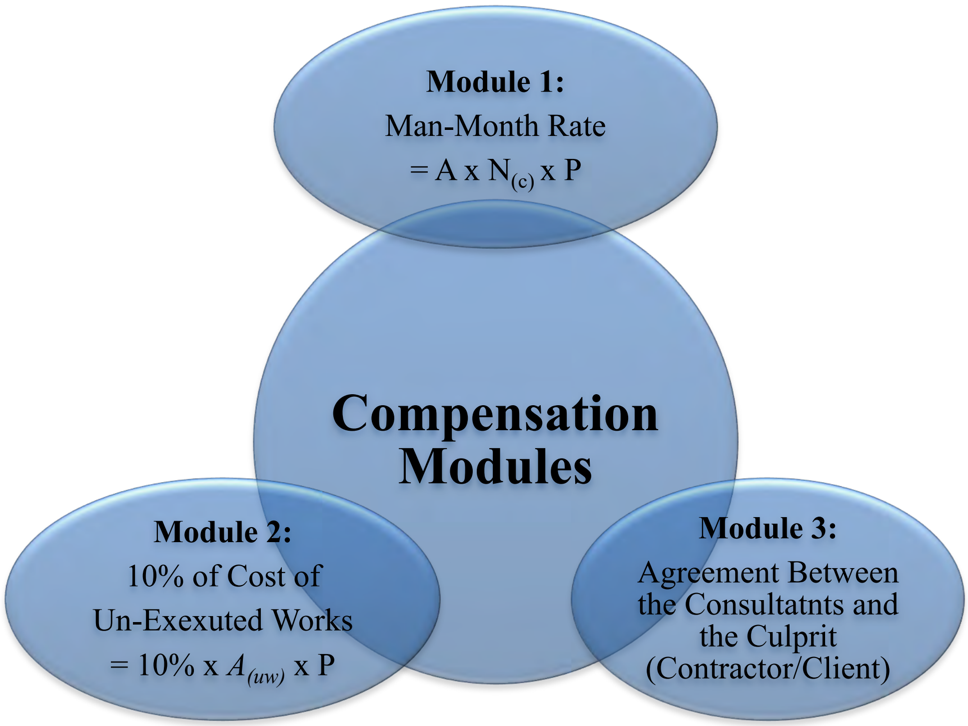

Figure 1. Postulated Conceptual Frameworks for Compensation of Consultants During *(UTO)*
(Source: Author's Perception, 2021)

4.1.1 Formation of the Nested Frameworks

Module 1 - Man – Mouth Rate: Stipulates an option for consultants' compensation during unwarranted time overrun during construction project execution.

Man – Mouth Rate = $A \times N_{(c)} \times P$

A = Amount Payable to a consultant According to Rank, $N_{(c)}$ *= Number of Consultant(s) and P = Period agreed upon*

Module 2 - 10% of Cost of Un-executed Works: Stipulates second option for consultants' compensation during unwarranted time overrun during construction project execution.

10% of Cost of Un-executed Works $=$ *10% x* $A_{(uw)}$ *x P*

$A_{(uw)}$ *= Amount of un-executed works and P = Period agreed upon*

Module 3 - Agreement Between the Consultants and the Culprit (Contractor/Client): Stipulates third option for consultants' compensation during unwarranted time overrun during construction project execution. This implies that the consultants and the culprit (Client or Contractor) will have to agree on modalities different from module 1 and 2.

Frameworks for compensation of consultants during unwarranted time overrun is the focus of the study. The study did not invent the wheel by examining the time performance of construction projects in Nigeria but Tetfund sponsored construction projects. The findings of this study agree with other previous studies (Ade-Ojo and Babalola, 2013; Nasser, 2013) whose sponsorship are likely from different sources. Thirty-six (36) out of the forty-six (46) respondents agreed that Tetfund in Nigeria always experience time overrun. While client and contractor have clauses in the SBD (2011) as cover during time overrun, no known clause for the consultants. This is not unlikely because time overrun has become a usual practice in project execution within the Nigerian construction industry. To worsen the situation, both parties to contract (client and contractor) are not willing to press for compensation which is contagious to the consultants. This laxity is also encouraging unhealthy contractual relationship as some client though not willing to claim liquidated and ascertained damages but would choose to delist the name of such contractor on the list of their preferred contractors and do this by introducing time performance clause in the invitation to tender as part of yardsticks for prequalification. This study thereby identified Man-Month Rate, 10% of Cost of Un-Executed Work and agreement between the consultants and the culprit (client or contractor) as frameworks on which consultants can claim for unwarranted time overrun. Even though it is suggested that such compensation frameworks should be included in the letter of commissioning of consultants and letter of award and the bureau of procurement as prefer means of implementation, the advocacy of such may likely as to be sponsored or moved through national bodies of the affected construction professionals.

5 Conclusion and Further Research

This study postulates frameworks for compensation of consultants during unwarranted time overrun of Tetfund sponsored projects in Nigeria. Man-Month Rate, 10% of Cost of Un-Executed Works and agreement between the consultants and the culprit (client or contractor) are possible modules on which consultants can claim for compensation for unwarranted time overrun. This is necessary as Tetfund sponsored projects experience time overrun in most time. The inclusion of any of the modules of compensations as indicated in the framework would likely serve as a deterrent to be lackadaisical by the contracting parties in carrying out their contractual obligations. The study recommends a further study on the time performance of Tetfund sponsored projects in Nigeria undertaking by corporate, private sectors to ascertain any compensation module(s) if any, for consultants in such setting if unwarranted time overrun occurs.

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Impact of Energy Access on the Delivery of Construction Projects in Lagos Metropolis, Nigeria

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Abstract:
The construction industry in Nigeria lacks sufficient clean energy resources, which is a basic requirement for sustainable development. Thus, it is important to assess the impacts of energy access on construction projects delivery in Lagos Metropolis, Nigeria. In light of this, research data were collected through questionnaires from the small, medium, and large construction companies in Lagos Metropolis, Nigeria. Data collected were analysed using both descriptive (frequency distribution and mean score ranking) and inferential statistics (Kruskal-Wallis test). The study revealed that the most significant impact of energy access on construction project delivery is increased productivity. Others are fast delivery of construction projects, improved effectiveness of project delivery, reduced stress of manual labour and saves cost overtime. Thus, this study serves as one of the earliest studies that contribute to the body of knowledge on impacts of energy access on construction project delivery.

Keywords: Access, construction, delivery, energy, Nigeria

1 Introduction

The United Nations Sustainable Development Goals (SDGs) 2015 brought to fore the importance of energy to development. The Sustainable Development Goal 7 (SDG 7): affordable and clean energy for all is the fulcrum for achieving other sustainable goals (Barron and Torero, 2017). In 2019, 770 million people lacked access to electricity globally. However, 75% of the population without energy access live in sub-Saharan Africa (IEA, 2020). In 2013, the number of people without access to electricity access in Africa peaked at 610 million but there was a progressive decline to around 580 million in 2019. This is because countries like Kenya, Senegal, Rwanda, Ghana, and Ethiopia made significant access growth. In 2019, the energy access rate in Kenya increased from the previous 20% in 2013 to almost 85% (IEA, 2019).

World primary energy consumption increases by a 10-year average rate of 1.6% per year. In 2018, it increased by 2.8%, whereas a 1.6% increase was recorded in 2019. North America, Europe, and the Commonwealth of Independent States (CIS) all recorded a dip in primary energy consumption while it was below average in South and Central America. There was no significant change in the consumption progression in Africa, Middle East, and Asia in comparison with previous years (Primary energy, 2020). U.S. Energy Information Administration (2020) reported that in 2017, about 1.5 quadrillion British thermal units of primary energy were consumed in Nigeria. Natural gas, petroleum and other liquids accounted for 97% of the total consumption while traditional biomass and waste (wood, charcoal, manure, and crop residues), coal, and renewables accounted for only a small amount of consumption (3%) in 2017.

The construction industry is responsible for the consumption of renewable and non-renewable resources. It is ranked as one of the largest consumers (Horvath, 2004; Holtzhausen, 2007; Dixit et al., 2010). The energy consumed by buildings globally is approximately 50%. (Tennakoon et al., 2019). Energy consumption during the life cycle of a building can be divided into three phases: embodied, operational, and decommissioning energy (Himpe et al., 2012). Embodied energy is consumed at the initial construction of a building and during building maintenance. It is the energy consumed during raw materials extraction, processing and manufacturing of construction materials and building components, transportation and installation of building materials and components, maintenance, and repair of a building (Kassim & Santhi, 2016). Operational energy is the energy required for heating, cooling, ventilation, lighting, equipment, and appliances. Decommissioning energy is the energy consumed in the process of demolishing a building and carting away the remains to a landfill or recycling center.

Nigeria is a country in sub-Saharan Africa. It is rich in the deposition of natural energy resources both renewables and non-renewables and has the 7th largest natural gas reserve globally. The economy of the country is dependent on crude oil which positions it among the top exporters of crude oil. However, there is minimal efficient utilisation of these resources, thus increasing energy poverty in the nation (Oseni, 2012). Over the last 20 years, there has been an upsurge in population growth, resulting in increased demand for modern energy needs.

Most of the secondary energy used in Nigeria is imported, basically due to a lack of functioning refineries in the country to convert the abundant primary energy from its crude state into a finished product (IEA, 2010). Studies have been carried out globally on the impacts of energy access (Barnes, 2014; Bhandari, 2007; Guye, 2017; Matt, 2017; Muawya & Walter, 2012; Olanrele et al., 2020; Tarun et al., 2013; Trace, 2016; Sovacool, 2014, Wagner, 2017). However, these studies have only concentrated on the impacts of energy access on health, education, and development in its broad sense. They failed to study the impacts of energy access on construction objectively. Thus, the need for this study. In light of the foregoing and the reliance of construction activities on energy supply, this study aims to assess the impacts of energy access on the delivery of construction projects in Lagos Metropolis, Nigeria. Construction drives the socio-economic development of a nation, and construction activities heavily depend on energy availability. Thus, this study brings to fore the benefits of energy access for construction activities so that the Nigerian government may be aware of these and in turn make policies that will aid efficient generation and access to energy for construction activities.

2 Energy in construction activities

Energy is the power generated when physical or chemical resources are utilised to provide light, heat, or work machines. (Energy, n.d.). Energy can be divided into two forms, primary and secondary energy. Primary energy is the energy found in nature i.e., energy in its unprocessed or raw form. It includes crude oil, hydropower, sunlight, wind, coal, and nuclear energy (Dixit et al., 2010; Dixit et al., 2014). A building consumes primary energy in two ways: direct consumption through delivered energy sources such as electricity and gasoline; indirect consumption through the use of construction materials (energy used in extraction and processing of raw materials, transportation, and assemblage of components) (Dixit, 2016; Monteiro et al., 2016). Secondary energy is the energy generated from the conversion of primary energy. It includes electricity, gasoline, heat, liquid fuel, and refined biofuel (Resourcefulness, n. d.). Fog et al. (1983) submitted that the activities responsible for energy consumption on a construction site are transportation, demolition, levelling, earthworks, lifting, compacting and mixing. Table 1 shows the classification of plant, tool, or equipment used in construction, type of energy used, and the construction process in which it is used.

Table 1: Classification of Plants, Tools and Equipment and Energy Used

Plant, tool or equipment	Energy Used	Construction Process
Placers rebators and routers	Electricity	Grooving, moulding and other joinery
Saws	Electricity, compressed air, petrol	Cutting, grinding
Rotary drill, rock drill, picks and breakers	Electricity, compressed air, petrol	Drilling, driving screw
Hammers	Electricity, compressed air, petrol	Hammering
Vibrator	Electricity, compressed air, petrol	Vibrating concrete
Forklift	Diesel	Transporting concrete
Elevators	Petrol or diesel	Hoisting
Cranes	Electricity	Hoisting
Mechanical auger	Diesel	Boring
Trenching machine, grader, bulldozer and angle dozer, scraper	Diesel	Excavation
Pumps	Electricity, Petrol, Diesel	Surface treatment and Water for works
Compressors	Electricity, diesel, petrol	Supply compressed air

(Source: Talukhaba et al, n. d.)

2.1 Impacts of Energy Access

Energy access is a state where households enjoy unrestricted access to reliable and affordable energy supply (Karanja *et al.*, 2017). The International Energy Agency (IEA) (2011) defines Universal Energy Access as "a household having reliable and affordable access to clean cooking facilities, the first electrical connection and then an increasing level of electricity consumption overtime to reach the regional average". The World Energy Outlook (2015) described energy access in terms of a specified minimum level of electricity consumption based on the household's location (rural or urban area). The minimum level of electricity consumption for rural households is assumed to be 250 kilowatt-hours (kWh) per year and 500 kWh per year for urban households (IEA, 2015). In a report by Sustainable Energy for all's Global Tracking Framework (GTF) (2013) energy access was described by developing a multi-tier framework (MTF). Thus, energy access is the availability of adequate, reliable, clean, convenient, affordable, quality, and healthy energy.

Several studies have considered the impacts of energy access. Tarun et al. (2013) evaluated the impacts of electricity available on the performance of rural SMEs. The study highlighted the impacts as low connection cost and cheap energy, uninterrupted service, reduced manpower and labour cost, higher profit margin, provision of quality products, growth and expansion of micro-enterprises, increase in women literacy rate, and economic advancement of women. Porcaro et al. (2017) examined modern energy access and health. The study considered energy access and health implications, with energy access and reliability gaps, at two levels: electrification of health care facilities and household energy. It revealed that access to modern energy enables: the usage of most of the basic life-saving interventions thus health workers report a fewer delay in providing life-saving care; ability to refrigerate vaccines; operation of basic amenities, including lighting, ventilation, and communication systems; safe management of medical waste; availability of information and communication (ICT) services.

Barnes et al. (2014) studied the development impact of energy access. The study revealed that impacts of clean energy access on economic development are the allocation of household time (especially women) previously spent on provision of energy towards improved education, income generation, and greater specialisation of economic functions; economies of scale in more industrial type energy provision; greater flexibility in time allocation through the day and evening; enhanced productivity of business and farms; improvement in education; health-related benefits -reduced smoke exposure, clean water, and refrigeration. Muawya and Walter (2012) submitted that access to affordable and reliable energy services will promote economic development through an increase in productivity, creation of activities that generate income, improvement in the creation of employment locally, reduced household expenses on cooking, lighting, and space heating, enhanced irrigation which increases food production and access to nutrition, and access to clean water, which improves health.

Bhandari (2007) investigated the impact of household access to energy on education. The study revealed that the time spent in learning and other activities such as travel to the place of study, doing course work, and assignments are dependent on the type of energy used by a household. Guye (2017) carried out a study on the impact of electricity access on education in Kenya. The study submitted that households with access to electricity have 4.08 more years of schooling on average compared to ones that do not. In a report submitted by ACP-EU Energy Facility (2010), the positive impacts of energy access on development are increased productivity, effective delivery of health services (longer operation hours, utilisation of life support and diagnostic equipment, vaccine refrigeration), extended opening hours for adult education, increased studying hours for children, and improved access to communication technology. Olanrele et al. (2020) opined that household access to grid electricity reduces children's study hours and decreases the rate of indoor air pollution.

Trace (2016) submitted that energy access promotes economic development, reduces poverty, increases productivity, promotes effective communication and delivery of information, improves transportation system, and enhances commerce and trade, agro-processing, small-scale manufacturing, and industry. World Bank (2008) submitted that access to energy leads to improved quality of schools through the availability of electricity-dependent equipment, increasing teacher quantity and quality, and increased study time. Sovacool (2014) reported that energy access leads to improved lighting and extended studying hours, use of ICT for learning, enhanced teacher retention, improved students' performance, improved sanitation and health, gender empowerment, and community resilience. Wagner et al. (2017) studied the potential links between electrification and education. The study reported that energy access enables studying after school hours, improves productivity and efficiency of other work, powers devices or IT services that enables learning, and improves educational outcome indirectly through improving health and well-being.

3 Methodology

This paper examines the impacts of energy access in the delivery of construction projects in the Lagos metropolis. Lagos, which is located in the Southwestern part of Nigeria, is the economic hub of Nigeria. Consequently, it is the most populated and fastest developing city in the nation, resulting in the demand for more infrastructures ranging from building to civil works. The research employed a quantitative research method through a questionnaire survey. The sampling technique used for this research work was purposive sampling. The variables and constructs used in this paper were established through an extant review of existing pieces of literature. A list of energy access impacts was adapted from the literature to formulate the research instrument.

The questionnaire was divided into two parts. The first section solicited information about each firm and its responding officer: firm's size, revenue, responding officer's designation, highest academic qualification, and years of experience; Section B sought information on the impacts of energy access on the delivery of construction activities in Lagos Metropolis. The responses of these firms in section B were obtained on five Likert scales. According to Lagos State Procurement Journal (2018), the number of companies registered with Lagos State Government (LSG) are 1929. They are grouped into classes based on the contract value they can handle. Class A is the lowest class and comprises companies that can handle contracts up to 10 million naira in value while class E is the highest with the ability to handle contracts above 1 billion naira. Others are shown in Table 2. However, the journal did not specify which of the companies are into construction. Thus, a pilot study was carried out by searching their names on google for their profile and scope of work. The result revealed that there are 62 registered construction firms in class A. 71, 294, 198, and 175 in class B, C, D, and E. However, 15% of the sampling frame was considered in determining the sample size for the study, which gave 9, 11, 44, 30, and 26 construction firms in classes A, B, C, D, and E, respectively. Thus, the total sample size was 120. The construction firms were further categorised into small, medium and large firms as follows; classes A and B were classified as small firms, firms in class C were classified as medium firms while firms in classes D and E were classified as large firms. The respondents from the construction firms were construction professionals: architects, structural, civil, mechanical, and electrical engineers, builders, and quantity surveyors. However, the internal validity of the constructs was ascertained by reviewing the questionnaire went through a peer-reviewed process and assessment by the research supervisor before it was administered. As the principal researcher, the lead author of this paper administered the questionnaire to the respondents physically.

A total of 89 construction firms responded to the survey —a response rate of 74.0%. IBM SPSS Version 23 was employed to analyse the data retrieved from the survey. The descriptive statistics employed were mean score ranking and frequency while the inferential statistics used was the Kruskal-Wallis test. The mean score ranking generated the significance index of the impacts of energy access. The result of the Kruskal-Wallis test determined the level of significance of the agreement between the respondents.

4 Findings and Discussion

The section presents the data collected, analysis carried out, and results generated as well as a discussion of findings.

4.1 Background Information on Firms and Responding Officers

Table 2 shows the general information about the firms surveyed and the responding officers. The results showed that 15 (16.8%) are small firms, 32 (36.0%) are medium firms and 42 (47.2%) are large firms. An evaluation of the academic qualification of the responding officers showed that about 39.3% have B. Sc. while only 7.9% have M.Sc. However, the highest proportion of the responding officers are engaged as engineers 38 (42.7%). This is because engineers are more predominant on site. The least represented professionals 6 (6.7%) are architects. This is because most architects are not residents on-site rather, a clerk of work represents them. It emerges that 66 responding officers (65.2%) have been active participants in the construction industry for less than 10 years while only 23 (25.9%) have been involved in construction activities for 10 years and above.

Table 2. Background Information on Firms and Responding Officers

	Frequency (f)	Valid Percent	Cumulative Percent
Size of the Firm			
Small	15	16.8	16.8
Medium	32	36.0	52.8
Large	42	47.2	100.0
Highest Academic Qualification of the Respondents			
OND	13	14.6	14.6
HND/PGD	34	38.2	52.8
B. Sc.	35	39.3	92.1
M. Sc.	7	7.9	100.0
Professional Designation of the Respondents			
Architect	6	6.7	6.7
Quantity Surveyor	25	28.1	34.8
Builder	20	22.5	57.3
Engineer	38	42.7	100.0
Years of Experience of the Respondents			
0 - 5	31	34.8	34.8
6 - 10	35	39.3	74.1
11 - 15	15	16.9	91.0
16 - 20	3	3.4	94.4
Above 20	5	5.6	100.0
Mean = 7.88			

4.2 Impacts of Energy Access on the Delivery of Construction Projects.

The result presented in Table 3 shows the impacts of energy access on construction project delivery. For small firms, improved economy (MS= 4.50) ranked first as the most significant impact of energy access on construction project delivery. Efficacy in project delivery (MS= 4.43) ranked second. Increased employment (MS= 4.33) ranked third. Improved effectiveness of project delivery (MS= 4.29), fast-tracked delivery of construction projects (MS= 4.29), and increased productivity (MS= 4.29) ranked fourth. The least significant impact was enterprise creation (MS= 3.50). The most significant impact of energy access by medium firms was the fast-tracked delivery of construction projects (MS= 4.78). Closely followed by increased productivity (MS= 4.72). The least significant impact of energy access was increased employment (MS= 4.09). For large firms, the most significant impact was improved economy (MS= 4.50). Closely followed by increased productivity (MS= 4.41). Finally, the least significant impact of energy access was saves cost overtime (MS= 3.85). The overall evaluation of the general view of the respondents on energy access impact on construction project delivery revealed that all the effects identified had a mean score greater than 3.00 which is the midpoint in a 5-point scale. This implies that all the identified variables were impacts of energy access.

Increased productivity (MS= 4.53) ranked first as the most significant impact of energy access on construction project delivery. Fast-tracked construction project delivery (MS= 4.50) ranked second. Improved economy (MS= 4.46), improved effectiveness of project delivery (MS= 4.36), reduced stress of manual labour (MS= 4.30) ranked third, fourth and fifth respectively. The least ranked impact was improved lighting conditions (MS= 4.05). This result conforms with the previous research findings that identified the highlighted benefits as significant impacts of energy access (ACP-EU Energy Facility, 2010; Barnes, 2014; Muawya & Walter, 2012; Tarun et al., 2013; Trace, 2016; Wagner et al., 2017).

Table 3: Impacts of Energy Access on Construction Project Delivery Based on Size of Firm

S/N		Size of firm								Kruskal Wallis
		Overall		Small		Medium		Large		
		Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk	Sig.
1	Increased productivity	4.53	1	4.29	4	4.72	2	4.41	2	.209
2	Fast-tracked construction project delivery	4.50	2	4.29	4	4.78	1	4.32	3	.028
3	Improved economy	4.46	3	4.50	1	4.41	5	4.50	1	.869
4	Improved effectiveness of project delivery	4.36	4	4.29	4	4.48	3	4.28	4	.773
5	Reduced stress of manual labour	4.30	5	4.14	7	4.44	4	4.22	5	.545
6	Use of communication technologies	4.24	6	4.00	9	4.38	6	4.18	7	.909
7	Triggers efficacy in project delivery	4.20	7	4.43	2	4.38	6	4.02	9	.514
8	Increased employment	4.18	8	4.33	3	4.09	11	4.22	5	.859
9	Enterprise creation	4.08	9	3.50	11	4.13	10	4.13	8	.372
10	Saves cost overtime	4.07	10	4.14	7	4.34	8	3.85	11	.200
11	Improved lighting conditions	4.05	11	3.71	10	4.19	9	4.00	10	.694

The findings of the present study agree with ACP-EU Energy Facility (2010). The study highlighted the positive impacts of energy access on development as increased productivity, effective delivery of health services (longer operation hours, utilisation of life support and diagnostic equipment, vaccine refrigeration), extended opening hours for adult education, increased studying hours for children, and improved access to communication technology. Furthermore, the findings of this study agree with Barnes (2014) who submitted that impacts of higher-quality energy and better use of existing fuels on economic development are the relocation of household time (especially women) away from energy provision and towards improved education, income generation, and greater specialisation of economic functions; economies of scale in more industrial type energy provision; greater flexibility in time allocation through the day and evening; enhanced productivity of business and farms; improvement in education; health-related benefits -reduced smoke exposure, clean water, and refrigeration.

This study also agrees with Muawya & Walter (2012) who submitted that access to affordable and reliable energy services will facilitate economic development through increased productivity, income-generating and livelihood activities from extended lighting, improved local employment creation, reduction in household income spent on cooking, lighting, and space heating, enhances irrigation which increases food production and access to nutrition, and access to clean water which improves health. The findings are in agreement with Tarun et al. (2013). The study highlighted the impacts as low connection cost and cheap energy, uninterrupted service, reduced manpower and labour cost, higher profit margin, provision of quality products, growth and expansion of micro-enterprises, increase in women literacy rate, and economic advancement of women.

Further analysis was carried out to test the level agreement of respondents on the impacts of energy access on construction projects using the Kruskal Wallis test. The result shown in Table 4 indicated that eleven of the twelve identified impacts had a significance value greater than 0.05. This implies that there is no difference in the perception of the respondents on these impacts. However, one of the impacts had a significance value less than 0.05: makes construction project delivery faster (sig= 0.028). This implies that there is a difference in the perception of respondents on this impact based on their size of the firm.

5 Conclusion and Recommendations

This paper examined the impacts of energy access on the delivery of construction projects. The study established that the most significant impact of energy access on the delivery of construction projects in Nigeria is increased productivity. Others are fast-tracked construction project delivery, improved economy, improved effectiveness of project delivery, reduced stress of manual labour. The study concluded that energy access will enhance the delivery of construction projects through improved productivity and project effectiveness. Therefore, the study recommends that the Nigerian government should enhance the generation and access to clean energy for construction activities so that the dividends of energy access can be made available to all, through improved productivity which in turns increases employment opportunities as it has been established that the construction industry is one of the largest employer of labour in the country. It is also noteworthy that the construction industry improves the economy of a nation. Thus, the Nigerian government will facilitate more construction activities by formulating policies that aid efficient generation and access to clean energy.

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Factors influencing construction of sustainable buildings in Lagos metropolis, Nigeria

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Abstract:
The recent increased demand for housing and infrastructure stems from the upsurge in the human population worldwide. The resultant effects are depletion of resources, generation of waste, pollution, energy consumption, and release of greenhouse gases into the atmosphere; thus, the need for environmentally sustainable buildings and construction practices. This study assessed the factors influencing the construction of sustainable buildings in Lagos Metropolis, Nigeria. Research data were obtained through questionnaires from construction professionals of construction firms who had participated in constructing identified sustainable buildings in Lagos Metropolis, Nigeria. The retrieved data were analysed using frequency distribution mean score ranking) and inferential statistics (ANOVA). The result of the study indicated that the top five significant drivers of sustainable buildings are energy efficiency, improved indoor environmental quality, pollution prevention, waste reduction, and resource conservation. Furthermore, the top four major barriers inhibiting the construction of sustainable buildings can be grouped as finance. Others are management support, government policies, limited sustainable products and materials, and organizational culture. This study assessed the drivers and barriers of sustainable construction in the Nigerian construction industry with a view to proffering measures that will lead to the adoption and implementation of sustainable construction in the country. Furthermore, this study will contribute to the existing literature on drivers of and barriers to sustainable construction in Nigeria.

Keywords: barriers, drivers, construction, sustainable buildings, Nigeria

1 Introduction

The recent upsurge in need for housing and infrastructure is a resultant effect of the rapid population growth around the globe (Alwan et al., 2017). Construction investment in Africa, Asia, and the Middle East are projected to rise to US$12.9 trillion by 2022 (Report Linker, 2019). The construction industry facilitates socio-economic development in every nation. Nevertheless, the activities of the industry have adverse impacts on the three major sustainability dimensions (economic, environmental, and social) (Karji et al., 2020). The current level of sustainability practice in the construction industry is low compared to the targeted green goals. The central challenge in our present world is the enhanced greenhouse effect i.e., global warming, a resultant effect of the release of GHGs (carbon dioxide, methane, nitrous oxide, and fluorocarbons) by anthropogenic activities (United Nations Framework Convention on Climate Change (UNFCC), 2011). Global emissions from buildings rose for the second consecutive year to 9.7 gigatonnes of carbon dioxide (GtCO2), representing a 2% increase (UNEP, 2019). In Africa, buildings consumed 61% of total final energy and contributed 32% to total carbon dioxide (CO2) emissions (IEA, 2019a). GlobalABC revealed in the Global Status report that global progress on reducing emissions is not on track due to slow-paced energy efficiency improvements compared to floor area and demand growth (IEA, 2019b).

The need to slow down climate change and global warming has made sustainable development a major issue among policy-makers and world leaders (Amuda-Yusuf et al., 2020). Sustainable building or construction has become one of the major global practices of the 21st century (Osuizugbo, 2018). *Green buildings are environmentally sustainable buildings, designed such that they are eco-friendly in all ways. Green building practices reduces the environmental impact of building (Saurabh, 2018)*. However, some of the developing countries in the West Africa such as Nigeria are yet to imbibe successfully and implement sustainability practices in the execution of construction projects (Akinshipe et al., 2019; Ametepey et al., 2015; Alabi, 2012; Baron & Donath, 2016; Osuizugbo, 2018). Nigeria has witnessed a slow transition from its traditional construction methods to contemporary sustainable construction (Adindu et al., 2020; Osuizugbo et al.,2020). A study carried out by Dania (2013) revealed that the adoption of sustainability practices in Nigerian construction industry is still lagging behind compared to the rest of the world. This was corroborated by Dahiru et al. (2014) who submitted that the lack of policy or environment limits the practice of green construction in Nigeria to support its adoption.

Previous researchers have investigated the drivers and barriers of the construction of sustainable building globally (Namian et al., 2021; Olowosile, 2020; Azazga, 2019; Ametepey et al., 2015; Tokbolat et al., 2019; Oke et al., 2018; Durdyev et al., 2018; Alsanad, 2015; Marsh et al., 2020; Aghimien, 2018; Tarja & Belloni, 2011) and few locally (Daniel et al., 2018; Onososen et al., 2019; Olowosile et al., 2019; Osuizugbo et al., 2020; Ifije & Aigbavboa, 2020). However, most of these researches were conducted internationally, adapting the results for individual countries could pose the danger of ecological fallacy. Additionally, studies conducted locally in Nigeria may not have elicited the cogent issues because most of the people who responded to the survey were general construction professionals, many of whom have not undertaken the construction of any sustainable building. Thus, this study will investigate the drivers and barriers of constructing sustainable buildings in Lagos Metropolis, Nigeria, which is the hub of construction activities in the country. The respondents will be professionals of construction firms that have undertaken sustainable building construction in the study area. The findings of this study would help all construction stakeholders and policymakers to develop strategies to ease the implementation of sustainable construction in the nation, which will ensure resource conservation and enhance greening the country.

2 Drivers of Construction of Sustainable Buildings

An extant review of the literature revealed several drivers promoting the construction of sustainable buildings. In the US, Roper & Beard (2006) identified five significant factors that promote sustainable building design and operation viz: pollution prevention, harmonization with the environment, resource efficiency, energy efficiency, and integrated and systematic approaches. Ahn et al., 2013 investigated the drivers of and barriers to green design and construction in the US construction industry. The study revealed that the significant drivers of sustainable design and construction are environmental or resource conservation, waste reduction, improving indoor environmental quality, and energy conservation. Alsanad (2015) reported that the major drivers that promote green practices in Kuwait to be educational programs, laws and legislation, economic incentives, and green design guidelines and construction standards. The five most significant drivers of sustainable construction in Cambodia were reducing building impacts on the environment, conservation of resources, energy efficiency, waste reduction, and improved indoor environmental quality (Durdyev et al., 2018).

Serpell et al. (2013) found out that corporate image, laws and legislation, market identification, company awareness, suppliers' pressure, cost reduction, and clients' requirement are the factors promoting sustainable construction in Chile. Tokbolat et al. (2019) explored the drivers of and barriers to implementing sustainability practices in Kazakhstan construction sector. The critical drivers are waste reduction, energy efficiency, resource conservation, ecology preservation, efficient water management, and the atmosphere. Oke et al. (2018) investigated sustainable construction in the Zambian construction industry. The study indicated that the significant drivers promoting the adoption and implementation of sustainable construction practices are advocacy and awareness, clients' demand, building regulations, developing regulatory mechanisms, and legislation or legal requirement. The study argued that adopting sustainable construction practices can be encouraged through government collaboration with academics, formulation of policies, and enforcement of regulations that aid sustainable construction.

Onososen et al. (2019) found out that financial incentives, government's support, increased awareness, provision of labelling standard, and a sustainable housing policy are the drivers of the adoption of sustainable construction in Nigeria. Tunji-Olayeni et al. (2020) identified five major drivers of sustainable construction in Nigeria through a qualitative method of assessment viz: corporate social responsibility, cost-effectiveness, clients' requirement, international pressure, and competitiveness. In addition, education and training, a sustainability assessment system, and the availability of the national building code are the drivers of sustainability practices in Nigeria (Omapariola et al., 2019). Oyalowo, 2014 conducted a study on barriers to and drivers of sustainable construction. The respondents were real estate developers and property managers. Findings of the study revealed that professional bodies, government regulators, government involvement in sustainable buildings, and investors are the drivers of sustainable construction.

2.1 Barriers Inhibiting Construction of Sustainable Buildings

Karji et al. (2020) found out that the four critical barriers to sustainable construction in the US are managerial barriers, legislative barriers, pre-construction barriers, and financial and planning barriers. The most critical barriers to the adoption of sustainable design and construction are inadequate knowledge and technical skills of subcontractors, long payback periods, tendency to maintain current practices, and initial cost outlay of the project (Ahn et al., 2013). Serpell et al. (2013) conducted a study on awareness, actions, drivers, and barriers of sustainable construction in Chile. The results indicated that the major barriers towards sustainable construction are the lack of financial incentives, lack of integrated design, and affordability. In Finland, Hakkinen & Belloni (2011) found out that the significant barriers of sustainable construction are lack of steering mechanisms, knowledge, economics, innovation, availability of methods and tools, client understanding, timing, cooperation, and networking and procurement and tendering.

Tokbolat et al. (2019) submitted that the barriers to adoption of sustainable practices in Kazakhstan construction sector are longer payback periods, in consideration of sustainability criteria in the bid evaluation, lack of promotion by government, lack of government incentives, cost of sustainable building option, higher priority dedicated to economic needs, lack of technical expertise, lack of training and education for professionals, and inadequate knowledge on benefits of adopting sustainable practices. Alsanad (2015) reported that the top five barriers to implementing green construction practices are lack of awareness, lack of government support/no incentives, no existing rule to adopt green building, lack of qualified staff, and unwillingness to change. The five most significant barriers to implementing sustainable construction practices are the cost of the sustainable-building option, lack of professional expertise, economic needs of higher priority, lack of statutory requirements that cover sustainable procurement, and lack of government incentives (Durdyev et al., 2018).

Aghimien et al. (2018) identified the main barriers to adopting sustainable construction practices *in* Zambian construction industry*: unavailability of local green certification, lack of government policies, and lack of financial incentives.* The top five barriers to adopting and implementing sustainable construction in South Africa are resistance to changing traditional construction processes, limited availability of green product suppliers, materials, and technologies, inadequate knowledge, lack of support and incentives from the government, and lack of building codes and regulations. (Marsh et al., 2020). Ametepey et al. (2015) submitted that the five critical barriers to adopting and implementing sustainable practices in the Ghanaian construction industry are lack of commitment from government, lack of professional knowledge, fear of higher investment costs, and cultural change resistance and lack of legislation and regulation. The key barriers to sustainable construction in the Ghanaian construction industry are higher initial financial outlay, lack of public awareness, lack of clients' demand for sustainable buildings, lack of strategy to promote sustainable construction, and lack of government support and incentives. (Djokoto et al., 2013).

Aghimien et al. (2019a) investigated the challenges of sustainable construction in developing countries. The results showed that fear of the increased cost of investment, resistance to change the traditional construction method, client's demand, inadequate knowledge and understanding of the concept of sustainability are some of the major challenges of sustainable construction in developing countries. In Nigeria, Akinshipe et al. (2019) investigated factors inhibiting the practice of sustainable construction. They found that lack of technical expertise and inadequate knowledge in sustainable construction practices are the most significant barriers to adopt sustainable construction. Onososen et al. (2019) submitted that increased financial outlay associated with green building, fear of the need to avoid risk, lack of awareness, lack of government support to drive the process, and inadequate green products are major barriers to sustainable construction. Aghimien et al. (2019b) reported that the significant barriers impeding the implementation of sustainable construction practices in Nigeria are inadequate knowledge of sustainable practices, information and management, regulation and policy, sustainable materials and technology.

3 Research Methodology

This paper examines the factors influencing the construction of sustainable buildings in Lagos metropolis, Nigeria. Lagos was selected as the study location because it is the hub of construction innovations in the nation. The research method employed was quantitative analysis through the use of a questionnaire survey. The respondents were built environment professionals in selected construction companies who had participated in constructing some identified sustainable buildings in Lagos metropolis, Nigeria. The research work employed the purposive sampling technique. The variables and construct employed in this study were established from an extant review of existing literature. A list of factors (drivers and barriers) influencing the construction of sustainable buildings was constructed from the literature review. The variables in the constructs were made up of 20 factors.

The research instrument was structured into two sections: Section A solicited background information on each firm and its responding officer. Other information included responding officer's designation, highest academic qualification, professional affiliation, and years of experience; Section B sought information on the factors influencing the construction of sustainable buildings in Lagos metropolis. The responses of these companies in section B were retrieved using five Likert scale where; 1 = Not influential, 2 = Fairly influential, 3 = Influential, 4 = Very influential, 5 = Quite influential. A pilot study was carried out to identify sustainable buildings in Lagos Metropolis (see Table 1). Consequently, five sustainable buildings in Lagos were identified and a sample frame of 16 firms (consulting and contracting) who participated in the construction was drafted and copies of questionnaire were administered to construction professionals in each firm. The internal validity of the research instrument was ascertained by subjecting the questionnaire a peer-review process by the research supervisor. The questionnaires were administered to the respondents physically by the principal researcher.

Eighty-nine copies of the questionnaire were distributed to the construction professionals and 62 copies were retrieved —a response rate of 69.66%. IBM SPSS Version 23 was used to analyse retrieved data. The data analysis tools employed in the study were mean score ranking which showed the significance index of the factors influencing the construction of sustainable buildings and ANOVA which was used to determine the level of significance of the agreement between the respondents.

Table 1: Background Information on Responding Officers

	Frequency (f)	Percentage	Midpoints (x)
Highest Academic Qualification			
OND	2	3.2	
HND	8	12.9	
BSc	35	56.5	
MSc	14	22.6	
PhD	3	4.8	
Professional Designation of Respondents			
Architect	19	30.6	
Quantity Surveyor	13	21.0	
Builder	13	21.0	
Engineer	17	27.4	
Years of Work Experience			
0-5 years	27	43.5	3
5-10 years	18	29.0	8
10-15 years	12	19.4	13
15-20 years	3	4.8	18
20-25 years	2	3.2	23
Mean = 7.75			

4 Results and Discussion

The section presents the analysis of the data retrieved from the survey.

4.1 Background Information on Responding Officers

Table 1 reveals the general information about the responding officers. An assessment of the respondents' academic qualification indicated that about 8 (12.9%) have HND, 35 (56.5%) have B. Sc. While 14 (22.6%) have M.Sc. The most represented professionals are architects 19 (30.6%). The least represented professionals 13 (21.0%) were quantity surveyors and builders. An assessment of the professional affiliation of the respondents showed that 19(30.6%) were affiliated with NIA, 17 (27.4%) were affiliated with NSE. An evaluation of the respondents' year of experience revealed that 45 responding officers (72.6%) have been active in the construction industry for fewer than 10 years while 17 (27.4%) have been engaged in construction works for longer than 10 years.

4.2 Factors influencing the construction of sustainable buildings in Lagos state

Table 2 shows the mean ranking of the factors influencing the construction of sustainable buildings based on the designation of the respondents and their overall mean ranking of the factors influencing the construction of sustainable buildings in Lagos Metropolis, Nigeria. The most significant driver of the construction of sustainable buildings based on the architects' responses was energy efficiency (MS= 4.05), followed by pollution prevention (MS = 3.55). The least ranked driver of construction of sustainable buildings was international pressure (MS = 3.05). Quantity surveyors ranked energy efficiency and improved indoor environmental quality (MS= 3.85) as the most significant drivers of the construction of sustainable buildings. The least ranked driver of construction of sustainable buildings was resource conservation (MS = 3.40). An evaluation of the builder's responses revealed that the most significant driver of construction of sustainable buildings was energy efficiency (MS= 3.94). This was followed by pollution prevention (MS= 3.72) and improved indoor environmental quality (MS= 3.61). Engineers ranked pollution prevention (MS= 3.78) as the most significant driver of construction of sustainable buildings. The least ranked driver was international pressure (MS= 3.36).

The overall ranking of the drivers of construction of sustainable buildings revealed that the most significant driver was energy efficiency (MS= 3.89). This was followed by improved indoor environmental quality and pollution prevention (MS= 3.66). The findings of this study agree with Roper & Beard (2006); Ahn et al. (2013); Durdyev et al. (2018); Tokbolat et al. (2019). The least ranked driver was international pressure (MS= 3.44). Further, inferential test was carried out using ANOVA to ascertain the agreement of the respondents on the drivers of construction of sustainable buildings. The result revealed that all the identified drivers had a significance value greater than 0.05. This implies that the respondents were in agreement in their ranking of the identified drivers.

The most critical barrier of the construction of sustainable buildings based on the architects' responses was cost factors (MS= 3.78), followed by financial resources and cost effectiveness (MS = 3.72). The least ranked barrier of construction of sustainable building was cultural and social resistance (MS = 3.16). Quantity surveyors ranked inadequate cost data for sustainable building (MS= 3.85) as the most critical barrier of the construction of sustainable buildings. The least ranked barrier of construction of sustainable building was capacity barrier (MS = 3.35). An evaluation of the builder's responses revealed that the most critical barrier of construction of sustainable building was financial resources (MS= 3.94). The least ranked barrier of construction of sustainable building was capacity barrier (MS = 2.77). Engineers ranked financial resources and cost factors (MS= 3.78) as the most significant barriers of construction of sustainable buildings. The least ranked barrier was limited range of sustainable products and materials (MS= 3.00). The overall ranking of the barriers of construction of sustainable buildings revealed that the most significant barrier was financial resources (MS= 3.86). This was followed by cost factors (MS= 3.78), cost effectiveness (MS= 3.68) and inadequate cost data for sustainable building (MS= 3.64). This implies that finance is a major determinant in the construction of sustainable buildings. This result agrees with the findings of Karji et al. (2020); Sepell et al. (2013); Ahn et al. (2013); Durdyev et al. (2018) who identified financial constraints as the main barrier inhibiting sustainable construction. The least ranked barrier was capacity barrier (MS= 3.18). Capacity barrier has a mean ranking of 3.18 which is greater than the midpoint on a 5-point scale. This implies that though it was ranked last, it is also a barrier of sustainable construction (Aghimien et al., 2019a; Aghimien et al., 2019b; Akinshipe et al., 2019; Djokoto et al., 2013). Further inferential test was conducted using ANOVA to ascertain the agreement of the respondents on the barriers of construction of sustainable buildings. The result revealed that all the identified barriers had a significance value greater than 0.05. This implies that the respondents were in agreement in their ranking of the identified barriers.

5 Conclusion and Recommendations

This paper examined the factors (drivers and barriers) influencing construction of sustainable buildings. The study established that the most critical driver of construction of sustainable buildings in Nigeria is energy efficiency. This is in sync with the need to reduce energy consumption in buildings and emission of greenhouse gases. Therefore, the Nigerian government should ensure there is a policy towards achieving energy-efficient buildings in the country. In the same vein, contractors must be willing and ready to construct energy-efficient buildings. Another driver revealed was client demand. Therefore, it is imperative for construction clients to be aware of the need for sustainable construction, make clear demands for sustainable buildings without recourse to the initial financial commitment.

The study also revealed that international pressure promotes sustainable construction in Nigeria i.e., construction firms whose headquarters are overseas are compelled to comply with the sustainable practices and policies of the company. Thus, our indigenous construction firms and the Nigerian government should take a clue from this and ensure the adoption and implementation and sustainable construction in Nigeria. Subsequent findings revealed that the significant barriers of sustainable construction are financial resources, cost factors, cost-effectiveness and inadequate cost data for sustainable buildings. The study concluded that finance is a critical barrier inhibiting sustainable construction in Nigeria. Thus, it is recommended that the government should make efforts to subsidize cost of materials required for construction of sustainable buildings. Consequently, financial incentives should be available to encourage construction of sustainable buildings. The study further revealed that government policies inhibit construction of sustainable buildings in Nigeria. Therefore, the government must make policies that aids and encourages construction of sustainable buildings and the adoption of sustainable practices generally in the country. Capacity barrier was also identified as a barrier to sustainable construction.

Table 2: Factors Influencing the Construction of Sustainable Buildings

S/N	Factors influencing the construction of sustainable buildings	Overall		Architect		Quantity Surveyor		Builder		Engineer		ANOVA	
		Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk	F	Sig.
	Drivers												
D1	Energy efficiency	3.89	1	4.05	1	3.85	1	3.94	1	3.73	2	0.60	0.61
D2	Improved indoor environmental quality	3.66	2	3.44	4	3.85	1	3.61	3	3.73	2	0.68	0.56
D3	Pollution prevention	3.66	2	3.55	2	3.60	6	3.72	2	3.78	1	0.29	0.82
D4	Waste reduction	3.57	4	3.44	4	3.84	3	3.33	7	3.57	4	1.55	0.20
D5	Resource conservation	3.46	5	3.50	3	3.40	7	3.55	4	3.42	6	0.14	0.93
D6	Client demand	3.45	6	3.11	6	3.70	5	3.38	6	3.57	4	2.37	0.07
D7	International pressure	3.44	7	3.05	7	3.75	4	3.55	4	3.36	7	2.09	0.10
	Barriers												
B1	Financial resources	3.86	1	3.72	2	4.00	2	3.94	1	3.78	1	1.14	0.33
B2	Cost factors	3.78	2	3.77	1	3.70	5	3.88	2	3.78	1	0.22	0.88
B3	Cost effectiveness	3.68	3	3.72	2	3.90	3	3.66	3	3.42	6	1.79	0.15
B4	Inadequate cost data for sustainable building	3.64	4	3.61	4	4.20	1	3.22	7	3.47	5	1.19	0.25
B5	Top management support	3.60	5	3.38	11	3.70	5	3.55	4	3.73	3	0.77	0.51
B6	Government policies	3.58	6	3.50	6	3.85	4	3.27	6	3.68	4	2.20	0.09
B7	Limited range of sustainable products and materials	3.41	7	3.44	9	3.65	7	3.16	10	3.36	7	0.99	0.39
B8	Organizational culture	3.37	8	3.61	4	3.50	11	3.16	10	3.21	9	1.26	0.29
B9	Delays in obtaining certification and permit for sustainable buildings	3.37	8	3.50	6	3.55	9	3.22	7	3.21	9	0.77	0.51
B10	Inadequate information regarding the financial and economic benefits and opportunities of sustainable building	3.36	10	3.27	12	3.50	11	3.33	5	3.31	8	0.26	0.85
B11	Cultural and social resistance	3.29	11	3.16	13	3.55	9	3.22	7	3.21	9	0.72	0.54
B12	Lack of incentives for promoting sustainable building	3.28	12	3.44	9	3.60	8	3.05	12	3.00	13	1.87	0.14
B13	Capacity barriers	3.18	13	3.50	6	3.35	13	2.77	13	3.10	12	2.47	0.06

Therefore, our academic institutions should make sustainable construction a key part of the curriculum. Likewise, construction firms should embark on regular training that will facilitate and improve the industry's knowledge of sustainable construction methods and processes.

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Dynamic Capabilities in Multicultural Project Teams: Conceptual Review, Framework Analysis and Practical Implications

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Abstract:
Contemporary projects often involve teams whose members are drawn from diverse cultures and geographical areas. Whilst researchers have investigated the role of culture in project success, they have mostly looked at it from a single lens [of a single culture]. There are significant knowledge and practice gaps in how multiculturalism shape team's effectiveness and project outcomes. This research investigates the value of cultural diversity in teams, including the integration of the strategic dynamic capabilities (DCs) framework that allows project executives and leaders to deploy the benefits of team's multiculturality as an asset in support of projects and organisational performance. It examines organisational cultures, systems and leadership that make the benefits of team's multiculturality work for all stakeholders. Initial results of the first phase of the study (an analysis of semi-structured interviews) constitute the key discussion points for this paper. In the end, the study elicits key variables that drive the effectiveness of multicultural teams [MTs] and help in developing an appropriate framework for supporting team-productivity. The additionality of the findings of the study is in its contributions to ongoing debates on the challenges and benefits of multiculturality, triggering further studies on how to harness the strengths of MTs in all forms of construction projects and management practices.

Keywords: Dynamic capabilities, multicultural teams, organisational culture, project management, management practice.

1 Introduction

Numerous factors contribute to delivering value in projects including effective management of scope, schedule, cost, risk, quality, and safety (Project Management Institute, 2017). Ultimately, project success is driven by people and how well they work together. Drucker (1997, p. 8) is apt: "The organization is, above all, social. It is people". Multicultural teams [MTs] are increasingly the norms for businesses and projects. Many studies agree that cultural diversity influences how well teams work together and ultimately, their productivity (Demirkesen & Ozorhon, 2017; Ely & Thomas, 2001; Henrie & Sousa-Poza, 2005). Thus, practitioners and researchers have continued to explore the relationship between such diversity, team effectiveness and outcomes.
This study contributes to such growing body of work by investigating the value of cultural diversity in project teams. It explores the integration of dynamic capabilities (DCs) frameworks that allows project executives and leaders to deploy the benefits of team's muticulturality as a strategic asset in support of projects and organisational. The study examines cultures, systems, and leadership

behaviours within organisations that support the harnessing of value in culturally diverse teams. Its ultimate objective is to elicit measurable variables that drive the effectiveness of multicultural teams and helps in developing appropriate frameworks for supporting productivity of project teams.

2 Review on Multicultural Teams and Project Success

Normative literature contains extensive evidence on the roles of culture in project success. A review on roles of culture ere, in particular, the relationships between project management teams and value, the influence of cultural diversity, and the way DCs framework can enable organisations and leaders to further harness the benefits of cultural diversity in teams in relation to project success is presented.

2.1 Project Management Teams and Value

Project owners and leaders are constantly exploring ways to maximise the values of project investments. Evidence by Merrow (2011) suggests many projects often fail to perform. Hence, research has multiplied on project performance and value, dimensions to project success and failure, and how they [i.e. performance, success or failure and outturn values] should be measured (Flyvbjerg *et al*., 2018; Love and Ahiaga-Dagbui, 2018; Olaniran *et al*., 2015; Olatunji, 2018). Whilst researchers have reported success on these, evidence is largely insufficient on the potentials for project teams; particularly, elements of cultural diversity in teams as key agents to maximising value.

Projects are procured to deliver future benefits. However, they are often measured by their present values. Traditional project components of scope, schedule, cost, quality, contracting and risks would add to value only if managed appropriately. How people work together on projects is a key part of this benefits realisation process. Researchers have explored the links between teamwork, team effectiveness and performance (Backhaus & Heiner, 2014; Fong & Lung, 2007; Spencer, 2013). Others have studied human resource systems, organisational support, and team leadership (Randeree & Ninan, 2011; Wang & Tian, 2012). Not much has been reported on harnessing the value of cultural diversity in teams despite the popularity of the latter. Moreover, most research efforts on the subject are more localised in the United States than in other places, including Australia where one in three residents is born overseas (Australian Bureau of Statistics, 2020).

2.2 Multicultural Teams

MTs perform tasks and activities in delivering project outcomes and values, as expected of teams. Why does the narrative on culture stir diverse reactions from stakeholders? Some alignment on the basics may be helpful. Culture is described as a mental software, a collective programming of the mind, which distinguishes one person, people, and teams, from another (Hofstede *et al*., 2010). It has also been portrayed as the shared way that groups understand and interpret the world as well as platforms that hold conditions for their bonding and meaningful communications (Gharajedaghi, 2011; Trompenaars & Hampden-Turner, 2002). Giorgi *et al*. (2015, p. 4) state that culture is a broad system anchored by values within which actors can manifest ideas, beliefs, stratifications, stories, and commitments.

The importance of culture has gained increased attention within the project management profession. For example, the Project Management Institute (PMI) commissioned a study on culture, in which 770 scholarly articles and 93 books were analysed. Findings from the study reinforced the need for cultural awareness and research (Henrie & Sousa-Poza, 2005). Recent editions of PMI's body of knowledge have maintained the significance of culture in successful project management processes and outcomes (Project Management Institute, 2017). Despite this, there is less research regarding cultural diversity in teams. Whilst the dynamism in the diversity in multicultural teams is, believe as the norm in business and projects, there is no equivalent increase in supporting theoretical knowledge and empirical frameworks.

Diversity can be approach from multiple viewpoints; including gender, race and ethnicity. Ely & Thomas (2001) did associate cultural diversity with differences in visible manifestations like skin colour or less visible aspects of values. Ethnicities and nationalities are the most relevant for this study. Thus, like Adler & Aycan (2018) expressed diversity in terms of the number of cultures represented in a team. For this study, MTs consist of members from multiple cultures.

2.2.1 Benefits of Multicultural Teams

Miller (1995) evinces the point that valuing diversity is more than making a positive impression with key stakeholders; rather, relying on the capabilities for competitive advantage. Miller (1995) reports a survey of 312 companies in the United States and reveals that only less than 10% of participants linked diversity to productivity. This suggests a latent preference to maintain the status quo of acquiring and preserving diversity as a positive image. Nonetheless, the findings indicate that valuing diversity can increase competition for markets, solve demand issues for labour and facilitate new beneficial ways of responding to changing market conditions.

Creativity is often cited as a benefit of cultural diversity due to wider range of perspectives, more and better ideas, and less inclination to groupthink (Glaveanu & Taillard, 2018; Stahl & Tung, 2015). Valued and supported MTs can help organisations to prepare for the future where work is anticipated to become increasingly diverse and global in nature (Un, 2016). Finally, MTs can provide the advantage of increased capacity for market penetration into diverse customers especially in this era of globalisation (Matveev & Milter, 2004).

2.2.2 Challenges of Multicultural Teams

Adler & Aycan (2018) and Wu *et al*. (2019) claim cultural diversity causes difficulties in teams, resulting in mistrust, miscommunication, decreased team cohesion, tension and stress, and unproductive time and efforts in dealing with these issues. Matveev & Milter (2004) also cited conflicts, decreased ability to validate ideas, arrive at consensus and execute actions promptly, complexities, and team inertia. Expectedly, stakeholders turn to organisational leaders with hope and solutions for harnessing the benefits whilst mitigating the challenges.

2.2.3 Making it Work: Organisational Culture, Leadership, and Dynamic Capabilities

Organisations deliver value by amplifying people's strengths whilst mitigating their weaknesses. How appropriate are the considered intentions of business leaders in maximising the value in MTs, at the same time mitigate the challenges? A profile described by Ladkin (2008) and Adler (2013) as *leading beautifully* suggests such leaders courageously value and envision great possibilities with culturally diverse teams, whether others share the same belief or not.

Thomas (2004) reports the IBM case where senior executives led the growth in its multicultural and women-owned businesses from $10 million to more than $300 million in just 3 years. The leadership achieved this success by promoting and building the capacity for harnessing the benefits of diversity in the organisation and teams. They led *beautifully*. Dynamic capabilities framework has the potential to enhance the solutions.

DCs are processes that enable organisations to purposefully create, deploy, and protect valuable, rare, inimitable, and non-substitutable (VRIN) assets (Teece, 2007; Eisenhardt & Martin, 2000; Helfat & Martin, 2014). VRIN's attributes and resource-based view (RBV) of firms have been develop in normative scholarship by Barney *et al*. (2011) – and others. These researchers have shown that DCs support superior business performance in the end. Studies by Adam & Lindahl (2017), Davies & Brady (2016), and Zerjav *et al*. (2018) have extended the same concepts [VRIN and RBV] to project management. However, limited attention have been given to DCs in harnessing the strategic value-additions of MTs, which arguably qualify as VRIN assets; thus, the potential to deploy the capabilities in support of long-term performances in businesses and projects. This is the core objective of this current study.

3 Research Methodology: Framework Development

3.1 Method Design and Approach

This study was design to answer three questions based on literature review and the need to further close identified gaps for harnessing the value in MTs. They are:

(1) What are the values in MTs, and the pros and cons?
(2) What organisational culture and leadership are required to harness the benefits of MTs?
(3) How can the key variables be articulated along with DCs in modelling a framework for valuing and managing MTs for long-term benefits?

The research aligns with the pragmatic philosophy and approach to theory development in that, a robust research will provide answers with multiple viewpoints and interpretations rather than a single point of view. It is aim at reconciling objectivism and subjectivism, facts and values, accurate and rigorous knowledge as well as different contextualised experiences as outlined by Saunders (2016). It involves collecting data to identify themes and explain patterns that help generate a new set of theories or modify existing ones. The latter will be tested iteratively through additional data collection until an overall theory is develop fully.

Findings reported in this study are a part of a broader study spanning three phases: Phase 1, a qualitative study (semi-structured interviews) – reported here; Phase 2, a quantitative study (questionnaire survey); and Phase 3, another qualitative study (case study) in which the study validates its key findings. They are being executed in succession in the order as stated. Other researchers have used this approach as well. For example, Gibson *et al*. (2020) used interviews and surveys in their study on revealing the attributes of global workers that lessen intrapersonal identity conflict and show that doing so is critical for thriving in global work contexts. Lammers *et al*. (2013) used a similar method in examining the relationships between group, organisational and professional identities. This current study has taken it to the next level of robustness by adding a third layer of case study in recognition of the value of depth and generalisability.

This paper is on the Phase 1 interview study, which has been designed to provide valuable insight into the context of MTs prior to commencing the quantitative phase (Liamputtong, 2013; Creswell, 2018). Considerations were given for access to targeted participants and theoretical saturation (see Saunders, 2016), and adequate representation of disciplines, experience levels, industry types, and diversity. The peer-reviewed and pilot-tested instrument comprises of open-ended questions to elicit the viewpoints of participants in line with the research objectives. Initially, interviews were planned to be face-to-face. However, adjustments were made to use Zoom due to the infection COVID-19 pandemic may cause.

3.2 Data Collection and Analysis

Twenty-five (25) individuals (15 males and 10 females) participated in the interviews. Their work experience ranged from 13 to 38 years, and their industries comprised of oil and gas, utilities, construction, Government, and professional services. Disciplines represented included project management, quantity surveyors, architecture, and human resource management. Whilst they have all worked in Australia at different periods, their cultural diversity spreads across 13 different nationalities by birth (see Figure 1 below).

A detailed thematic analysis was conducted on the transcribed interview data to make more meaning of the datasets and in the context of the research questions and objectives. It involved the development of central themes, as well as drawing out the importance of words or texts. Content analysis software, NVivo 12 was used for data analysis and including providing the required automation and bulk data processing. *Intentionality*, *value*, *challenges*, and *making it work* are the key themes established from the interviews and analysis (see Table 1 below). They form the main nodes for further analysis. The need for intentionality in harnessing the benefits of MTs constitute a significant early contribution from this study. Valuing cultural diversity, exploring VRIN, and leveraging off the gender diversity gains are sub-themes that were unearthed from the *value* node. It is the same with leadership, organisational culture and system, recruitment, and training coming up as sub-themes of the *making it work* node.

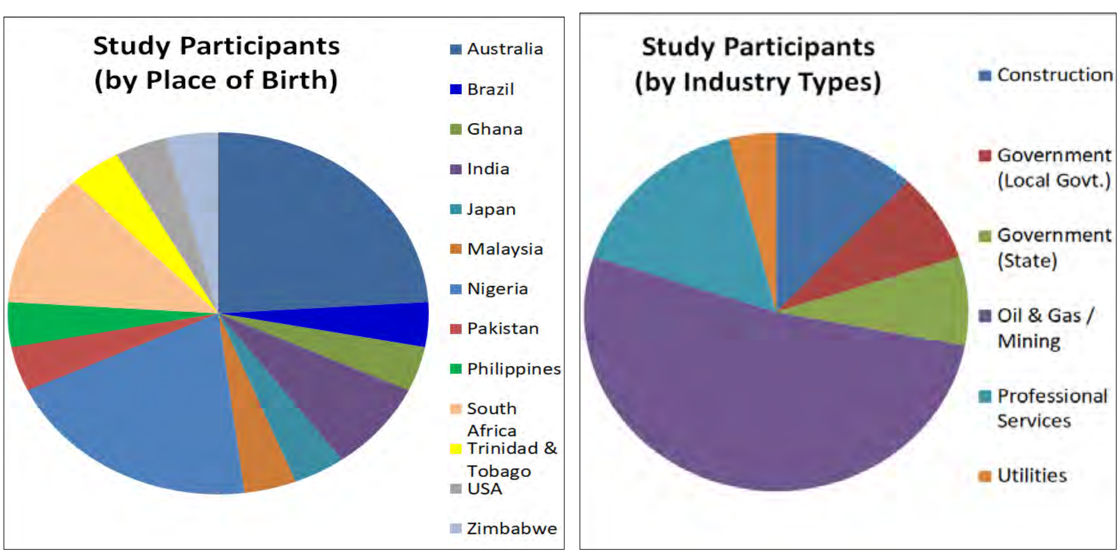

Figure 1. Demographics of Study Participants

Table 1. A Snapshot of High-Level Findings from Phase 1 Interview Study

Nodes		
Name	Files	References
1 - Introduction	0	0
2 - Intentionality	0	0
2.1 - Intentional	13	19
2.2 - Non-Intentional	13	15
3 - Value	0	0
3.1 - Sees value in culturally diverse teams	25	46
3.2 - Rare - Non-imitable - Non-substitutable	9	12
3.3 - Leverage Gender diversity gains (the Multiplier effect)	9	11
3.4 - Does not see value in culturally diverse teams	1	2
4 - Challenges	18	31
5 - Making it work	0	0
5.2 - Leadership	20	46
5.3 - Organisational Culture and System	20	52
5.4 - Recruitment	6	11
5.5 - Training	16	24

3.2.1 Intentionality

This theme became evident during this study in 2 forms: (i) are leaders intentional with forming, valuing, and developing culturally diverse teams. (ii) How critical is the intentionality factor in harnessing the value in MTs? The results of the analysis show an even level of intentionality (see Table 1 above): almost an equal number of project leaders were intentional about having culturally diverse teams just as the reverse. Below are some of the excerpts from the participants:

> *No, we did not go out intentionally to recruit a culturally diverse team. It just morphed.*
>
> *I hired members of my team based on the required skills first. However, I was also intentional in my target for diversity because of my role in servicing a culturally diverse consumer base.*
>
> *This is intentional for us. It does not necessarily have to be in the form of direct employment, but it could be by spend like contracting, suppliers, consultants, think-tanks participation. This way diversity via the thought process could be facilitated.*

3.2.2 Values and Challenges

Participants agreed to the value of MTs, and the challenges as well, to a lesser degree:

> *A diverse team is a stronger team. A culture or work environment where there is mutual respect, it is developed over time. This makes people to be appreciated and happy and they give you 100%. Increased productivity will be evident.*
>
> *In terms of rarity: yes, you do not find it easily. Like the team next to us, which is less diverse, and they perform their job, but it is different to ours. Moreover, it takes time and efforts to develop to such high performing, culturally diverse team.*

It is harder to form, manage and lead a culturally diverse team. Managers are under pressure to deliver results at any cost especially during boom. Thus, it is easier to manage than to lead. Therefore, they lead as an easier way since there are less variables unlike a culturally diverse team. The latter requires leadership (not management), etc.

3.2.3 Making It Work

The results also indicate a strong alignment on the need for *making it work* - enhancing the values and managing the challenges. Here are some findings towards this objective.

The success of push for harnessing value out of cultural diversity and making it work will ultimately depend on leadership and aligned organizational culture / system.

There's need to educate leaders around having the foresight for alternative perspectives. They need to think about the value of diversity and inclusion. Remove the barriers against openness including training for reducing or removing conscious and unconscious biases, using recruitment systems without identifiers, and establishing supply chain for talents and diversity.

Our differences are deep. Mind-sets will be challenged. The concept of harnessing the value in cultural diversity is almost against the natural leanings. We really have to step back and holistically promote a system that supports value for differences in thinking, etc. This is not going to work, without a strong leadership spine.

4 Practical Implications

Phase 1 of this study has further acknowledged the benefits of valuing cultural diversity in teams, and this aligns with other scholars (Miller, 1995; Adler & Aycan, 2018; Stahl & Tung, 2015; Un, 2016; Glaveanu & Taillard, 2018). The results also show similar alignment on requirements for harnessing these benefits including the right organisational culture (MüHlbacher & BöBel, 2018), organisational systems (Orlando & Johnson, 2001), and leadership (Thomas, 2004; Adler, 2013). It went further by opening an aspect that has had little or no attention in the literature – intentionality. The intentionality in harnessing the benefits in MTs is tied to leadership. Ladkin (2008) and Adler (2013) described as *leading beautifully.* Valuing cultural diversity in teams and making it work will require *leading beautifully*.

Our mixed-method approach has provided the real-life contextual understandings, multi-level perspectives, and reasonable generalisation that this topic deserves. The potential for triangulation across evidence and instances gives extra validity to the outcomes. The research framework is delivering the deeper elaboration of the aspects and issues relating to the value and management of cultural diversity in teams that neither qualitative nor quantitative method can provide alone. *Intentionality, value*, *challenges* and *making it work* are core themes to take into the next phase of this study. They have already opened some subthemes including diversity of ideas, optionality, and intentional leadership. All these, singly or in combination, are potentially part of the dynamic capabilities in multicultural teams to explore further.

5 Conclusion

This study contributes to ongoing debates on the value of cultural diversity in teams including the benefits and the challenges. The findings have provided additional and indication for the competitive advantages in MTs as valuable, rare, inimitable, and non-substitutable (VRIN) assets. They provide dynamic capabilities for creativity, optionality, and learning. Intentional and courageous leadership is required to drive the organisational culture and systems that will harness these benefits of team's multiculturalism and make it work for all stakeholders in construction projects and management practices. The results of this Phase 1 qualitative study (semi-structured interviews) are not generalisable due to the relatively small sample size. Moreover, however, we have a solid foundation for Phase 2 and Phase 3 of the research consisting of a quantitative study (questionnaires) and a case study, respectively. It is hope that further findings will provide triangulation and validation along with building a deployable framework.

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Entry modes used by multi-national firms in crossing borders into the Nigerian construction market

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Abstract:
The contribution of multi-national firms to the Nigerian construction market is significant due to the huge demands for basic infrastructure in the country. However, multi-national firms seeking entry into the Nigerian construction market need to decide which entry mode to use in entering the market. This paper examines the profiles of multi-national firms operating in the Nigerian construction market and assesses the entry modes used by the multi-national firms to access the market. A quantitative research approach was adopted where data were collected through copies of questionnaires administered on directors, chief executives, managers, and senior personnel working for the multi-national construction firms in Nigeria. Descriptive and inferential statistics were used to analyse the data collected. The study reveals that some multi-national firms have established themselves in the Nigerian construction market because of their financial capabilities, technical know-how, manpower, equipment and machines to participate in the market. The study also established that multi-national construction firms in Nigeria have used entry modes like licensing, branch office/company, joint venture company, sole venture company and built operate transfer/equity project to enter the market and these entry modes were effective. The paper concludes that the multi-national firms that are working in the Nigerian construction market are competent and the entry modes they used to access the market are effective.

Keywords: construction market, entry modes, foreign market, multi-national firms, Nigeria

1 Introduction

Nigeria is a developing country with infrastructure deficit. This is because continuous government spending on infrastructure over years and most indigenous construction companies are not financially capable of financing projects independently without mobilisation. This has necessitated the multi-national contractors to participate in Nigerian construction market (NCM) because of their level of financial, human and experimental capabilities and technical know-how in fixing the infrastructure problem in the country. However, due to the extent of uncertainties that characterised foreign market operation, it is essential to understand market entry mode before taken decision to explore opportunities in the market (Odediran and Windapo, 2016).

Entry mode is an international market system through which firms access foreign markets when opportunities available or a decision to expand operation into the international market is made

(Odediran, 2016). The choice of an entry mode for a target market is influenced by three determinant factors: ownership advantages of a firm, location advantages of a market, and internalisation advantages of integrating transactions within the firm (Ling, IBBS and Cuevo, 2005). The most common modes of market entry into foreign markets are exporting, licensing, joint venture, sole venture, representative office, strategic alliance, local agent, branch office/company and build, operate and transfer project (Chen and Messner, 2008). Since the nature and complexity of international business environment are unique from one country to another, it entails higher external risks (country and industry factors) and internal barriers (firm and project factors) to enter the foreign market (Cui and Jiang, 2009).

Moreover, market entry strategies help a firm entering into a new foreign market to expand their businesses in terms of services, products, technology, human and other resources. Entry strategies into a market require some major decisions, which include the choice of a target market, the objectives and goals in the target market, the choice of an entry mode to penetrate the target market, the marketing plan to penetrate into the target market as well as the control system to monitor performance in the target market (Chen, 2015). It is required of the firm to decide which market to enter (market selection decision), how to enter (entry mode decision), and when to enter (entry timing decision). All these decisions require certain level of commitment in terms of resources (Chen, 2015).

Multi-national construction company (MNCC) is a company in the fields of building or civil engineering construction that operates in several countries and has employees far beyond the country of its creation taking into account characteristics of national markets of foreign countries (Chen, 2015). Multi-national corporations are the result of globalisation. They occupy a central role within the process of globalisation as evidenced through global foreign direct investment inflows. Their concentrations within Europe and in western economies has led to size constraints. Therefore, there is a need for new geographical areas to operate whereby they will face a lot of competition in the market (Odediran, 2016; Odediran and Windapo, 2016). However, since it is obvious that there are constraints to the operations of MNCCs in foreign markets, this study examines the profiles of multi-national firms operating in the Nigerian construction market. It assesses the entry modes used by the multi-national firms to access the market.

2 Literature Review

2.1 Capabilities Requirements of Multi-national Companies for International Market Operation

Multi-national construction company (MNCC) is a company or corporation in the fields of building or civil engineering construction that operates in several countries and has employees far beyond the country of its creation taking into account characteristics of national markets of foreign countries (Ngowi, Pienaar, Talukhaba and Mbachu, 2005). Multi-national corporations are the result of globalisation. They occupy a central role within the process of globalisation as evidenced through global foreign direct investment inflows. Their concentrations within Europe and in the western economies has led to size constraints. Therefore, there is a need for new geographical areas to operate whereby they will face a lot of competition in the market (Shen, 2013).

Large multi-national construction firms often competed within one another's domestic markets because their domestic construction markets are by far the world's largest. For example, from the

1970s, Japanese construction firms followed Japanese manufacturing, trade, and service corporations and began constructing the factories and offices abroad, especially in the US (Deng, Pheng and Zhao, 2014). More than one-third of the companies have 100 employees and above on their payrolls. A large number of these companies conduct one form of construction service in cross-border. One-third of these companies have annual revenues that are well above 250 million dollars, while the annual revenues of more than one-tenth are greater than 450 million dollars (Gunhan and Arditi, 2005). The assets of more than one-fifth of the companies are greater than 1 billion dollars which showed that the resources of the majority of the companies are adequate for cross-border entry decisions and operation (Xiaopeng and Pheng, 2013).

Experience of multi-national companies implies knowledge; thus, the more experience a firm has gained in the international marketplace, the more knowledgeable and confident it will be about the opportunities and threats that the global market presents. Reliable information about international markets enhances a firm's competitiveness by better responding to environmental changes (Sillars and Kangari, 1997). Al-Sabah, Menassa and Hanna (2012) reported that the international experience of a firm appeared to have a significant influence on mode of entry choice. Firms' perceived risk and uncertainty pertaining to international construction also decrease as they gain more experience in foreign markets. Furthermore, such experience tends to improve their skills and knowledge about foreign customers (Odediran and Windapo, 2016)

Human resources that relate to the quality and composition of staff in the firm and the commitment of management to exporting are intrinsic to the success of firms in their exporting endeavours (Low and Shi, 2001). For example, if a firm lacks qualified employees to handle export-related matters effectively, then export performance could be negatively affected. As such, empirical evidence from previous relevant research suggests that lack of export training or qualified personnel for exporting is a cardinal obstacle to exporting. Inadequate human capital resources in a firm could also lead to a lack of a dedicated or special department responsible for exporting activities. This situation, which is usually the case for SMEs, indicates poor export performance (Suárez-Ortega, 2003). Therefore, firms' number of employees cannot be overlooked because of its significance in exporting a firm's services. Firms employee size determines its workforce, financial strength, worth and human resources (Miller, 2013).

2.2 Entry Modes into International Markets

Entry mode is an institutional arrangement that makes possible the entry of a company's products, technology, human skills, management or other resources into other country (Odediran, 2016). An entry mode defines "how" an entrant enters a foreign market, by abstracting the pattern of institutional settings to support the entry process. There are two major managerial decisions to make when considering market entry which include 1) the timing of market entry and 2) the mode of the market entry (Chen, 2015). The flow of business between two countries is a direct indicator of the extent of interaction between the two countries. The higher the volume of bilateral business, the more knowledge firms have accumulated about the host country market, and the more confident they are in adopting permanent modes. Therefore, the stronger the trade relationship is, the more possible that entrants will use permanent entry modes (Chen, 2008).

Multi-national enterprises (MNEs) may favor a mode of entry entailing less resource commitment when the sales growth of a target industry is declining (Low and Shi, 2001). With other things being equal, MNEs are expected to favor low resource commitment modes of entry when a host market is in its embryonic or declining state. A strategic alliance is a long-term inter-corporate association without an affiliated organisation based on trust and a mutual respect for each participant's business needs, used to further the common interests of the members that can include customers, governments, suppliers, engineers, financial institutions, and contractors (Abdul-aziz et al, 2013). International construction and contracting firms worldwide are increasingly asked to offer financing packages or take equity in projects (Wolff and Pett, 2000). A build-operate-transfer (BOT) or equity project provides a vehicle for an international contractor to pursue such projects. The BOT/PPP/PFI perspective emphasises combining the complementary skills and resources of public agencies and private parties to achieve a win/win result. A traditional construction firm can be the concessionaire or just a partner of the project company in a BOT project. The contractor is also responsible for facility construction, normally under a turnkey contract (Suárez-Ortega, 2003). A joint venture (JV) company occurs when two or more legally separate bodies form a jointly owned entity in which they invest and engage in various decision-making activities (Odediran, 2016). A joint venture company is termed an international joint venture company where at least one party (or parents) is based outside the country where the venture is taking place (Hastak and Shaked, 2000). Construction organisations have extensively used international JVs to enter new construction markets around the world (Mohamed, 2003). A representative office normally prohibited from engaging in direct, profit-making business activities, can do business communications, product promotion, market research, contract administration, and negotiations on behalf of their head office and other such non-commercial activities (Hastak and Shaked, 2000). The most apparent advantages the representative office has over other entry modes are its simplicity and flexibility. Closing a representative office is also relatively easy compared to terminating a joint venture.

Licensing means a mode that may include licensing, franchising and technology transfer that involve a contract between parties in different countries on the licensee’s use of limited rights or resources such as patents, trademarks, trade names, technology, or managerial skills from the licensor (Chen, 2005). This allows the licensee to provide construction services in the host country similar to the one the licensor has already been providing in its home country (Chen, 2005). A significant portion of international trade is carried out through agents. The common use of local agents is also very common in international construction. Agents can provide principle information on local market conditions (social, legal, economic, political, and financial); contacts with local owners, governments, and suppliers/subcontractors; and assistance in visa application, permission application, driver’s license application, import/export, taxes, property and equipment lease/purchasing, communication infrastructure, and bidding information (Mat Issa et al, 2014).

The sole venture (SV) subsidiary offers international contractors increased flexibility and control to set up and protect their own processes and procedures and expand as quickly as they wish. Although it can be established more quickly than a JV company which involves time consuming negotiation, the establishment of a SV subsidiary is still lengthy as well as complex and costly. (Chen, 205). Many multi-national enterprises use a SV company only after expanding into markets through other modes that have helped them accumulate enough host country experience.

3 Research Methodology

This paper investigates the entry modes used by multi-national companies in crossing borders into the Nigerian construction market. A quantitative research approach was employed whereby data were collected through copies of questionnaire administered on 36 directors, managers and senior personnels who are professionals and working for multi-national construction companies in Nigeria. The populations for this study were the MNCCs that are registered with the six States in Southwestern Nigeria. The information about the MNCCs is obtained through a pilot study conducted on various ministries, agencies, and parastatals of the states in Southwestern Nigeria to know the list of MNCCs registered and operating in each of the states.

The instrument used in collecting data was structured into major sections that include the officers who responded to the survey, their designation, year of work experience and number of the full-time employees. The research instrument was used to collect information from 36 directors, managers and senior personnels. However, data collected were analysed using both the descriptive (frequency distribution and mean score). Frequency distribution describes the respondents' responses to the background information examined and the number of firms with their usage of entry modes. Mean score measures the rate at which multi-national firms used entry modes.

4 Findings and Discussion

The data collected in the study were presented and analysed under the following sub-headings:
The profile of multi-national firms operating in the Nigerian construction markets. The results on Table 1 show the profile of multi-national firms operating in the Nigerian construction markets as surveyed and responses to the research questions. It emerged that 16.7% of the companies had been in the construction business between 0 -5 years, 16.7% had between 11-15 years of experience in construction business. However, 16.7% and 27.8% had been in business between 16-20 years and 21-25 years, respectively. Similarly, 22.2% had been in business for over 25 years.

The results further show that 47.2% of the multi-national construction firms are registered with the six states in southwestern Nigeria. Information about the companies' total revenues shows that about 8.3% and 13.9 had revenues that range between 51-100 million dollars and 101-500 million dollars respectively. Similarly, 8.3% and 13.9% of the construction firms had revenues that range between 151-200 million dollars and 201-250 million dollars respectively, while the revenues of approximately 55.5% of the companies had above 250 million dollars. Further assessment shows that approximately 5.6% of the construction firms have assets of about 51-100 million dollars, 8.3% and 27.8% have assets between 101-150 million and 151-200 million, respectively; while 58.3% have above 250 million worth of assets.

Approximately 33.3% of the companies who responded to the survey had 12 permanent staffs, while 66.7% of the companies had permanent employees. These findings are in line with a similar study of BEEPS (2009) and Odediran (2016), which established that considerable construction firms had more than 19 years of experience. Findings of this study agree with previous studies as regards firms' years of experience. Similarly, the study established that multi-national firms have average revenue of above $250million and above $250 million worth of assets. This finding is also in line with Ortega (2003) and Leonidou (2004), which opined that assets and revenue are key to firm's success.

Table 1. Profile of Multi-national Firms

Profile of Companies	Frequency	Valid percentage
Experience of Construction Business		
0-5 years	6	16.7
11-15 years	6	16.7
16-20 years	6	16.7
21-25 years	10	27.8
Above 25 years	8	22.2
Total	**36**	
Company Total Revenue (Dollars)		
51 – 100 million	3	8.3
101– 150 million	5	13.9
151-200 million	3	8.3
201 – 250 million	5	13.9
> 250 million	20	55.6
Total	**36**	
Company's Total Assets (Dollars)		
51 – 100 million	2	5.6
101 – 150 million	3	8.3
201 – 250 million	10	27.8
Above 250 million	21	58.3
Total	**36**	
Total Number of Permanent Employees		
0 – 50	12	33.3
51 – 100	24	66.7
Total	**36**	

N = 36

4.1 Modes of Entry Used by the Multinational Construction Firms

The section assessed modes of entry used by the multi-national companies to enter the Nigerian construction market. The responses obtained are presented in Table 2. The table shows the mean score and rank concerning usage of modes of entry used by the Multi-national companies.

The table analyzed the usage of modes of entry by multinational firms in crossing border into the Nigerian construction market based on the designation of the respondents. The top five (5) high ranking entry modes as perceived by the directors are joint venture project (MS = 3.33), bot/equity project (MS = 3.33), licensing (MS = 3.00), sole venture project (MS = 2.67) and joint venture company (MS = 2.67). Similarly, the top five (5) high ranking entry modes as perceived by Mangers are joint venture project (MS = 4.00), joint venture company (MS = 3.25), bot/equity project (MS = 3.20), strategic alliance (MS = 2.40) and branch office/company (MS = 1.80). Furthermore, the top five (5) high ranking entry modes as perceived by senior personnel are joint venture project (MS = 3.38), joint venture company (MS = 3.36), licensing (MS = 3.20), bot/equity project (MS = 2.83) and branch office/company (MS = 2.68). Likewise, the top five (5) high ranking entry modes as perceived by others are joint venture project (MS = 3.78), joint venture company (MS = 3.73), bot/equity project (MS = 3.55), licensing (MS = 3.36) and branch office/company (MS = 2.18).

Table 2. Modes of Entry Used by Multinational Construction Firms

	Overall		**Director**		**Manager**		**Senior Personnel**		**Others**		**ANOVA**	
Entry Modes	**MS**	**R**	**MS**	**R**	**MS**	**R**	**MS**	**R**	**MS**	**R**	**F**	**Sig**
Joint Venture Project	3.65	1	3.33	1	4.00	1	3.38	1	3.78	1	1.32	0.28
Joint Venture Company	3.42	2	2.67	4	3.25	2	3.36	2	3.73	2	0.97	0.43
BOT/Equity Project	3.19	3	3.33	1	3.20	3	2.83	4	3.55	3	1.51	0.22
Licensing	3.04	4	3.00	3	1.60	6	3.20	3	3.36	4	3.71	**0.01***
Branch Office/Company	2.48	5	2.33	7	1.80	5	2.68	5	2.18	5	0.63	0.65
Sole Venture Project	2.43	6	2.67	4	1.60	6	2.43	7	2.11	6	0.60	0.67
Representative Office	2.22	7	2.00	9	1.00	9	2.60	6	2.09	7	1.57	0.20
Sole Venture Company	2.17	8	2.33	7	1.00	9	2.32	8	2.00	8	1.29	0.29
Local Agent	1.88	9	2.67	4	1.20	8	2.17	9	1.45	9	2.20	0.09*
Strategic Alliance	1.86	10	1.33	10	2.40	4	1.96	10	1.36	10	1.99	0.11

$P \leq 0.05$. MS = Mean Score; R = Rank; *Significant at 5%

The overall ranking results show that joint venture project (MS = 3.65) was ranked 1st as the most used entry modes by multi-national firms to enter into the Nigerian construction market. This simply means that most of the multi-national firms find joint venture project as a significant way of entering into the Nigeria construction market. The joint venture company (MS = 3.42) and BOT/equity project (MS = 3.19) were ranked 2nd and 3rd. This indicates that multi-national firms would prefer both entry modes in gaining access into the Nigeria construction market. Entry modes such as licensing (MS = 3.04) and branch office/company (MS = 2.48) ranked 4th and 5th, respectively, and this also indicates that multi-national firms would prefer to use BOT/equity and licensing as one of the major entry modes into the Nigeria construction market as it makes it easier for them to gain access.

The results agreed with earlier studies on entry modes as opined by Mat Issa (2014) and Detzer (2010). They submitted that multi-national firms would prefer entry modes such as joint venture and branch office/company as it reduces risk on the part of the multi-national firm/company. This was also supported by the studies of Chen (2005) who identified entry modes such as BOT/Equity, licensing and joint venture company. This indicates that the firm will be willing to explore the cross borders market if it sees an opportunity to share the unforeseen risk. The results also agreed with studies on entry modes by Mohammed (2003), Hastak and Shaked (2000), Pheng and Leong (2000), Suarez-Ortega (2003) and Tsui (2004)

The respondents' views were tested using ANOVA test as shown in Table 2. The results indicate that there are significant differences in the perceptions of the respondents. However, at 5% confidence level ($P \leq 0.05$) there was a significant difference in the perceptions of the four groups of respondents on usage of licensing with a significance value of 0.01. This implies that there was a significant difference in the opinions of the respondents surveyed on the entry mode. While other modes of entry had significant values such as joint venture project (0.28), joint venture company (0.43), BOT/equity project (0.22), branch office/company (0.65), sole venture project (0.67), representative office (0.20), sole venture company (0.29), local agent (0.09) and strategic alliance (0.11) which is higher than the alpha value 0.05. This simply means that there was no significant difference in the opinion of the respondents. Similarly, the study tested the level of effectiveness of these entry modes as shown in Table 3. The table 3 highlights the effectiveness of these entry modes as perceived by respondents surveyed.

Table 3. Level of Effectiveness of Entry Modes Used by Multi-national Companies

	Overall		**Director**		**Manager**		**Senior Personnel**		**Others**		**ANOVA**	
Entry Modes	**MS**	**R**	**MS**	**R**	**MS**	**R**	**MS**	**R**	**MS**	**R**	**F**	**Sig.**
Licensing	3.50	1	4.33	1	3.40	5	3.48	1	3.27	5	1.73	0.16
Branch Office/Company	3.49	2	3.00	9	3.80	2	3.44	2	3.64	2	0.55	0.70
Joint Venture Company	3.44	3	4.00	3	3.40	5	3.40	3	3.27	5	1.37	0.26
Sole Venture Company	3.42	4	4.33	1	3.80	2	3.40	3	3.09	8	1.41	0.25
BOT/Equity Project	3.41	5	3.67	6	4.00	1	3.32	5	3.45	3	1.87	0.14
Sole Venture Project	3.40	6	4.00	3	3.20	8	3.28	7	3.80	1	2.47	0.06
Representative Office	3.38	7	3.00	9	3.80	2	3.32	5	3.36	4	0.85	0.50
Joint Venture Project	3.30	8	4.00	3	3.20	8	3.20	9	3.27	5	0.85	0.50
Local Agent	3.20	9	3.33	8	3.40	5	3.24	8	3.00	9	0.29	0.88
Strategic Alliance	3.04	10	3.67	6	3.20	10	2.88	10	2.91	10	0.61	0.66

$P \leq 0.05$ MS = Mean Score; R = Rank

The top five (5) high ranking effective entry modes as perceived by directors are licensing (MS = 4.33), sole venture company (MS = 4.33), joint venture company (MS = 4.00), sole venture project (MS = 4.00) and joint venture project (MS = 4.00). Similarly, the top five (5) high ranking effective entry modes as perceived by managers are bot/equity project (MS = 4.00), branch office/company (MS = 3.80), representative office (MS = 3.80), sole venture company (MS = 3.80) and licensing (MS = 3.40). Furthermore, the top five (5) high ranking effective entry modes as perceived by senior personnel are licensing (MS = 3.48), branch office/company (MS = 3.44), joint venture company (MS = 3.40), sole venture company (MS = 3.40) and bot/equity project (MS = 3.32). Likewise, the top five (5) high ranking effective entry modes as perceived by others are sole venture project (MS = 3.80), branch office/company (MS = 3.64), bot/equity project (MS = 3.45), representative office (MS = 3.36) and joint venture project (MS = 3.27).

The overall ranking results showed that licensing (MS = 3.50) was ranked 1st as the most effective entry modes used by multi-national firms to enter into the Nigerian construction market. This simply means that most of the multi-national firms find licensing as a major system of entering into the Nigeria construction market. Branch office (MS = 3.49) and joint venture company (MS = 3.44) were ranked 2nd and 3rd, respectively. This indicates that multi-national firms would prefer both entry modes in gaining access into the Nigeria construction market. Entry modes such as sole venture company (MS = 3.42) and BOT/equity project (MS = 3.41) ranked 4th and 5th respectively, and this reveals that multi-national firms would prefer to use BOT/equity and sole venture company as one of the most effective entry modes into the Nigeria construction market.

Upon considering years of experience in accessing the effectiveness of entry modes, entry modes such as joint venture company, sole venture company, bot/equity project, branch office/company and licensing all ranked highest as the most effective entry modes. The findings of this study agree with earlier studies on entry modes and decision making by Root (2000), Pheng and Leong (2000), Suarez-Ortega (2003) and Tsui (2004).

The respondents' views were tested using ANOVA test as shown in Table 3. The results indicate significant differences in the respondents' perceptions, as shown in the table. However, at 5% confidence level ($P \leq 0.05$), there was no significant difference in the opinions of the four groups of the respondents on the effectiveness of entry modes examined. The modes of entry had significant values such as joint venture project (0.50), joint venture company (0.26), branch office/company (0.70), strategic alliance (0.66), licensing (0.16), sole venture project (0.06), sole venture company (0.25), representative office (0.50), BOT/equity project (0.14) and local agent (0.88) which is higher than the alpha value of 0.05. This simply means that there was no significant difference in the opinion of the respondents' designation.

5 Conclusion and Further Research

The paper concludes that the multi-national firms that are operating in the Nigerian construction market are capable and competent. It also concluded that entry modes such as joint venture project, joint venture Company, branch office/company, strategic alliance, licensing, sole venture project, sole venture company, representative office, bot/equity project and local agent are used by multi-national firms in entering the Nigerian construction market. Further research could be risks encountered by the multi-national firms in crossing border into the Nigerian construction market.

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Effect of Moisture on Durability of Concrete Components in Residential Buildings

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Abstract:
Moisture is any visible, measurable, or perceived water indication due to natural and artificial occurrences within and around the building. This research tends to establish causes, effects, and method of controlling the menace usually caused by moisture in residential buildings. This research used descriptive and deductive approach and made use of Nondestructive methods of investigation. Data for this research were retrieved from a structured questionnaire administered to occupants and professionals (in building construction/maintenance) in the Lekki-Ajah axis of Lagos State, Nigeria. The research finds out that the areas of the building where moisture occur most are the bathroom, toilet and laundry room. Poor quality of construction materials, bad workmanship, and rising dampness are major causes of moisture in residential building. Moisture greatly affects the corrosion of metals used in building and also aid microbial/vegetation growth and discolouration of wall paint in the building. The research recommends the use of quality damp proofing materials, proper installation of service pipes, the establishment of a good maintenance program, timely inspection by regulatory agencies (before, during and after the construction work) as ways through which moisture can be controlled in buildings to checkmate the effect of moisture on Building components and to enhance healthy living for occupants of Buildings.

Keywords: Durability, healthy living, moisture, occupants and residential building

1 Introduction

According to WHO (2009), moisture is a visible, measurable or perceived indication of water infiltration into Building components orchestrated by indoor occurrences, climate problems, and errors during assembling and installing building components, which causes various leakages and water movement (vapour and liquid) in building components. Moisture has caused great defect and threatens many buildings, and it is recognized as one of the most dangerous building enemies. Moisture problems occur when an excess of moisture accumulate or get entrapped in parts of the building that ought to be dried, and this could occur due to design oversight, construction error or improper maintenance. (Ahzahar et al 2011, Almas et al 2011, Chew, 2005 and Kubba, 2008). This paper examined the effects of moisture on the concrete component of residential buildings, the wellbeing of occupants of buildings and suggest ways through which the effect can be mitigated to improve the health of the building and its occupants.

2 Literature Review

Othman et al. (2014) express that defects in building components have a shortcoming that makes them unable to fulfil their intended function. Building defect is a failure in the functionality, performance and comfort index of the structure, its fabric, services and associated facilities. (Pheng and Wee, 2001). Defects in the building can be categorized into the patent and latent defects. Patent defects can be physically observed during construction's inspection, usually within the defect Liability Period. Latent defect, on the other hand, occurs after the building is occupied. In addition, building defects sometimes occur due to wear and tear (Olanrewaju et al., 2010). Moisture causes a different type of defect in buildings which include but not limited to stain, discolouration of paint, peeling of paint and plaster, blistering, corrosion, and efflorescence (Flores-Colen et al., 2008). One of the major causes of staining in the building is rainwater (Hassanaian et al., 2013). Discoloration, peeling and blistering occur due to water leakages and seepage (Kian, 2001; Hassan et al., 2011). Corrosion of metal and aluminium occurs due to incompatibility of materials, Pollution, exposure, presence of moisture and microorganism, while the growth of vegetation is favoured by pores, moisture and rise in temperature (Kubba, 2008). WHO (2009) expressed that the growth of microbes such as mould, fungi, and bacteria occurs because of excess moisture in the building elements, which can pollute the indoor air and consequently constitute a health risk to human health.

The moisture condition of a building has a decisive effect on its deterioration processes and its service life (EPA, 2013). Leakages mainly cause moisture problems in a building in roofs, walls and ceilings. Chew (2005) concludes that water leakage through cracks, faulty pipes, and joints is the main source of moisture infiltration in the building. Waterproofing failure is also a major contributor to moisture infiltration into the building, as opined by Kian (2001). Building experiences water problem due to its location, inappropriate materials during construction, improper design and poor workmanship (Ahzahar et al. (2011).

WHO (2009) stated that the movement of moisture in the building from wet areas to dry areas, external walls to the internal walls could cause condensation in walls and ceiling especially when a vapour barrier is not in use and can also encourage deterioration of internal finishes. EPA (2013) and Almas et al. (2011) stated that moisture is responsible for 76% of building defects, while WHO (2009) views that moisture causes 75% - 80% of defects in the building. Kubba (2008) and Wessen et al. (2002) also corroborated that moisture is significantly responsible for the growth of microbes in the building.

According to (EPA 2013), control of moisture infiltration in the building is germane to buildings' functional ability and performance to render comfort and satisfaction to occupants and protect occupants from hazards and health challenges.

ASHRAE (2004) noted that moisture problems are sometimes caused by negligence and quackery during construction and installation. If moisture is adequately controlled in the building, it will prevent unhealthy conditions for both the building and its occupants, and this will help to have a durable, safe and energy-efficient (EPA, 2013). However, moisture problem in the building may also cause sick building syndrome, a situation that may affect the economic and social values of the building (EPA, 2013). Furthermore, Guimeraes et al. (2013) and (EPA 2013) expressed that moisture amidst poor ventilation will encourage the growth of moulds. Moulds could cause health challenges like irritations, stuffiness of the nose, cough, amongst others.

The durability of concrete is the tendency of concrete to tolerate the harmful effects of the environment it will be subjected to, during its life cycle, without experiencing deterioration above acceptable limits. Moisture is one of the many causes of concrete durability problem. (Balamurali, 2015). Infiltration of water, oxygen, carbon dioxide, chloride, sulphate, and related substances negatively affects the durability of concrete (Brandt et al., 2012). There are three main moisture problems in concrete, including carbonation, moisture cycle, and contaminants (EPA 2013).

3 Research Methodology

3.1 Study Population

The study area for this research work is Lekki/Ajah area in Eti Osa Local Government, Lagos State, Nigeria. The study population is the residential buildings that fall under the study area.

3.2 Sampling

Fifty houses in Lekki/Ajah area in Eti Osa Local Government, Lagos State, were randomly selected for the research.

3.3 Research Instrument

A structured questionnaire was used to collect data from respondents while moisture meter, rebound hammer and surface temperature pro were used to investigate the concrete components of the buildings.

4 Findings and Discussion

Table 1 above shows that moisture occurs most in the bathroom (mean 1.29), followed by toilet (mean 1.39), and followed by the laundry room (mean 1.44). This indicates that most areas where moisture occurs in the residential building are bathrooms, toilets, and laundry rooms.

Table 1. Area of the Building that Moisture Occurs Most

Area of the Building	N	Minimum	Maximum	Mean	Std. Deviation	Ranking
Bathrooms	41	1.00	3.00	1.2927	.55874	1st
Toilet	41	1.00	4.00	1.3902	.66626	2nd
Laundry room	41	1.00	4.00	1.4390	.74326	3rd
Floor	41	1.00	3.00	1.6829	.60988	4th
Wall	41	1.00	3.00	1.7561	.66259	5th
Roof	41	1.00	5.00	3.0488	.97343	6th
Furniture	41	2.00	5.00	3.1951	.64107	7th
Sitting room	41	1.00	5.00	3.2683	.92262	8th
Bedrooms	41	1.00	5.00	3.2683	1.00061	9th
Wardrobe	41	2.00	5.00	3.5366	.80925	10th
Wallpaper	41	1.00	5.00	3.6098	1.02172	11th

Table 2. Causes of Moisture in Concrete Component in Residential Building

Causes of Moisture	N	Minimum	Maximum	Mean	Std. Deviation	Ranking
Poor quality of construction materials	41	1.00	2.00	1.3415	.48009	1st
Bad workmanship	41	1.00	3.00	1.3659	.62274	2nd
Rising dampness	41	1.00	3.00	1.3659	.62274	3rd
Leaking pipes	41	1.00	4.00	1.3902	.73750	4th
Roof leakages	41	1.00	3.00	1.4146	.54661	5th
Defective damp proof course/damp proof membrane	41	1.00	4.00	1.5366	.74490	6th
Inadequate or lack of building maintenance program	41	1.00	4.00	1.7561	.73418	7th
Loose or missing roof tiles/slates	41	1.00	5.00	1.7805	.96209	8th
Porosity in concrete components	41	1.00	3.00	1.7805	.68964	9th
Improper design	41	1.00	3.00	2.0244	.52382	10th
Overflow pipe continuous running	41	1.00	4.00	2.0732	.78709	11th
Poor drainage system	41	1.00	4.00	2.0732	.68521	12th
Blocked or broken roof gutter	41	1.00	4.00	2.1951	.87234	13th
Porous or cracked bricks	41	1.00	5.00	2.2195	.98773	14th
Blocked or broken downpipes	41	1.00	5.00	2.2927	.92854	15th
Damped basement	41	1.00	5.00	2.3415	.96462	16th
Cracked or blocked drains	41	1.00	5.00	2.4146	.94804	17th
Lack of adequate roof space ventilation	41	1.00	4.00	2.7561	.79939	18th
Condensation	41	1.00	4.00	2.7805	.82195	19th
Poor ventilation system	41	1.00	5.00	2.8049	.98029	20th
Use of ineffective humidity control	41	2.00	5.00	3.3171	.90662	21st

Table 2 shows that Poor quality of construction materials, Bad workmanship, rising dampness, leaking pipes, Roof leakages, Defective damp proof course/damp proof membrane, Inadequate or lack of building maintenance program, Loose or missing roof tiles/slates, Porosity in Concrete components and Improper design ranked 1^{st} to 10^{th} among causes of moisture in Concrete components.

Table 3 above shows that corrosion of metal is the main effect of moisture on concrete component (mean 1.39), followed by microbial growth/vegetation growth (mean 1.51), and followed by discolouration of wall paint (mean 1.59).

Table 3. Effect of Moisture on Concrete Component in Residential Building

Effect of Moisture	N	Minimum	Maximum	Mean	Std. Deviation	Ranking
Corrosion of metals	41	1.00	4.00	1.3902	.66626	1^{st}
Microbial growth/ vegetation growth	41	1.00	2.00	1.5122	.50606	2^{nd}
Discolouration of wall paints	41	1.00	5.00	1.5854	.74080	3^{rd}
Reducing the life span of the building	41	1.00	4.00	1.6341	.69843	4^{th}
Health risk to the occupants	41	1.00	2.00	1.6829	.47112	5^{th}
Cracking of the building walls	41	1.00	2.00	1.6829	.47112	6^{th}
Deterioration of floor coverings	41	1.00	3.00	1.8049	.55765	7^{th}
Chalking of paints	41	1.00	5.00	1.8293	.80319	8^{th}
Weakening of roofing sheets	41	1.00	5.00	2.0244	.90796	9^{th}
Flashing	41	1.00	5.00	2.1707	.97217	10^{th}
Sagging of walls	41	2.00	5.00	3.2439	.94288	11th

The above data illustrates that the effect of moisture in residential building cause corrosion of metal, microbial growth/vegetation growth around the building and also causes discolouration of wall paint.

Table 4. Method of Controlling Moisture in Residential Building

Method of Controlling Moisture in	N	Minimum	Maximum	Mean	Std.	Ranking
Using quality DPM material for foundation construction	41	1.00	2.00	1.3171	.47112	1^{st}
Plumbing lines should be where it can be easily located	41	1.00	3.00	1.4146	.59058	2^{nd}
Good maintenance program	41	1.00	3.00	1.4878	.63726	3^{rd}
Quality building materials	41	1.00	3.00	1.5122	.55326	4^{th}
Using water-impermeable material for construction	41	1.00	3.00	1.5366	.55216	5^{th}
Laying tiles to the wall	41	1.00	3.00	1.5610	.59367	6^{th}
Installation of wall cladding to prevent the wall from	41	1.00	3.00	1.5854	.54661	7^{th}
Checking and replacing all leaking pipes	41	1.00	4.00	1.6341	.62274	8^{th}
Manufacturing, shipping and storing building materials in	41	1.00	4.00	2.1707	.94611	9^{th}
Good architectural design	41	1.00	5.00	2.7805	1.01272	10^{th}
Chemical injection method	41	1.00	5.00	2.9512	.97343	11^{th}

Table 4 above shows that using quality DPM material for foundation construction is the best method to control moisture (mean 1.31), followed by plumbing lines should be where it can be easily located (mean 1.41), followed by a good maintenance program (mean 1.49). This implies that controlling moisture in residential building uses quality DPM materials for foundation construction; plumbing lines should be at places where they can be located easily for repair and strategizing a good maintenance program that will help the building perform its function.

Table 5. Action by Regulatory Agencies to Reduce the Effect of Moisture on Residential Building

Actions	N	Minimum	Maximum	Mean	Std.	Ranking
Inspection and certification of materials before use	41	1.00	2.00	1.2439	.43477	1st
Educating and mandating contractors to build according to	41	1.00	2.00	1.4878	.50606	2nd

Table 5 above shows that regulatory agencies should inspect and certified materials before use to reduce the effect of moisture on residential buildings (mean 1.24), followed by educating and mandating contractors to build according to regulations/codes (mean 1.49). This indicates that inspection and certification of materials before use and educating and mandating contractors to build according to regulations/code is the main role that the government agencies can use to reduce moisture on a residential building.

4.1 Summary of Findings

- The areas of the building where moisture occur most are the bathroom, toilet and laundry room.
- Poor quality of construction materials, bad workmanship, and rising dampness are major causes of moisture in residential building.
- Moisture has a great effect on the corrosion of metals used in building, and also aid microbial growth/vegetation growth, discolouration of wall finishes, and constitutes health risk to Occupants.
- Using quality DPM materials for constructing foundation will reduce the rising of moisture into the building,
- Location of service pipes at the area where they can be easily accessed for maintenance in case of leakages can help to reduce the spread of moisture in the building.
- Adoption and execution of a good maintenance program can enhance the quality performance of the building.
- Specification and monitoring of building materials by government agencies can ensure appropriate material during the construction of the building.
- Sequential inspection of buildings during and after construction by regulatory agencies can ensure conformity to building standards and regulations and enhance the good health of the building and its occupant.

5 Conclusion and Recommendations

After reviewing the findings on the effect of moisture on the durability of the concrete component in residential building, the following conclusion and recommendations were reached.

5.1 Conclusion

- The leading cause of moisture in the concrete component of residential building are using poor quality materials, bad construction methodology, and bad workmanship for building construction.
- Moisture penetration and rising moisture have a great effect on building concrete components by corroding the metals/reinforcement used for constructing concrete components; it aids the fast growth of the microbial organism and vegetation in the building and constitutes a health risk to occupants of buildings.
- Moisture in the building can reduce the life span of the building, which can cause the building not to perform the function which it was designed for. Hence the location of service pipes in an area where they can be easily accessed for maintenance in leakages is essential.
- The use of quality damp proofing material (DPM) for the construction of the foundation will reduce rising dampness in the building,
- Adoption and execution of a good maintenance program can enhance the quality performance of the building.
- Specification and monitoring of building materials by government agencies can ensure appropriate material during construction of the building, and sequential inspection of buildings during and after construction by regulatory agencies can ensure conformity to building standards and regulations and enhance good health of the building and its occupant.

5.2 Recommendation

- Government agencies should strictly engage in inspection and certification of materials used for building construction before they are used for construction project, and they should educate the contractors to build according to the building codes/regulations.
- Quality damp proofing materials should be used during the construction of the foundation of the building.
- A good maintenance program will help keep and restore the building to its original position so that it can continue to perform its function as expected.
- Construction of building should always be handled by professionals who will ensure the quality of construction methodology, materials, workmanship, and cost.
- Government and Professionals should continuously educate homeowners and occupants on the need to make concrete components moisture-free
- Government and professionals should invest more in developing sustainable building materials that can prevent the negative effect of moisture.

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Benefits of the adoption of digital technologies on South African construction projects

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Abstract:
The construction industry has been noted to be the only industry with the least technological advancements, while other sectors are reaping the benefits. The construction industry is facing a lag in productivity on construction projects which could be solved through the implementation of digital technologies. The research focusses on the current adoption of digital technologies on South African construction projects and their effect on productivity. A case study research design was employed, where construction projects that met the criterion were reviewed through interviews with the responsible construction professionals. The digital technologies that were adopted on the projects were identified. The effect on cost, time and quality due to the adoption of the digital technologies was noted and the data obtained was analysed using a thematic data analysis technique. A cross-case analysis, as well as existing literature, were used in validating the information collected from each case study. The results revealed that digital technologies are used on construction projects in South Africa. Although the adoption varies from project to project, it emerged that more benefits are realised on construction projects with a higher level of adoption of digital technologies. The study found that the adoption of digital technologies on South African construction projects leads to an increase in project productivity, time and cost-savings. Based on these findings, the study concludes that construction projects which use digital technology will have higher productivity and lower cost and time overruns.

Keywords: Cost, digital technology, level of adoption, productivity, quality, time

1 Introduction

Digitisation is an advancement in technology that is accelerating the pace of change. This is seen through companies in different industries that are benefiting from digitisation (Laczkowski *et al.*, 2018). Despite the availability of these technologies, the construction sector is experiencing a 30% productivity gap which can be traced back to gains from the implementation of digital technology (Laczkowski *et al.*, 2018).

Furthermore, researchers have found that there is low productivity in the construction industry and construction projects, and view that the levels of productivity will be improved on construction projects and the industry with the adoption of digital technologies (Enshassi *et al.*, 2007; Pan *et al.*, 2016; Barbosa, Woetzel, *et al.*, 2017; Seadon and Tookey, 2019). However, there is limited research into understanding the level of adoption of digital technologies in the

South African construction industry. Previous studies mainly examined the barriers to adoption and benefits of digitalisation (Chan & Kumaraswamy, 1997; Peansupap & Walker, 2006; Emmanuel *et al.*, 2018). Therefore, this research examines the level of adoption of digital technologies in the South African construction sector towards determining whether the application of these technologies increases productivity on construction projects. The research objectives are to establish the current level of adoption of digital technologies by construction companies, in South Africa, including their level of productivity on construction projects. Lastly, the study establishes how the use of digital technologies affects time, cost and quality on construction projects.

2 Literature Review

Many articles and studies conducted on digital technology adoption in construction projects, both locally and internationally, have been reviewed. Firstly, the low productivity performance in the construction industry was highlighted by Changali *et al.* (2015); Blanco *et al.* (2016); Marks (2017). Reasons for the low productivity within the construction industry is due to many factors such as lack of coordination, undefined roles and responsibilities, reliance on hard copy documentation and lack of digital adoption (Chan & Kumaraswamy, 1997; Changali *et al.*, 2015; Agarwal *et al.*, 2016; Blanco *et al.*, 2016). Both Laczkowski *et al.* (2018) and Marks (2017) similarly believe the foremost reason for the stagnation within the construction industry is due to insufficient investment in technology by firms.

2.1 Types of digital technologies in use in the construction industry

Digital technologies identified throughout the studies conducted globally were summarised into ten technologies. These were Building Information Modelling (BIM), 3D and 4D Simulations, Virtual Reality (VR), AutoCAD/Revit, WinQS, GIS/GPS, Radio Frequency Identification Technology (RFID), Navisworks, Information Communication Technology (ICT) and E-Procurement (Peansupap & Walker, 2006; Ahuja *et al.*, 2009; Lu *et al.*, 2011; Costin *et al.*, 2012; Kekana *et al.*, 2015; Merschbrock & Munkvold, 2015; Barbosa, Woetzel*, et al.*, 2017). A total of 12 research papers and studies were found specifically on the adoption of BIM (Froise, 2014; Changali *et al.*, 2015; Kekana *et al.*, 2015; Merschbrock & Munkvold, 2015; Agarwal *et al.*, 2016; Blanco *et al.*, 2016; Ezeokoli, Okoye*, et al.*, 2016; Fang *et al.*, 2016; Barbosa, Mischke*, et al.*, 2017; Barbosa, Woetzel*, et al.*, 2017; Ayinla & Adamu, 2018; Wolf, 2018). These were conducted both globally by Merschbrock & Munkvold (2015) and Agarwal *et al.* (2016) as well as locally by Kekana *et al.* (2015). The adoption of AutoCAD and Revit was studied by Ibem & Laryea (2014); Kekana *et al.* (2015) in the context of both the Nigerian and South African construction industry respectively.

2.2 Level of adoption of digital technologies

Analysing various measures of the level of adoption was conducted through literature review. The measure of the level of adoption of BIM is noted through a study conducted by Ayinla & Adamu (2018) was by creating a composite model of the Bew -Richard BIM maturity model and the Singh and Holmstrom technology adoption model. The Bew – Richard BIM model divides the levels of adoption into four levels; level 0 can be described as the pre-BIM stage while level

3 stage is where a fully integrated system is in use and is interoperable without any data loss (Ayinla & Adamu 2018). Furthermore, the Singh -Holmstrom technology adoption model analyses the time of adoption and classifies it into five groups. The groups can be categorised into laggards, late majority, early majority, early adopters and innovators (Singh & Holmström, 2015). Similarly, Bin Zakaria *et al.* (2013) conducted a study on the adoption of BIM within the construction industry. A qualitative analysis method was chosen to determine the level of adoption and conducted through semi-structured interviews. Bin Zakaria *et al.* (2013) noted the difficulty involved in analysing qualitative data and therefore used a coding system to organise and categorise quotes and data. Lastly, Bin Zakaria *et al.* (2013) used a mapping analysis approach to find out the relationships between the various categories of BIM adoption. Furthermore, the level of adoption of ICT in the Indian construction industry was established in a study conducted by Ahuja *et al.* (2009).

2.3 Drivers of digital technology adoption on construction projects

Team adoption was observed to be one of the main drivers to digitalisation in the construction industry. Blanco *et al.* (2019) stated that the strategy to adopt new technology is from the top-down. The support of top management plays a key role as the support is essential for the development of infrastructure and the people in regards to the adoption of ICT within the organisation (Peansupap & Walker, 2006). Moreover, adequate training of employees was also noted to drive the adoption of digital technology. Ezeokoli, Okolie, *et al.* (2016) pointed out within the South African context that training on digital technology tools is one of the leading influencers of the adoption of digital technology. Similarly, Peansupap & Walker, (2006) state that a critical motivator in the use and adoption of digital technology is where people's knowledge is developed of how to successfully apply ICT and how it would support their work practices.

Small-scale pilot strategies, according to Peansupap & Walker, (2006) is said to drastically overcome the barriers to investment in IT technology, therefore also becoming a primary driver of adoption. The acceleration of adoption is done through governments by implementing five simple measures suggested by Blanco *et al.* (2019). The first would be to set bold aspirations. Secondly, create meaningful incentives such as providing additional financial support for first adopters. In addition to incentives, the third suggestion would be for governments to help reduce the risks and barriers that develop due to the emerging technology. Blanco *et al.* (2019)'s fourth suggestion is to ensure transparency – in both cost and progression. The progress of large projects relies on real- time information through digital technology which requires transparency. The fifth and final suggestion would be to build capabilities. Low skilled labourers are prominent within the construction industry, and according to Blanco *et al.* (2019) government investment in training programs will overcome these issues.

2.4 Barriers to digital technology adoption on construction projects

Underinvestment in IT and technology more broadly was observed by Blanco *et al.* (2016) and Marks (2017) as key barriers to digital technology adoption on construction projects. The studies conducted recognised that the failure to adopt new technology was one of the main internal challenges to improving productivity. The lack of confidence in the benefits within the innovations results in the absence of senior management support. This leads to underinvestment in IT and technology more broadly (Blanco *et al.*, 2016). According to Marks (2017), the fragmentation of the digital technology offerings will continue to be a area and is another significant hurdle the construction industry is faced with. Blanco et al. (2016) submit that the immature development of technology is the cause of fragmentation as many programs perform a particular task and provide a specific solution, but lack integration problematic area and is another significant hurdle the construction industry is faced with. Companies are found to engage in technological solutions that only address one specific problem instead of an integrated solution across the three main areas of construction (Blanco *et al.*, 2018).

Another barrier noted within literature is technology adoption gaps. The first gap is the lack of technological awareness which influences investment decisions. Many senior managers are unaware of the potential innovation benefits that lie behind the adoption of IT (Peansupap & Walker, 2006). This lack of technology awareness will also obliterate their outlook upon an investment opportunity. The knowledge of digital systems and lack of training is a global barrier as revealed by Chan & Kumaraswamy (1997); Peansupap & Walker (2006); Emmanuel *et al.* (2018).

2.5 Impact of digital technology on productivity

Through a study by Hartmann *et al.* (2008), an analysis of five case studies and the impact of 3D and 4D models on aspects such as design, costing and construction was conducted. The conclusions of the study revealed a 60% decrease in design requests, 80% of respondents reported time-saving when the 3D models were used for cost. This is noted to have a significant impact on productivity with regards to the adoption of digital technology.

A moderate impact of digital technology adoption was noted by Costin *et al.* (2012) through a case study conducted on the impact of RFID technology. Costin *et al.* (2012) compared the expenses to implementing this technology to the savings made by identifying poor productivity in the workforce. A deduction of a 2.2 minimum Return on Investment (ROI) from the study was made and stated that the return would be higher if used in future projects (Costin *et al.*, 2012). Implementations of GIS/GPS was studied by Li *et al.* (2005) on the construction of a waste plant in New Zealand. The conclusion reached was that the investment in the GIS/GPS increased costs in comparison to the non- integrated system, but further utilisation in the future may decrease the costs thereof (Li *et al.*, 2005). This resembles a negative impact on the implementation of digital technology. Within South African literature, challenges of digital collaboration and ICT were conducted by Ezeokoli, Okolie, *et al.* (2016); Ozumba and Shakantu (2018).

Further, the general understanding of BIM (Kekana *et al.*, 2015) and Catalyst of BIM (Froise, 2014) was also conducted in the South African construction industry context. However, there was no study of the impact of the implementation of digital technology on productivity was found in literature, within the South African context. This has led to an interest in researching further and determining the impact of digital technology on construction productivity.

3 Research Methodology

The aim and objectives of the research were achieved by adopting a qualitative research approach using interviews as the method of data collection. A qualitative research approach was adopted due to the nature of data required to be collected and the importance of the participants' perspective in the data. A multi-case study research design was followed using semi-structured in-depth interview of professionals that were targeted based on their knowledge on the implementation of digital technologies on the construction projects that were studied. A multi-case study research design was best suited for this research study because the researchers focused on each project to get an understanding of how these technologies brought about changes in productivity. Also, because one source of data may not reflect the range of digital technologies adopted on construction projects. The projects studied were identified using a purposive sampling technique. Although the reliability of primary sources of data may be called into question due to the subjective nature of the data, the criteria for selection of the case studies were that the project should be based in Cape Town with a contract value of R4 million or more. Also, digital technology must have been implemented on the project.

Interviews with construction professionals on the construction projects that met the criteria set for the selection of case studies were used in obtaining primary data. An inductive approach was used in data analysis; the framework for the research was developed through the data that was collected. Thematic data analysis which is a commonly used inductive approach to data analysis was employed. To do this, the textual data collected from interviews were first transcribed, various themes and categories were developed, like terms found in the data were grouped to reduce unnecessary information by crossing out repetitions and similar data (Burnard, 1996). The phases described by Braun and Clarke (2006) were followed in the study to analyse the reduced data.

To analyse and determine the level of adoption, interviews were conducted on various project managers where questions were directed to their use of ICT, benefits, barriers and industry drivers. Following this, a Likert scale was used to aid the analysis of the qualitative perceptions obtained from the interviews following an earlier study conducted on the adoption of ICT undertaken by Peansupap & Walker (2005) who determined the adoption level of ICT, using a mixed-method research approach. The data obtained was analysed using a cross-case analysis. The projects under study were compared by uncovering the digital technologies adopted and examining how their adoption affected time, cost and quality, thereby understanding their effect on the productivity of construction projects. The level of adoption of the digital technologies in the cases studies determined using a seven point Likert Scale is shown in Table 1 where 1 represents no adoption and seven represents excellent adoption following a previous study done by Ahuja *et al.* (2009).

Table 1. Likert Scale of the level of adoption

Likert Scale of the level of adoption		
No. of stages		**Rating:**
1		No adoption
2	**x**	Poor adoption
3	**xx**	Below Average adoption
4	**xxx**	Average adoption
5	**xxxx**	Above Average adoption
6	**xxxxx**	Good Adoption
7	**xxxxxx**	Excellent Adoption

4 Findings and Discussion

The study is specific to the South African construction industry, which is known to have low levels of productivity and a sluggish approach to the adoption of digitalisation. An interview-conducted with AEC professionals was used to establish what digital technologies are used in South Africa and how their level of adoption affects productivity (time, cost and quality) within the industry.

The projects under study are Case Study 1, Case Study 2 and Case Study 3. Case Study 1(CS1) is a 36 storey mixed-use development and is going to be Cape Town's tallest residential tower, with street-level retail space and elevated apartments on floors 12 to 36. Case Study 2 (CS2) is located just off the R43 between Worcester and Ceres and consists of two phases. The first phase was the construction of a chapel which was completed in March 2017, and the second phase is the construction of a school, creche and aftercare facilities. Case Study 3 (CS3) is a two-storey residential development located in Higgovale Cape Town, with an estimated contract value of R9 Million.

The three case studies as seen in Table 2 have only one digital technology that all the projects have implemented, and that is Revit. The other digital technologies are either found in two case studies or only one case study. Digital Technologies found in two case studies are Navisworks, Synergy, Lumion, CCS, Drones and HD Cameras. Those found in only one case study are BIM, Snag R, AutoCAD, Sketch-Up, Photoshop, Enscape, and VR. Also noted in Table 2 is that CS1 and CS2 have more similar digital technologies in common than they do with CS3. CS1 and CS2 have Revit, Navisworks, Synergy, CCS, Drones and HD Cameras in common.

Table 2. Common Occurrences found in the Case Studies

Common Occurrences			
Themes	**Case Study 1 (CS1)**	**Case Study 2 (CS2)**	**Case Study 3 (CS3)**
Digital technology adopted	Revit	Revit	Revit
	BIM	-	-
	Navisworks	Navisworks	-
	Synergy	Synergy	-
	-	-	Google Drive
	-	AutoCAD	-
	Lumion	-	Lumion
	CCS	CCS	-
	-	Sketch Up	-
	-	-	Enscape
	-	Photoshop	-
	Snag R	-	-
	-	-	VR
	Drones	Drones	-
	HD Camera	HD Camera	-
Level of adoption	Design	Design	Design
	Construction	Construction	-
Performance	Time-Saving	Time-Saving	Time-Saving
	Cost Saving	-	-

Table 2 also shows that the level of adoption of digital technology is limited to the design and construction phase, although in CS3, the adoption was limited to the design phase. And regarding performance, time-saving was the main benefit noted from the implementation of digital technology, although in CS1 cost-saving was also noted. The results also revealed that a total of 14 digital technologies are used in the industry among the participants interviewed. From these technologies, Revit, Navisworks, and Synergy were the three highest adopted technologies respectively. Further, the analysis of their effects on productivity was deduced from the responses of the participants interviewed, which further revealed Revit and Navisworks having the greatest effect.

Using the Likert Scale developed for the research the data collected from each case study were analysed, the results are shown in Table 3. The analysis shows that the Revit software was used across all six stages of project development for both CS1 and CS2 and is described as an "excellent" level of adoption. In comparison to CS3, which only adopted Revit over four stages of the project development, classified as an "above average" level of adoption. Similarly, for the use of AutoCAD by CS2, an "excellent" level of adoption is recognised. Furthermore, the analysis of the level of adoption of Navisworks between CS1 and CS2 is noted to obtain two different levels. For CS1, Navisworks was adopted only in the Design Development and therefore obtains a rating of "poor adoption". While CS2 chose the use of Navisworks in both the Design and Development stage and the Documentation and Procurement stage resulting in an "average" level of adoption. The cloud-based storage tool, Synergy, was similarly adopted by both CS1 and CS3. Each project only used Synergy in the Construction stage and consequently obtaining a "poor" adoption level. The level of adoption of CCS, the programme for contractors is "averagely" adopted amongst CS1 and CS3, both using it across the last three stages of the project development. Similarly, Lumion is also employed by CS1 and CS3 and equally adopted over two phases. This leads to a rating of "poor" level of adoption.

Table 3. Level of adoption of digital technologies and their effect on performance

Technology	Case Study 1	Case Study 2	Case Study 3
Revit	“excellent”	“average”	“excellent”
AutoCAD	"no adoption."	“excellent”	"no adoption."
Navisworks	“poor”	"below average."	"no adoption."
Synergy	“poor”	"no adoption."	“poor”
CCS	“average”	“average”	"no adoption."
Lumion	"below average."	"no adoption."	“below average”
Drones	“no adoption”	“no adoption”	“no adoption”
HD Camera	“poor”	“poor”	“no adoption”
Snag R	“poor”	“no adoption”	“no adoption”
Sketch Up	“no adoption”	“below average”	“no adoption”
VR	“no adoption”	“no adoption”	“average”
BIM	“no adoption”	“no adoption”	“no adoption”
Photoshop	“no adoption”	“poor”	“no adoption”
Enscape	“no adoption”	“no adoption”	“above average”
Performance	Time saving Cost Saving	Time saving	Time-saving

From the analysis of the level of performance of the digital technologies in the three case studies, time-saving was noted to be the most significant aspect of productivity affected. Both cost and quality aspects were affected by Navisworks while all other technologies showed no effect on the cost and quality aspects of productivity. The results reveal that "excellent" levels of adoption of digital technologies translate into higher levels of productivity time wise.

The findings confirm the observations of Aghimien *et al.* (2018), where Revit has yet to be adopted by contractors during the construction phase. Contractors prefer to use 2D plans rather than 3D models as noted by C1. Furthermore, Cao & Miyamoto (2003) define AutoCAD as one of the most powerful platforms for 2D and 3D designs. CS1 and CS3 both state that AutoCAD was their previous digital tool implemented on projects although they have recently moved over to Revit and find that they have more benefits than AutoCAD. Through further review of literature, any mention of Synergy specifically has not been noted, yet Ibem & Laryea (2015) have mentioned the use of cloud-based systems being used in South Africa for use in e-Procurement. Similarly, there has been no mention of Snag R app being used globally or within South Africa. Other technologies found through the interviews conducted have not been found in literature.

5 Conclusion and Further Research

The South African construction industry is faced with low productivity in the construction industry. The research examines the level of adoption of digital technologies in the South African construction industry and their effect on productivity towards providing an insight into the effects of digital technology on productivity. Firstly, literature was reviewed, and the types of digital technologies used and their level of adoption on construction projects was uncovered. After that, a case study research design that employs interviews was used in collecting information on the extent to which digital technologies was being adopted on construction projects. The gaps in the technology market and where digitalisation is lacking throughout the construction industry was observed in literature. It emerged from the study that digital technology is widely adopted amongst professionals in the South African construction industry while contractors are the worst adopters of the digital technologies. The barriers to adoption of digital technologies in both a global and South African context was substantiated by the study. The findings also show that the benefits of using digital technology outweigh the initial costs, while it reduces costs in the long run. Based on these findings, the research concludes that digital technology adoption on construction projects will affect the time and cost aspects of productivity.

Further research can examine the barriers to the adoption of digital technology on construction projects using a quantitative research approach and how these can be combated. Quality is an aspect of productivity that is not significantly affected by the adoption of digital technologies. Further research can look at technologies that target project quality and why they are not being adopted on construction projects.

6 Acknowledgement

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Strategic management in construction firms with focus on small and medium enterprises: A case study eThekwini, South Africa

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Abstract:
Small and Medium Enterprises (SMEs) play a vital role in the economy and have contributed significantly to the growth of the economy, however, there is still a high-level failure rate. Many face a threat of failure within the first few months of establishment and the lack of strategic planning may prevent them from achieving their full potential. Therefore, the aim of this study is to address the factors that influence the adoption of strategic management in an organization and to identify persuading factors that contribute to strategic management to improve performance and to categorise challenges faced by SMEs in implementing a strategic plan. The results advocate that majority of the eThekwini-based SMEs in the construction industry are applying strategic management practices in their business and through this application they have improved the performance of their business. Furthermore, the study found that there were high levels of agreement with the challenges facing the implementation of a strategic plan in an organization. The research concluded that that majority of the eThekwini-based SMEs in the construction industry are applying strategic management practices in their business and through this application they have improved the performance of their business. The study also concluded that there were high levels of agreement with the influencing factors that drove SMEs to adopt a strategic plan and high levels of agreement with the contributing factors of strategic planning in improving performance of the business. Furthermore, the study found that there were high levels of agreement with the challenges facing the implementation of a strategic plan in an organisation.

Keywords: Challenges, construction industry, small and medium enterprise, Strategic planning, South Africa

1 Introduction

The Construction Industry is known for its economic contribution to South Africa. The sector is regarded as a key engine of job growth and is recognised for its contribution to infrastructure production (Anamalay, 2014). According to Ntuli (2016), the construction industry is vulnerable to the political and socioeconomic environments. South Africa acknowledges the role of small and medium-sized enterprises (SMEs) actively participating in the economy. They contribute to the growth of the economy by generating jobs and alleviating the country's social problems (Mashwama, Thwala, & Aigbavboa, 2020). In addition, in South Africa, statistics published by the South African Federation of Civil Engineering Contractors (SAFCEC) in 1992 indicated that this sector's productivity was supposed to decrease overall. This is link to the government turning its attention to housing and other associated programs, which were mostly aim at meeting the demands of historically deprived populations. At that time, major construction firms struggled financially, and some went bankrupt. Even though these firms contribute significantly to the economy, there is still a strong failure rate.

Small, medium, and micro businesses continue to be the driving force behind economies around the world. They contribute significantly to the growth of employment, alleviating poverty and contributing to innovations in the sector. However, there is a high failure rate and poor performance among small and medium enterprises (SMEs). According to Global Entrepreneurship Monitor, small enterprises account for 50 percent of all job openings in South Africa and contribute more than 45 percent of the country's GDP (Chikeya, 2019). However, statistics have shown that only 37 percent of small businesses survive in the first four years and a 9 percent chance of survival leading up to 10 years. Furthermore, statistics also reveal that 70 to 80 percent of SMEs fail in the first year.

Although most firms agree that a good strategy lays the foundation for growth and development, many of these firms do not know or agree on what constitutes a good strategy (Lombardi, Tiscini, Trequattrini, & Martiniello, 2020). According to Barney and Hesterly (2010), having a good strategy can add value to an organization, however, many seem to be divided in agreeing on what a strategy is and what contributes to a good strategy. Without a coherent strategy, a business has no direction in pursuing opportunities and cannot identify its objective, which results in lack of focus and vision needed to move the organization forward. Therefore, the objective of this study to identify the reasons that affect an organization's acceptance of strategic management, as well as the motivating factors that lead to strategic management to increase efficiency, and to define the obstacles that SMEs face when executing a strategic plan.

2 Literature Review

Various challenging factors continue to hinder SA's economic growth and development of the SME sector (Sitharam & Hoque, 2016). According to latest Annual Report 2018 to 2019 presented by the Construction Industry Development Board (CIDB), there were 51 513 contractors listed on the register of contractors, of which approximately 85% of the contractors were Grade 1 contractors, indicative of the appeal that the industry has on entrepreneurs. Agreeing to statistics, 90 percent of emerging black contractors do not survive their first five years in the building industry (Ntuli, 2016). Strategic planning entails developing and executing an organization's long and short-term goals. Having a development strategy in place will help businesses gain the advantages of potential prospects and achieve a sustainable edge in the industry (Kibuuka & Tustin, 2019).

2.1 The Construction Industry in South Africa

The construction industry is known for its complex characteristics and risks associated with projects. The industry recorded a decline of 14.3% in the face value of construction projects awarded compared to 2017 and reported a decrease in tender activity following the elections period. In 2019, the infrastructure budget reduced by 12% and as result, it left the construction industry unsettled (Nkomo & Thwala, 2014). The civil construction sector relies on government spend to keep the industry afloat and their performance plays a critical role in the sector. SOEs are the big spenders of government's budget. Government anticipates spending at least 43% of the infrastructure budget in the next three years (Cokayne, 2019). The decline in infrastructure projects is of great concern to the construction industry. However, the industry remains optimistic. The industry is struggling and as a result, several construction companies are filing for business rescue. Sustainability is the key element to success for small businesses in the construction industry (Gunduz, Naji & Al-Salahi, 2020). The barriers to entry for the construction industry remains low, which encourages black entrepreneurs to enter the market, thereby, increasing competition. Many of these start-up companies are inexperienced and may experience difficultly with finances or a lack of technical or managerial expertise and as a result, many businesses fail. Therefore, government has taken initiatives; such has Broad-Based Black Economic Empowerment (B-BBEE) and the Construction Industry Development Board (CIDB) to support black owned companies (Anamalay, 2014).

2.2 Role of strategic Management in SME

Strategic management is the science of making, applying, and reviewing decisions (David, David, & David, 2013). The goal of strategic management is to improve an organization's market position and accumulate internal capital to achieve a competitive edge over competitors (Parthasarthy, 2008). Small and medium-sized businesses (SMEs) often neglect strategic management in their organizations. Strategic management methods enable an organization to identify opportunities and threats. The process in addition aids in the development of the organization's competitive edge (Wenzel, Stanske et al. 2020). Organizations that implement strategic management in their operations often have increases in profits and turnover, increased efficiency through coordinated allocation of personnel and supplies, better interactions with internal and external partners, and strengthened employer and employee ties. It also instils a feeling of pride and loyalty in workers, making them feel motivated. Furthermore, strategic management offers a framework for staff to better understand and participate in the process (Ehlers & Lazenby, 2004).

2.3 Environmental Scanning

The internal environment of a company consists of a variety of resources and capabilities. Improving these skills and tools may provide the organization with a competitive edge. For organizations to gain a strategic edge by skills and resources, the internal environment must be examine. SMEs that adopt a strategic objective tend to be more focused on growth within the business, it provides a formalized structure of the business (Kibuuka and Tustin 2019).This mechanism is an opportunity for organizations to find weaknesses in their organizational structure and provides a realistic understanding of the specifications. Furthermore, it allows the integration of theories and techniques such as the SWOT analysis (Gürel & Tat, 2017), resource-based perspective (Hamdoun, 2020), and value chain analysis (Benachio, Freitas, & Tavares, 2020).

3 Research Methodology

3.1 Questionnaire and data collection

For data collection, Mori's previous study was used to develop and base the questionnaire on (Mori, 2013). The questionnaire had two sections. The first section contained demographics details of respondents. Second section comprised questionnaire on strategic planning that drove businesses to adopt a strategic plan and factors that refine performances, and the challenges businesses face in implementing a strategic plan. All questions were closed-ended, which allowed the variables to be analysed statistically. Additionally, the Cronbach Coefficient Alpha for this analysis was 0.876, which is an acceptable measure of reliability (Msani, 2011). There were no major problems noted or encountered, and the data collected was reconciled with what was initially plan to collect. The questions were short, simple, and unambiguous. An online survey tool was used to distribute the questionnaire to the participants and to retrieve the data by using QuestionPro Software. The self-administered questionnaires were given to 106 small and medium enterprises from 18th September 2020 to 4th October 2020. These construction companies are registered with CIDB as active participants in the industry. The respondents were individuals who were involved in the strategic planning of the business. There were three reminders that were sent out after a week to ensure proper follow-up on the responses.

3.2 Validity of data

The method that is use as a measure of reliability is Cronbach's Alpha. The Cronbach Coefficient Alpha for this analysis was 0.876, which is an acceptable measure of reliability (Table 1).

Table 1: Cronbach Alpha Results

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

a. Ethical considerations

Ethical clearance to conduct the study was obtained from the Durban University of Technology Ethics Committee (IREC: 18FREC). Informed consent was obtained from each participant prior to the study; thereby ensuring protection and privacy of participants.

b. Data analysis

The descriptive and inferential statistics were used to analyse the data for the study**.** The raw data were collected and then captured onto an electronic spreadsheet. The SPSS statistical package version 26.0 was used to analyse the data for this study, and the required statistical tests were performed. The data were collated, after which the following tests were carried out, cross tabulation, correlation, chico-square test, and Cronbach Alpha. The Cronbach alpha test was used to measure internal consistency of the data within a group.

4 Findings and Discussion

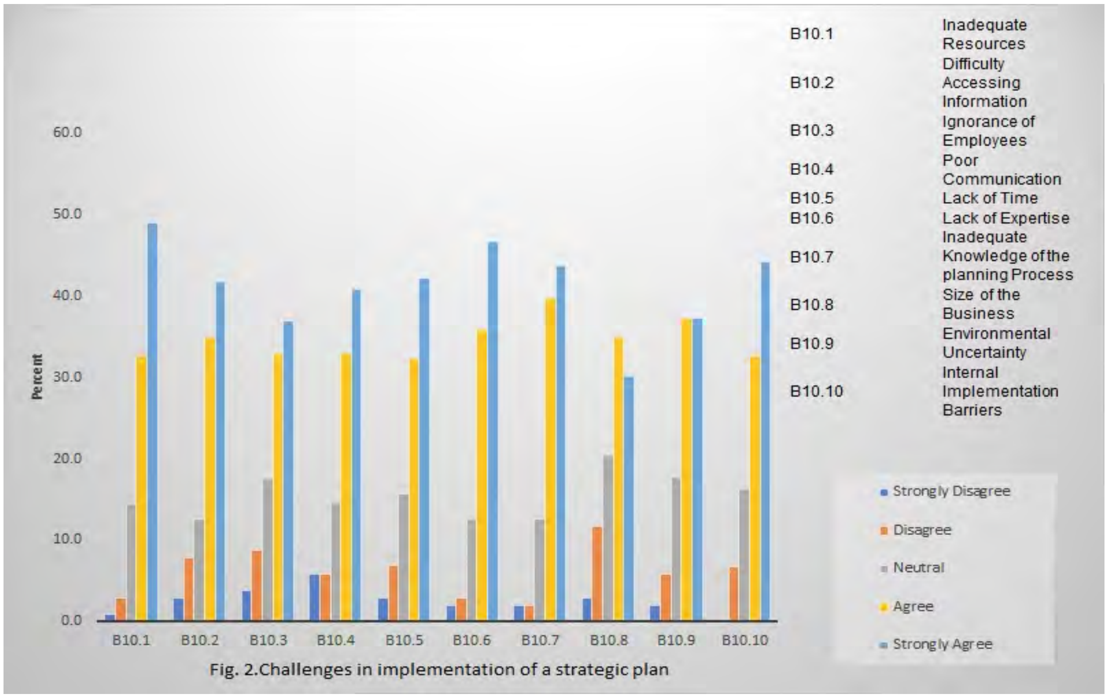

Fig. 2.Challenges in implementation of a strategic plan

5 Conclusion and Further Research

The present study highlighted the factors that drove the business to adopt a strategic plan, the contributions of strategic planning in improving performance of one's enterprise and the challenges facing the implementation of a strategic plan in an organisation**.** The findings of the research revealed that majority of the eThekwini-based SMEs in the construction industry are applying strategic management practices in their business and through this application; they have improved the performance of their business. In addition, it was found that strategic planning could reduce the level of uncertainty in the environment and provide a structured approached in dealing with issues. Furthermore, strategic management promotes the development of the SMEs as they are encouraged to plan and commit to short and long-term goals. As a result, there is a probability that SMEs will attain business success through strategic management. Recommendations include that SMEs develop procedures and policies to address the challenges faced in implementing a strategic plan. Despite these findings, even though businesses adopt strategic planning in their operations, success is not certain due to other influences. Improper implementation or expertise in strategic management could lead to businesses not achieving their goals.

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Environmental implications of construction activities in a fast-growing city: A case study of Ota, Nigeria

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Abstract:
Globally, cities are regarded as engines of growth and sustainable development. However, the socio-environmental implications of rapid urbanisation and industrialisation, such as unprecedented construction activities, urban degradation and poverty exacerbation, have constrained cities from fulfilling their socio-economic function of providing a functional, livable, and sustainable environment. Ota, the case study city, has witnessed failures in the execution of policy frameworks and programmes aimed at conserving the environment through proper regulation and management of construction activities. It is based on this backdrop that this study examines the environmental implications of construction activities in Ota city, Nigeria. This study adopted a cross-sectional research design and a systematic random sampling technique was used to administer 400 copies of the questionnaire to residents of Ota. The study revealed that industrial agglomeration remained the major factor influencing rapid construction activities in Ota. Findings also revealed that factors such as social damage and urban structure damage (3.483), urban degradation and urban stress (3.188), increase in transport and logistics externalities (3.128), floods and erosion disaster (3.095), and loss of wildlife and green area (3.090) constitute the major negative impacts of construction activities on Ota city. The study concluded that an efficient and sustainable approach to the use and management of environmental resources and construction activities are needed for the development of a sustainable city**.** It recommended the implementation of sustainable measures capable of ameliorating the environmental implications of construction activities in Ota city, Nigeria and other cities with similar issues.

Keywords: Construction, environment, environmental implications, Nigeria, Ota city

1 Introduction

The environment has been an age-long phenomenon and its contributions to the survival, growth and prosperity of man cannot be underestimated. Man has been making use of his environment in various ways and through several processes before the period of early civilization to date (World Economic Forum, 2014). Specifically, man's quest to satisfy his socio-economic and industrial needs and aspirations has led to exploitation and exploration of resources domicile within his environment and led to disturbance of environment with accompanying consequences (Adejare *et al.*, 2016; Akanmu *et al.*, 2016). The unwanted consequences of the impact of human actions on the immediate and remote environment are being felt through farming and agricultural practices, urbanisation and industrialisation, exploration of mineral resources, and more importantly, construction activities (Hardingham-Gill, 2018). Although facilitating improved socio-economic development and prosperity of any nation, the construction activities and industry promote improved socio-economic development and prosperity of any nation (Oke *et al.,* 2016; Kheni *et al.,* 2008). However, recently, weak management has sporadically increased the various environmental issues and implications on man's welfare and public health of urban areas, including cities (Anands, 2013; Kheni *et al.,* 2008; Watuka & Aligular, 2002). Worthwhile, the construction activities through continuous exploitation of renewable and non-renewable resources, project development, and demolition have always generated huge and diverse quantities of waste, a major urban environmental challenge (Oke *et al.,* 2016; Kheni *et al.,* 2008; Watuka & Aligular, 2002). Nevertheless, the alarming rate of environmental issues and implications occasioned by the unguided construction activities have now become a factor militating against the development and sustainability of cities.

In other words, cities are the engine of growth and catalyst for livable and sustainable development (Odufuwa *et al.*, 2018). The failure of most cities including Ota to meet and fulfil its socio-economic functions of human development and livability undoubtedly constrained by the unguided rate of urbanisation and industrialisation (Hardingham-Gill, 2018; Anands, 2013). These constraints have resulted in environmental issues and implications such as degradation, distress and poverty exacerbation (Ogunsesan *et al.*, 2016; Ogboi *et al.*, 2015). Nigerian cities, including Ota, have been witnessing a monumental increase in urbanisation due to an unprecedented increase in birth rate. This has caused a sporadic rise in the city's population, poverty, and industrial growth in the last decades. In addition, many immigrants from other parts of the country have put high pressure on this city and its adjourning urban areas. It is not an overstatement that the more significant number of migrants attracted in the last decades and the increasing industrial growth have pressurised the available employment opportunities and triggered housing demands in the city of Ota, Nigeria. Meanwhile, the quest to address the increasing housing demands and social exclusion in the city of Ota has increased construction activities both legally and illegally built.

The persistent increase in the illegal construction activities and high rate of poverty in the city of Ota have made efforts put in place by the built environment stakeholders in Ogun State, most especially the government to fail in controlling the sporadic development in the city of Ota. Various institutional policy frameworks and programmes meant to regulate the construction activities and conserve the environmental resources have equally failed and thus serve as a major tool for promoting environmental hazards and misfortunes in the city of Ota. Indeed, environmental issues and implications are a major concern to the city and thus questioned the functionality, livability and sustainability of Nigerian cities and urban centres in the global ranking of cities. However, the issue of quality of life brings into focus and attention, the concept of the environment (Odufuwa *et al.*, 2018; Ogunsesan, 2002), while the needs to reconcile socio-economic and industrial growth as well as development necessitate conservation and retaining the rare quality of the environment (Egunjobi, 1990). Hence, the quest to address these environmental issues and implications particularly in fast-growing cities including Ota becomes an interest to stakeholders, most especially the built environment professionals.

Based on this backdrop, the study assessed the environmental implications of construction activities in Ota, a fast-growing Nigerian city. In achieving this aim, the study examines socio-economic characteristics of residents of Ota, evaluates the factors influencing the rapid construction activities in the city of Ota, appraises the contemporary environmental implications of the construction activities in Ota city, and examines the measures towards ameliorating the environmental implications of the construction activities for sustainable development of the city of Ota, Nigeria. In other words, this study evolves strategies to enhance environmental quality in the city in particular and other cities with similar issues and proffer possible policy implications and measures to improve the city environment.

3 Material and Methods

3.1 Study Area

Politically, Ota city situates in Ado-Odo/Ota local government area (LGA) of Ogun State in southwestern Nigeria. Ado-Odo/Ota LGA was created on May 29, 1989, when it was carved out of the defunct Ifo/Ota LGA and Ado-Odo/Igbesa administrative areas of Egba South local government. It shares a boundary with Alimosho LGA in Lagos State to the south, Ipokia LGA to the west, Yewa South LGA to the northwest, and Ifo LGA to the north and northeast. Geographically, Ota city, covering an area of 878 square kilometres, lies between latitudes 6º 41'N and 6º 68'N and longitudes 3º 41'E and 3º 68'E (Olukanni et al., 2014). The city is one of the fastest-growing areas in Ogun State and has been categorised among the Development Pressure Areas not only in the State but the country as well (Ogun State Government, 2008). With the industrial concentration in Ota, the city is ranked third most industrialised in the country behind Ikeja and Apapa (both in Lagos) and has encouraged the continuous migration of people into the area for employment opportunities and greener pasture (Salako, 2009; Ogunseye & Kadiri, 2017).

3.2 Study Methodology

A cross-sectional design that explored descriptive, explanatory and exploratory methods was adopted towards understanding and addressing the research objectives. The descriptive method was used in the presentation and analysis of both the qualitative and quantitative information relative to this research study, while exploratory and explanatory methods were used to explore and give vivid explanations to the issues raised in the study. The cross-sectional design was found suitable for identifying the specific phenomena within a particular time and thus, the best approach for this research. Both primary and secondary data sources of data were explored and used for data collection in this study. The primary data were obtained through personal fieldwork involving the self-administration of a questionnaire administered on residents and complemented with field observation by researchers. The questionnaire addresses questions on the socio-economic characteristics of the respondents, the factors influencing the rapid construction activities in the city of Ota, the contemporary environmental implications of the construction activities in Ota city, and measures towards ameliorating the environmental implications of the construction activities for sustainable development of the study area. While, secondary data were sourced from both published and unpublished materials, including magazines, gazettes, and journals.

In other words, the populations for the study comprised the total number the people living within Ota city based on the 2006 National Population Census. It comprises the residents' population since virtually all residents engage in physical development and construction activities in one form or the other in the study area. The respondents that are the residents were sampled using Taro Yamane Sample Formula [n= N/1+N(e)2] based on the 2006 population figure of Ota as projected in 2020 to be 247,601. In other words, a total of 400 residents were considered for this study. A systematic random sampling technique was adopted for this study. It was used to administer a questionnaire on a resident as a representative found in an apartment at every fifth (5th) building within the study area. Data obtained were analysed using descriptive and inferential statistics (Summation of Weighted Value – SWV). The descriptive statistics engaged the use Likert scale to analyse the different opinions of the residents based on the research questions. Statistical Package for Social Sciences (SPSS) IBM version 21 was used for data analysis.

4 Findings and Discussion

4.1 Socio-economic characteristics of respondents

The results of the analysis of data on the socio-economic characteristics that include gender, age, income, occupation, household size and educational characteristics among other respondents are presented in Table 1. It is observed from Table 1 that close to two-thirds (68.5%) are male, while the remaining one-third (31.5%) are female denoting the eagerness and sense of feelings attached to residential development/construction by male than female. Also, the age distributions of the respondents significantly varied and established respondents to be adults in which only 3.2% is less than 20 years, while more than one-tenth (19.5%) is between 21 and 40 years, while slightly more than one-third (31.2%) is between 41 and 60 years and the remaining 46.0% is more than 60 years. Likewise, the educational characteristics of the sampled in the study area show that a substantial portion of respondents is literate as only 2.0% has no formal education, while more than one-quarter (29.5%) has primary school level education and close to half (43.5%) has secondary level education and the remaining one-quarter (25.0%) obtained tertiary level education. Regarding marital status, only less than one-quarter (18.8%) is unmarried, while the remaining 81.2% is married, denoting that different marital groups dominate the study population.

There is a mixture of ethnic affiliations among the respondents in the study area in which close to half (47.0%) belongs to Yoruba ethnic, while slightly less than one-quarter (19.8%) belong to Hausa/Fulani ethnic affiliation. Also, the Igbo ethnic nationality accounts for slightly less than one-quarter (20.5%), while the remaining 12.8% are non-Nigerians denoting foreigners from other countries who take solace in Ota and its proximity to Lagos for their socio-economic engagements. The period of living in the study area by respondents ranges from less than 5 years to more than 5 years. Accordingly, slightly more than one-tenth (14.2%) has less than 5 years of residency, while the remaining 85.8% have been residing in the study area for more than 5 years. This indicates that most of the residents have been residing in the study area for a long period and as such, familiar with spatial development and construction activities in the area. Concerning the employment status, it was observed from the results of the analysis that less than one-tenth (8.8%) are students, while close to half (43.8%) are in private employment and almost one-quarter (23.0%) are civil/public servant. Also, 11.8% were self-employed while 12.8% are unemployed. It can be inferred from this result that a substantial number of residents is gainfully employed with notable means of livelihood and socio-economic engagement.

In addition, the average monthly income ranges from below ₦30,000 to above ₦150, 000. Precisely, only 4.5% of the respondents earn less than ₦30,000 among the respondents, while more than one-tenth (17.2%) earn between ₦30,000 and ₦70,000 monthly, and more than one-third (41.2%) earn between ₦70,001 and ₦ 110,000. Also, those who earn between ₦110,001 and ₦150,000 accounts for less than a quarter (17.8%), while the remaining 19.2% earn above ₦150,000 monthly. This shows that most of the respondents are gainfully engaged with a reasonable income, which is more than the national minimum wage of ₦30,000; hence, the quest to satisfy necessities of life in which residential and property construction and development is a priority. On the household size, the analysis showed that slightly more than one-tenth (14.8%) have between 1 and 3 persons in the household, while more than half (65.2%) have between 3 and 7 persons. Likewise, 18.2% have a household size that consists of between 7 and 11 persons, while the remaining 1.8% have a household size that exceeds 11 persons. Lastly, analysis of the ownership of housing units of dwelling reveals that slightly less than two-thirds (64.5%) is living in owner-occupied homes, while the remaining that is slightly more than one-third (35.5%) are residing in a rented apartment.

Table 1. Socio-Economic Characteristics of Respondents

Gender	**Frequency**	**Percent**	**Income**	**Frequency**	**Percent**
Male	274	68.5	Below 30,0000	18	4.5
Female	126	31.5	30,000 -70,000	69	17.2
Total	400	100.0	70,001 – 110,000	165	41.2
Age	**Frequency**	**Percent**	110,001 – 150,000	71	17.8
Less than 20 years	13	3.2	Above 150,000	77	19.2
21 – 40 years	78	19.5	Total	400	100.0
41- 60 years	125	31.2	**Education**	**Frequency**	**Percent**
Above 60	184	46.0	No formal education	8	2.0
Total	400	100.0	Primary	118	29.5
Employment status	**Frequency**	**Percent**	Secondary	174	43.5
Civil/ public servant	92	23.0	Tertiary	100	25.0
Self-employed	47	11.8	Total	400	100.0
Private employee	175	43.8	**Marital status**	**Frequency**	**Percent**
Student	35	8.8	Single	75	18.8
Unemployed	51	12.8	Married	325	82.2
Total	400	100	Total	400	100.0
Ethnicity	**Frequency**	**Percent**	**Household size**	**Frequency**	**Percent**
Yoruba	188	47.0	Less than 3	59	14.8
Hausa	79	19.8	3-7	261	65.2
Igbo	82	20.5	7-11	73	18.2
Foreigner	51	12.8	Above 11	7	1.8
Total	400	100.0	Total	400	100.0
Period of Stay in housing unit	**Frequency**	**Percent**	**Ownership of housing unit**	**Frequency**	**Percent**
Less than 5 years	57	14.2	Owner occupied	258	64.5
Above 5 years	343	85.8	Rented occupied	12	35.5
Total	400	100.0	Total	400	100.0

(Source: Authors' Survey, 2021)

4.2 Perceived factors influencing rapid construction activities

The analysis of factors influencing rapid construction activities was done on 4-point Likert's scale with a gradation value consisting of Strongly Disagree, SD=1; Disagree, D=2, Agree, A=3 and Strongly Agree, SA=4. The index for each variable was arrived at by dividing the Summation of Weight Value (SWV) by the total number of responses. In line with Akanmu *et al.* (2016), the SWV for each of the variables was obtained through the addition of the product of the number of responses to each aspect and the respective weight value attached to each rating. This is expressed mathematically as thus:

$$\mathbf{SWV} = \sum_{i=1}^{4} \boldsymbol{X_i}\, \boldsymbol{Y_i} \text{………equation 1}$$

Where:

SWV = Summation of Weight Value,

X_i = number of respondents to rating i

Yi = the weight assigned a value (i = 1, 2, 3, 4). Therefore, the higher the Relative Importance Index – RII and the Mean Index Value -MIV, the higher the level of effectiveness for the variable under consideration which is expressed quantitatively as;

$$\mathbf{RII} = \frac{\mathbf{SWV}}{\sum_{i=1}^{4} \boldsymbol{X_i}} \text{……………equation 2}$$

Table 2 shows the result of the whole analysis in which the Mean Index Value MIV is estimated to be 2.446. Undoubtedly, industrial agglomeration (3.308) was the most factor influencing rapid construction activities in the study area and is closely followed by increasing rate of housing demands (3.178), the foreign exchange rate on importation (3.105), rapid urbanization (3.030), unguided population (2.838) and poor enforcement of development legislation (2.505). However, the absence of a functional spatial development plan, access to capital, instability in governance and politics, weak policy framework, weak public enlightenment and unexpected geological condition/ disaster are among the least factors influencing rapid construction activities in Ota city, Nigeria. Importantly, industrial agglomeration has always been the major propelling factor for other construction activities that accommodate other ancillary facilities, services and utilities aside from the magnetic power of the industrial cluster of Ota in attracting people, investments, and which thereby induced construction activities.

Table 2. Measured of the perceived factors influencing rapid construction activities

Factors	SD	D	A	SA	TWV	RII	MIV	RK
Rapid urbanization	36	66	642	468	1212	0.758	3.030	4
Poverty / poor income status	191	46	300	344	881	0.551	2.203	9
Unguided population	47	66	774	248	1135	0.709	2.838	5
Increasing rate of housing demand	44	36	483	708	1271	0.794	3.178	2
Weak policy framework	175	162	156	368	861	0.538	2.153	11
Poor enforcement of development legislation	129	46	495	332	1002	0.626	2.505	6
Unexpected geological condition/ disaster	363	68	9	0	440	0.275	1.100	13
Absence of functional spatial development plan	120	248	282	248	898	0.561	2.245	8
Industrial agglomeration	38	78	255	952	1323	0.827	3.308	1
Access to capital	83	362	168	320	933	0.583	2.333	7
Weak public enlightenment	185	364	99	0	648	0.405	1.620	12
Instability in governance and politics	179	150	126	416	871	0.544	2.178	10
Foreign exchange rate on importation	84	42	192	924	1242	0.776	3.105	3
							MIV = 2.446	

4.3 Environmental implications of the construction activities

The environmental implications of the construction activities in Ota were measured and assessed in Table 3. Table 3 shows the result of the whole analysis in which the MIV is estimated to be 2.631. In this regard, the negative impact of construction activities on society, such as social damage and urban structure damage with fear of the unknown, is the most prominent environmental implication with the highest index value of 3.483. This is closely followed by urban degradation and urban stress (3.188), increase in transport and logistics externalities (3.128), floods and erosion disaster (3.095), loss of wildlife and green area (3.090). In addition, unguided development control (2.983), spatial encroachment (2.918), rapid urbanization and industrialization (2.898), illegal dumping of construction waste (2.845), violation of environmental norms (2.825), severe damage to the ecosystem (2.823), depletion of agricultural land (2.745) and development of sprawl and slums **(**2.683) are among the possible adverse environmental implications of construction activities. However, the remaining factors that include violation of policy framework, unprecedented population, air and noise pollution, and increased construction waste are less significant.

Table 3. Environmental implications of the construction activities in Ota

Implications	**SD**	**D**	**A**	**SA**	**TWV**	**RII**	**MIV**	**RK**
Violation of policy framework	143	36	378	452	1009	0.631	2.523	14
Water pollution	335	108	33	0	476	0.298	1.190	20
Floods and erosion disaster	71	50	297	820	1238	0.774	3.095	4
Air and noise pollution	228	238	159		625	0.391	1.563	19
Urban degradation and urban stress	49	66	336	824	1275	0.797	3.188	2
Spatial encroachment	17	152	690	308	1167	0.729	2.918	7
Poor sanitation and land use disorganization	185	254	87	236	762	0.476	1.905	17
Increasing level of poverty	187	144	405	24	760	0.475	1.900	18
Development of sprawl and slums	50	158	657	208	1073	0.671	2.683	13
Unprecedented population	109	82	612	184	987	0.617	2.468	15
Unguided development control	55	38	612	488	1193	0.746	2.983	6
Violation of environmental norms	25	288	321	496	1130	0.706	2.825	10.5
Increase construction waste	158	78	291	424	951	0.594	2.378	16
Rapid urbanization and industrialization	77	0	630	452	1159	0.724	2.898	8
Loss of wildlife and greenery	51	54	471	660	1236	0.773	3.090	5
Negative impact to the society such a social damage, urban structure damage with fear of the unknown etc.	13	0	504	876	1393	0.871	3.483	1
Depletion of agricultural land	69	14	843	172	1098	0.686	2.745	12
Illegal dumping of waste	105	0	441	592	1138	0.711	2.845	9
Severe damage to ecosystem	101	10	474	544	1129	0.706	2.823	10.5
Increase in transport and logistics externalities	56	2	537	656	1251	0.782	3.128	3
							MIV= 2.631	

4.4 Measure towards ameliorating the environmental implication of construction activities for sustainable city development

Twelve (12) measures identified for ameliorating the environmental implication of construction activities for sustainable city development were assessed and findings are presented in Table 4. The analysis, which quantitatively expressed as the MIV of approximately 2.553 is presented in

Table 4. Importantly, comparing the mean index value of the analysis with individual relative index value revealed that preparation and implementation of the spatial development plan (3.415); attitudinal change and compliance with construction guidelines and development (3.360), and strengthening legal and socio-economic framework (3.105) are major measures towards ameliorating environmental implications of construction activities in the study area. In like manner, strengthening public awareness of environmental and socio-economic impacts of illegal constructions (2.923) and strengthening technical documentation, revision and control mechanism of projects (2.868) are other viable measures for improving adverse environmental implications of construction activities in the Nigerian built environment.

Other measures such as the introduction of a mechanism of improvement of illegal constructions to achieve a standard level of reconstruction, adaptation or removal; strengthening the legal relationship between urban planning and construction industry, reducing the cost of planning, design, registration and approval of title documents; strengthening of existing legal instruments and sustainable resources management approach for environmental protection; introduction and thorough implementation of economic-wide environmental policies such as the imposition of fines and levies; introduction of safety and security technological processes and monitoring team and involvement of public strategic participatory and assistance in control measures are less paramount among the assessed measures.

Table 4. Measures towards ameliorating the environmental implication of construction activities for sustainable city development

Measures	SD	D	A	SA	TWV	RII	MIV	RK
Strengthening legal and socio-economic framework	59	6	525	652	1242	0.776	3.105	3
Strengthening of technical documentation, revision and control mechanism of projects	93	4	510	540	1147	0.717	2.868	5
Strengthening of public awareness of environmental and socio-economic impacts of illegal constructions	87	126	132	824	1169	0.731	2.923	4
Introduction of mechanism of improvement of illegal constructions to achieve a standard level of reconstruction, adaptation or removal	165	50	465	220	900	0.563	2.250	6
Introduction of safety and security technological processes and monitoring team	217	46	195	380	838	0.524	2.095	11
Introduction and thorough implementation of economic-wide environmental policies such as the imposition of fines and levies	208	44	252	344	848	0.530	2.120	10
Strengthening legal relationship between urban planning and construction industry	199	58	246	360	863	0.539	2.158	7
Involvement of public strategic participatory and assistance in control measures	220	46	201	360	827	0.517	2.068	12
Reduce cost of planning, design, registration and approval of title documents	202	46	264	348	860	0.538	2.150	8
Strengthening of existing legal instruments and sustainable resources management approach for environmental protection	208	46	234	364	852	0.533	2.130	9
Preparation and implementation of spatial development plan	41	28	249	1048	1366	0.854	3.415	1
Attitudinal change and compliance with construction guidelines and development	64	0	192	1088	1344	0.840	3.360	2
							MIV= 2.553	

4.5 Contribution to Knowledge

The study has added to the existing literature on environmental planning and resources management as it has extensively discussed the environmental implications of construction activities using a case study of a fast-developing economy.

5 Conclusion and Recommendations

This study has significantly examined the environmental implications of construction activities in the fast-growing city of Ota, Nigeria. Quality academic justice has been done on the study objectives that include the socio-economic characteristics of residents in the city, the perceived factors influencing rapid construction activities in the study area, environmental implications of the construction activities in the study area, and measures towards ameliorating the environmental challenges and implications in the Ota city and other cities with similar issues. Worthwhile, as the emergence of man on earth has been characterised by utmost dependence on the natural environment, humans have to rely mostly on its nature for growth and survival. Hence, the exploration and exploitation of resources domiciled in the natural environment have been the pre-occupation of man and accompanying environmental disadvantages and consequences. In conclusion, the above environmental implications or consequences caused by divergent human actions, particularly the construction activities in the study area, are numerous. They combined to impact the functionality and livability of Ota city adversely. No doubt the environmental implications from the construction activities don't just occur. They were caused by rapid urbanization or unprecedented population growth, increasing rate of housing demands, high poverty/poor income status, and unguided population growth. Other factors noted in this study are the absence of a functional spatial development plan, weak policy framework, poor enforcement of development legislation, industrial agglomeration, poor access to investment capital, weak public enlightenment and instability in governance and politics to mention a few.

To ameliorate these identified environmental challenges and implications, sustainable measures which include adequate preparation and implementation of the spatial development plan, total compliance with construction guidelines and development by stakeholders, including the residents, strengthening the legal relationship between urban planning and construction industry, strengthening the legal and socio-economic framework, and strengthening of the technical documentation were recommended. In addition, revision and control mechanisms for project developments, strengthening public awareness of environmental and socio-economic impacts of illegal constructions and introduction of improvement measures for illegal construction to achieve a standard level of reconstruction, adaptation or removal were the best possible measures capable of ameliorating the environmental challenges and implications in Ota city, Nigeria and other cities with similar issues.

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Effect of Total Quality Management on the Safety Performance of Construction Firms in Nigeria: Construction Professionals' Perception in Federal Capital Development Authority, Abuja

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Abstract:
Past studies revealed that the lack of Total Quality Management (TQM) implementation in construction projects in Nigeria leads to poor safety performance on construction sites. This study assessed the effect of TQM on the safety performance of construction firms in Nigeria. A quantitative research approach was employed through the use of a questionnaire survey. One hundred twenty-seven copies of the questionnaire were administered to construction professionals in Federal Capital Development Authority (FCDA), Abuja, with a response rate of 48%. Relative Importance Index (RII), Mean Item Score (MIS) and Spearman Rank correlation analysis were employed for data analyses. It was revealed that: TQM practices have a significant effect on the safety performance of construction firms ($p < 0.01$), and strategies for improving TQM practices of construction firms are effective (Group MIS = 4.19). However, it was concluded that the effect of TQM on the safety performance of construction firms in Abuja is significant. It was recommended that management of construction firms adopt TQM practices right from the conception stage to implement TQM practices throughout the project life cycle. The study's findings are beneficial to construction firms and built environment practice by revealing effective strategies that can bring about 84% improvement in construction firms' safety performance.

Keywords:
Construction Firms, Effect, Safety Performance, Strategies, Total Quality Management.

1 Introduction

Total Quality Management (TQM) has been described as a modern system in the field of quality as defined by quality assurance and quality control. Nowadays, many firms have embraced the application of quality to improve construction practices' safety and improvement (Koutsougiannis, 2020). Lack of strict policies on building construction regulations often leads to TQM practices being neglected in Nigeria (Ede, 2016). This often leads to high rates of accidents, hazards, and unsafe practices, among other issues in Nigeria, which affects construction workers' safety performance. In line with all these, one of the factors affecting safety performance is an organisational factor referred to as factors that could cause accidental conditions in the context of safety performance. Researches have revealed the relationship between organisational factors and worker's safety behaviour (Neal *et al*., 2000; Zacharatos *et al*., 2005) and safety outcomes such as injuries, incidents, and accidents (Hunag *et al.*, 2006).

From a theoretical standpoint, quality management and safety management programs have similar characteristics. In construction work, a company's ability to deliver a quality product safely is the key to business success. The similarity between quality management and safety management has been well articulated by researchers (Kwan, 2016). In the light of TQM principles, some safety management theorists have drawn an analogy and put forward different Total Safety Management (TSM) models in the hope of achieving a significant leap forward in safety management. Hence, a positive relationship exists between TQM and safety management (Husin *et al*., 2008; Kwan, 2016). Therefore, TQM tends to bring about improved safety performance at construction sites.

Unfortunately, the use of TQM has not been adequately researched in the realm of health and safety (H&S) of construction workers on-site (OSTN, 2006; Issa *et al*., 2020). Although TQM ideas have been around for many years, their concepts and principles have not been generally applied to continuous safety improvement as a management strategy in occupational safety and health (OSTN, 2006). On the other hand, TQM has been practised in developed countries while the concept is still new in developing countries (Issa *et al*., 2016). This study, therefore, focused on the lack of implementation of TQM in construction projects which leads to injury and illness incidence rates in the construction industry being higher than in all other industries as a result of the frequent occurrence of accidents and injuries to workers at workplaces. This leads to poor H&S performance on construction sites.

Given the problem identified above, it is imperative to note that the safety performance of construction workers is paramount in getting a good return for human resources. Therefore, a quality manager is assigned to each project to be responsible for the implementation and coordination of quality control. However, there is still a failure of the safety performance of construction workers on-site as the number of accidents that occurs in the construction industry is still very high compared with other industries. In order to solve the problem identified, this study assessed the effect of TQM on the safety performance of construction firms in Abuja, Nigeria, to improve the safety performance of construction firms. The following objectives were pursued in order to achieve the study's aim:

i. To identify the stages of construction projects where TQM practices are most required.
ii. To examine the TQM practices required for the improvement of the safety performance of construction firms.
iii. To determine the safety practices of construction firms most likely to be influenced by TQM practices.
iv. To determine the relationship between TQM and the safety practices of construction firms.
v. To propose strategies for improving TQM practices for the enhanced safety performance of construction firms.

In view of the fourth objective of the study and the review of literature relating to it (Section 2.4), the following hypothesis was formulated for the study:
H_1: There is a significant relationship between TQM and the safety practices of construction firms.

2 Literature Review

This section gives a detailed discussion of the main theme of the aim and objectives of the study. This provides a reasonable basis for identifying the major variables required for the study's fieldwork.

2.1 Stages of Construction Where TQM Practices Are Most Required

Several procedures must be undergone for a successful project outcome, from the simplest to the most complex stage of a construction project. In construction, projects usually vary based on size, the number of stakeholders involved, budget and date of delivery. Irrespective of the case, however, a construction project is always a long and demanding process. It is therefore interesting to note that management of the distinct phases of a project is easily achievable now with higher precision due to the continuous progress of digital solutions; because of this, six main stages of a construction project where the use of TQM may be required were identified (Koutsougiannis, 2020). These are: Conception of the project; Design Stage; Pre-construction stage; Procurement stage; Construction stage; Post-construction stage.

2.2 TQM Practices Required for the Improvement of Safety Practices of Construction Firms

The management leadership's most important responsibilities for effective implementation of TQM practices led to a significant correlation between leadership management and soft TQM practices. Therefore, it is essential to emphasise that management leadership is a key factor in successfully implementing TQM practices (Mokhtar & Yusof, 2010). Soft TQM practices include education and training, employees' relationship, client's focus, and supplier's management, while hard TQM practices include process management, quality & data reporting, and product & service design (Ahmad *et al*., 2014). Reporting further on the factors influencing TQM practices, the following were identified: top management, human resources management, education & training, clients' focus, information & analysis, continuous improvement, process management, and supplier management (Faihan *et al*., 2013). Going by the assertion of past studies (Mokhtar & Yusof, 2010; Faihan *et al*., 2013; Ahmad *et al*., 2014), TQM can therefore be viewed as a quality-oriented approach affecting quality performance that has been corroborated by leading studies (OSTN, 2006; Husin *et al*., 2008; Kwan, 2016; Issa *et al*., 2020). In view of this, it has been submitted that the characteristic features of TQM practices (management leadership, process management, employees' involvement, and client's focus), as earlier identified, are main parameters that have been generally agreed upon by past studies to be capable of improving the quality performance of organisations (Sadikoglu & Zehir, 2010). Critically viewing the attributes of TQM practices, it can be understood that the attributes can be very influential in the improvement of the safety practices of construction firms

2.3 Safety Practices of Construction Firms Most Likely to be influenced by TQM

The adoption of TQM practices in a firm builds up a culture which seeks to enhance all pursuits consistently, and especially it concentrates on an entire knowledge of the numerous business procedure by the usual daily participation of all involved (Neal *et al*., 2000; Zacharatos *et al*., 2005; Ugboro & Obeng, 2010). The construction industry becomes more popular with a fewer rate of accidents. Keeping workers aware of safety issues, training them on these issues, communicating and discussing ways to improve these safety programs and concerns, and documenting these issues are the leading measures for reducing the rate of accidents. Regardless of this, TQM can influence some of the safety practices undertaken by a construction firm through the following practices: Awareness, Training, Communication, Documentation, Proper Equipment, Supervision and Transparency (ILO, 2005; Adediran & Adediran, 2008; Health and Safety Authority, 2013; Faihan *et al*., 2013).

2.4 Impact of TQM on Safety Performance of Construction Workers

In TQM, quality is everyone's business; it can be achieved only through mutual trust, coordination, and teamwork (Mohamed, 1997). It needs the Project Manager (PM) to participate in the process instead of inspecting it. As a foremost principle of TQM, top management entails a deep commitment from the PM on-site and leadership on his part. The responsibility of the PM is to ensure that proper equipment is given to workers and an adequate work area for the job at hand. Therefore, a lack of proper equipment leads to an unsafe construction site. This is because there may be an avenue for someone to get injured on-site, and workers are prone to errors without proper equipment. Provision of water always is also important to prevent dehydration. It is also essential to keep to time for rest and break of workers from the PM as lack of rest in time might impact their safety. From the perspective of supplier management at the TQM implementation level, it follows through with what quality and what standard of materials are being brought to the site. This significantly aids in avoiding any slight accident that is likely to occur due to low-quality material standards.

Furthermore, training is also an important principle of TQM. The preparation of employees for the TQM process is enhanced by organising training programmes. Therefore, these imply that TQM impacts workers' safety performance by making them go through rigorous training to help them be better at what they do (Husin *et al*., 2008; Ali & Omran, 2016). Similarly, it was revealed that the safety performance of the workers might depend impactfully on the construction firm, out of the measures to be improved upon by TQM in the construction industry, as this assures of quality work to be done on-site, the good rhythm of working by the workers on-site and fast work on-site as the workers will be joyful that their safety is kept at the utmost of the construction (Hasse *et al*., 2015).

In line with the above, it has been established by past studies that there exists a positive relationship between TQM practices and workers'/company's productivity or performance (Loushine *et al*., 2006; Husin *et al*., 2008; Kwan, 2016). This, therefore, implies that TQM is an ethical and holistic strategy of a firm in terms of continuous improvement in products/services or processes, including all stakeholders, to bring about clients' satisfaction and improvement of the performance and sustainability of firms. In view of this, all aspects of TQM practices should be effectively managed in a firm (Sadikoglu & Olcay, 2014).

2.5 Strategies for Improving TQM Practices for Enhanced Safety Performance

Studies have identified several Mohamed (1997) suggested the following strategies for improving TQM practices for enhanced safety performance (Mohamed, 1997; Willar, 2012; Kakkad & Ahuja, 2014; Ali & Omran, 2016). These strategies for improving TQM practices for improved project performance are summarised as follows:

i. Organisations should ensure the availability of quality records that comply with quality procedures and the need to retain quality procedures for a specified period.
ii. Strategic identification conduct should be employed to discover job competency gaps that will address skills and training.
iii. Organisations should create standard working systems for the check to occur at all basic phases of procedures identified.
iv. Evaluation exercises ought to show how the subcontractors' item will be confirmed; the area of review and test focuses, acknowledgement criteria; and witness check focuses.
v. Persistent quality mindfulness programmes should be developed at all levels of the organisation.
vi. Organisations should develop a multi-purpose planned prize framework to expand staff motivation.
vii. Organisations should develop quality goals that can be estimated, with the outcomes being checked and conveyed.

It has been revealed by some of these past studies that these strategies are so effective that they can bring about 82% improvement in safety performance at construction sites (Ali & Omran, 2016). Imperatively, the studies reviewed have emphasised that these strategies are effective strategies for improving TQM practices for enhanced safety performance.

3 Research Methodology

A quantitative research approach was employed for the study. The use of a well-structured questionnaire was adopted for data collection. Descriptive statistical tools were used to analyse the data collected. Research population involves a large collection of individuals or object that is the focus of a scientific query. It refers to the total number of the considerable population for the research (Morenikeji, 2006). The targeted population for this research was made up of selected construction professionals (Architects, Quantity Surveyors, Builders and Engineers) working in Federal Capital Development Authority (FCDA) in Abuja. There are a total of 286 professionals in FCDA, and 194 of them are registered under their respective professional bodies. The population size is, therefore, 194. The sample size for the study is 127 based on Krejcie and Morgan (1970) Table. The representative sample size for a population size of 190 on Krejcie and Morgan (1970) Table is 127. Since the population size of 190 is the nearest number to 194 on Krejcie and Morgan (1970) Table, then the sample size for this population size (127) was adopted for this study. A simple random sampling technique was adopted to select the sample size from the entire population. Therefore, 127 professionals were randomly selected from the total number of professionals in FCDA (194).

The study considered Abuja and FCDA in Abuja because Abuja is the capital city of Nigeria, and as a result, it is the hub of all construction activities due to the rapid development that takes place there (Kadiri *et al*., 2014). In addition, all the medium and large-sized construction firms in Nigeria usually have construction projects in Abuja. FCDA is a Government organisation in Abuja that is massively and actively involved in construction projects ranging from simple housing projects up to heavy roads and other related engineering construction projects. FCDA is also one of the major clients and initiator of construction projects in Abuja. FCDA also have competent professionals who oversee project supervision and vested with the responsibilities of ensuring compliance to site safe and quality management. Because of this, construction professionals in FCDA were considered for the study.

The data for the study were collected with the aid of a questionnaire survey during the tail end of the COVID-19 pandemic lockdown up to the last quarter of 2020. A structured questionnaire was employed to collect data on the research objectives based on a five-point Likert's Scale format. The questionnaire contains five sections. The first section addressed issues relating to the profile of respondents, while the other section addresses the study's objectives respectively. Of the 127 copies of a questionnaire distributed, 61 copies were returned and used, giving a response rate of 48%. In order to validate the research instrument used, a reliability test was carried out on the data collected. The reliability test result shows that all the items loaded have a fairly good correlation coefficient (r = 0.337 - 0.567). A high Cronbach's Alpha of 0.773 was observed, indicating that the research data are reliable and hence the research instrument is valid.

Analysis of data was carried out using descriptive methods of analysis such as Frequency, Percentage, Relative Importance Index (RII), Mean Item Score (MIS) and Spearman's Rank Correlation analysis. RII was employed to examine stages of construction where TQM are most required. MIS was used to examine the TQM practices required to improve the safety performance of construction firms. MIS was also used to identify the safety practices most likely to be influenced by TQM practices. Spearman's Rank Correlation analysis was used to determine the relationship between TQM and safety practices of construction firms. MIS was also employed to examine the strategies for improving TQM practices for the enhanced safety performance of construction firms in order of effectiveness. The decision rule adopted for the RII and MIS is summarised in Table 1.

Table 1. Decision Rule for Data Analysis

SCALE	**Cut-Off Point**		**Interpretation**			
	RII	**MIS**	**Level of Importance**	**Level of Significance**	**Level of Effectiveness**	**Level Required**
5	0.81 - 1.00	4.51 - 5.00	Very Important	Very Significant	Very Effective	Very Required
4	0.61 - 0.80	3.51 - 4.50	Important	Significant	Effective	Required
3	0.41 - 0.60	2.51 - 3.50	Fairly Important	Fairly Significant	Fairly Effective	Fairly Required
2	0.21 - 0.40	1.51 - 2.50	Less Important	Less Significant	Less Effective	Less Required
1	0.00 - 0.20	1.00 - 1.50	Least Important	Least Significant	Least Effective	Least Required

(Source: Adapted and Modified from Shittu *et al*., 2015)

4 Findings and Discussion

4.1 Results and Discussions on the Stages of Construction Projects where TQM Practices are most required

Relative Importance Index (RII) was employed to rank the identified stages of construction projects where TQM practices are most required in order of importance. This RII result is presented in Table 2.

Table 2. Stages of Construction Projects where TQM Practices are most required

CODE NO	STAGES	RII	RANK	DECISION
B1	Conception Stage	0.92	1st	Very Important
B4	Procurement Stage	0.87	2nd	Very Important
B5	Construction Stage	0.87	2nd	Very Important
B2	Design Stage	0.84	4th	Very Important
B6	Post-construction Stage	0.80	5th	Important
B3	Pre-construction Stage	0.78	6th	Important
	Group RII	***0.85***		***Very Important***

Table 2 shows the results of five (5) identified stages of construction projects where TQM practices are most required. The result shows that the conception stage is the most important stage, with an RII value of 0.92. This is followed by the procurement stage and construction stage, which are also very important, with RII values of 0.87 each. The design stage is the next ranked stage which is also very important with an RII value of 0.84. The least ranked are the pre-construction and post-construction stages, which are important with RII values of 0.80 and 0.78, respectively. Averagely, all the identified stages of construction projects where TQM practices are most required are very important (Group RII = 0.85). The study of Koutsougiannis (2020) slightly disagrees with this by indicating that the stages where TQM will be mostly required in the stages of construction projects are the pre-construction stage, construction stage and procurement stage. This study shows that all the stages are very important to TQM application, with the conception stage as the most important.

4.2 Results and Discussions on the TQM Practices Required for Improvement of Safety Performance of Construction Firms

Mean Item Score (MIS) was employed to rank the level of the requirements of the identified TQM practices required to improve the safety performance of construction firms. This result is presented in Table 3.

Table 3. TQM Practices Required for Improvement of Safety Performance of Construction Firms

CODE NO	TQM PRACTICES	MIS	RANK	DECISION
C1	Human Resources Management	4.52	1st	Very Required
C4	Suppliers Management	4.51	2nd	Required
C3	Process Management	4.31	3rd	Required
C6	Customer Focus	4.25	4th	Required
C5	Training	4.23	5th	Required
C2	Top Management	4.10	6th	Required
C7	Workers Relationship	4.08	7th	Required
	Group MIS	***4.29***		***Required***

Table 3 shows that seven major TQM practices are required to improve the safety performance of construction firms in Abuja. It was shown that Human Resource Management and Suppliers' Management are the most required TQM practices with MIS values of 4.52 and 4.51, respectively. The other five (5) TQM practices are also required. These range between Process Management (MIS = 4.31) and Workers Relationship (MIS = 4.08). On average, all the identified TQM practices for improving the safety performance of construction firms in Abuja are required (Group MIS = 4.29). The studies of Sadikoglu & Zehir (2010), Mokhtar & Yusof (2010), Ahmad *et al*. (2014) and Faihan *et al*. (2013) also confirmed, in agreement with the finding of this study, that the dimensions of TQM such as management leadership, process management, employee involvement and customer focus are commonly accepted activities to improve the quality performance of firms. This also shows that these TQM practices can be very influential in improving the safety performance of construction firms.

4.3 Results and Discussions on the Safety Practices of Construction Firms Most Likely to be Influenced by TQM Practices

MIS was also adopted for ranking the identified safety practices of construction firms most likely to be influenced by TQM practices. This MIS result is presented in Table 4.

Table 4. Safety Practices of Construction Firms Most Likely to be influenced by TQM Practices

CODE NO	SAFETY PRACTICES	MIS	RANK	DECISION
D1	Proper Equipment Usage	4.67	1st	Very Likely
D6	Supervision of work carried out.	4.25	2nd	Likely
D7	Transparency of duties and information.	4.23	3rd	Likely
D2	Awareness	4.20	4th	Likely
D3	Training of Staffs	4.20	4th	Likely
D5	Communication within Workers and management	4.17	6th	Likely
D4	Documentation of Work progress	4.15	7th	Likely
	Group MIS	***4.27***		***Likely***

As shown in Table 4, the study identified seven major safety practices of construction firms likely to be influenced by TQM practices. It was revealed that Proper Equipment Usage (MIS = 4.67) is the safety practice of construction firms most likely to be influenced by TQM practices. The remaining six (6) safety practices of construction firms also have high chances of being influenced by TQM practices. These range from Supervision of Work Carried Out (MIS = 4.25) to Documentation of Work Progress (MIS = 4.15). On average, all the safety practices of construction firms identified have a high likelihood chance of being influenced by TQM Practices (Group MIS = 4.27). The study of Adediran & Adediran (2008) slightly differs from the finding of this study by revealing that through training, workers can identify improvement opportunities as it is directed at providing the skills and knowledge required for all workers to be able to contribute to the ongoing quality improvement process of production. In this study, Proper Equipment Usage is the safety practice of construction firms most likely to be influenced by TQM practices instead of training in the study of Adediran & Adediran (2008).

4.4 Results and Discussions on the Relationship between the Level of Implementing TQM and Firms' Safety Performance

Spearman rank correlation was employed to determine the relationship between the level of implementing safety TQM practices and construction firms' safety performance. The correlation result is presented in Table 5.

Table 5: Relationship between the Level of Implementing TQM and Firms' Safety Performance

VARIABLES		OBSERVATIONS		INFERENCES		
X_1	X_2	R (%)	LOS	P_{value}	Strength of Relationship	Remark
Level of Implementing TQM Practices	Firms' Safety Performance	42.0 (0.420)	0.01	0.001	Slightly Strong	SS

KEY:

SS = Statistically Significant

R = Correlation Coefficient

LOS = Study's Level of Significance

P_{value} = Calculated Probability Value

It was observed from Table 5 that there exists a slightly strong, positive and significant relationship between the Level of Implementing TQM practices and Firms' Safety Performance. The correlation coefficient (R-value) observed was 42% (0.420), indicating a slightly strong association between the variables. The probability (P_{-value}) value of 0.001 observed was less than the level of significance adopted for the study (0.01). This implies a significant relationship between the variables. The study's hypothesis (H_1) was therefore accepted. The positive correlation observed between the variables indicates a tendency that an increase in the level of implementing TQM practices will increase firms' safety performance and vice versa. In line with the finding of this research, Husin *et al*. (2008) reported that a positive relationship exists between TQM and safety practices. Sadikoglu & Olcay (2014) also reported that TQM practices improve various performance measures in the firms, including safety. Hasse *et al*. (2015) also revealed that training is another principle of TQM that aids the preparation of employees towards the TQM process. Therefore, TQM has a significant impact on workers' safety performance by making them go through rigorous training to help them be better at what they do.

4.6 Results and Discussions on the Strategies for Improving TQM Practices for Enhanced Safety Performance

MIS was also adopted to rank the identified strategies for improving TQM practices for enhanced safety performance in the order of effectiveness. This MIS result is summarised in Table 6. The result of the ten (10) identified strategies for improving TQM practices for the enhanced safety performance of construction firms in Abuja is presented in Table 6. It was shown that the most effective strategy for improving TQM practices for the enhanced safety performance of construction firms is Appointing a Quality Consultant with an MIS value of 4.48. The remaining nine (9) TQM practices for the enhanced safety performance of construction firms are also effective, with high MIS values ranging between 4.36 (Job Competency has to be ensured among workers on site) and 3.97 (Setting up persistent quality mindfulness program). On average, all the identified strategies for improving TQM practices for enhanced safety performance in Abuja are effective (Group MIS = 4.19). Similarly, the studies of Mohamed (1997), Willar (2012) and Kakkad & Ahuja (2014) emphasised that these strategies are effective strategies for improving TQM practices for enhanced project performance. In addition, Ali & Omran (2016) revealed that these strategies are so effective that they can bring about 82% improvement in safety performance at construction sites.

Table 6. Strategies for Improving TQM Practices for Enhanced Safety Performance

CODE NO	STRATEGIES FOR IMPROVING TQM PRACTICES	MIS	RANK	DECISION
E1	Appointing a Quality Consultant	4.48	1st	Effective
E10	Job Competency has to be ensured among workers on site.	4.36	2nd	Effective
E2	Making a Quality standard	4.28	3rd	Effective
E4	Make available education and training requirements for all levels of staff.	4.20	4th	Effective
E3	Create organisational structures and assign responsibilities	4.18	5th	Effective
E7	Planning prize framework to expand staff inspiration and fulfilment	4.18	6th	Effective
E5	Assessment and testing exercises (counting any examination and test plans)	4.15	7th	Effective
E9	The field managers ought to be very responsive to workers.	4.08	8th	Effective
E8	Successful costing of administration or item is given.	3.98	9th	Effective
E6	Setting up a persistent quality mindfulness program	3.97	10th	Effective
	Group MIS	***4.19***		***Effective***

5 Conclusion and Further Research

The study revealed that the Conception Stage is the most important stage of construction projects where TQM practices are required. Human Resource Management and Suppliers' Management are the most required TQM practices. Proper Equipment Usage is the safety practice of construction firms most likely to be influenced by TQM practices. The relationship between TQM practices and the safety performance of construction firms is significant. The most effective strategy for improving TQM practices for the enhanced safety performance of construction firms is Appointing a Quality Consultant. Therefore, it can be concluded that the effect of TQM on the safety performance of construction firms in Abuja, Nigeria, is significant. Therefore, proper implementation of TQM practices improves the safety performance of construction firms. Based on the findings and conclusions of this study, the following recommendations were made:

i. The management of construction firms should adopt TQM practices right from the conception stage of a project to ensure that TQM practices are implemented throughout the project life cycle.
ii. Construction firms should focus more on Human Resource Management and Suppliers' Management when implementing TQM practices to build up a mechanism for improving the safety performance of construction firms.

iii. Construction firms should prioritise the strategy of Appointing a Quality Consultant when setting up a mechanism for improving the safety practices of workers on site. This will ensure continuous improvement of the relationship between TQM practices and the safety performance of construction firms.

The findings of this study will make a significant contribution by enabling construction firms to cajole their Quality Managers into doing more to improve the safety performance of construction workers on site. This will also improve the safety performance of the built environment practice at large in Nigeria.

In the light of the limitations of this study, the following are suggested for further studies: Impact of TQM practices on the performance of safety supervisors in construction projects; Comparative analysis of the effect of TQM practices on the safety performance of small, medium, and large-sized construction firms in Nigeria; and Comparative analysis of the effect of TQM practices on the safety performance at various stages of construction projects in Nigeria.

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The Impact of Business Forums on Construction Health and Safety (H&S) in South Africa

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Abstract:
The basis for the study is to investigate the impact of business forums on construction health and safety (H&S) in South Africa. It is notable that when coercive power is used by business forums to gain a stake in a project, H&S legislation and regulations are flouted. The goal of the study was to investigate the impact of business forums on construction projects, project cost escalation, project timelines, H&S, and the local economy. The study explored the regulatory tools that the industry must implement with a view to managing stakeholder involvement on construction projects. The study employed a quantitative paradigm, which entailed the use of a structured questionnaire to collect data in an endeavour to understand concepts, opinions, and experiences of the respondents. The sample population consisted of principal contractors, subcontractors, and communities surrounding projects and business forums who demand a stake from the project. The study determined that there was a lack of stakeholder engagement, limited law enforcement, and H&S non-compliance occurs. Conclusions include that there is a sense of entitlement among business forums, and business forums negatively impact the health and well-being of project stakeholders. The study recommends that the stakeholders should be managed, and stakeholder engagement should be regulated, which will contribute to projects running smoothly, being completed within the stipulated time, and within budget.

Keywords: Business forums, construction, health and safety, performance, projects

1 Introduction

Construction is a dynamic industry with an abundance of complex processes. It entails the successful coordination of numerous distinct business entities such as professionals, tradespeople, suppliers, trade unions, investors, local governments, experts, contractors, and other stakeholders. Due to construction projects having an impact on a country's economy, their successful completion often leads to wealth creation, socioeconomic expansion, and higher living standards (Sunjka & Jacob, 2013). The study was conducted to explore the impact of business forums on the health and safety in the South African construction industry. The anecdotal evidence indicates that when coercive power is used by business forums to gain a stake in projects, H&S legislation and regulations are flouted.

Construction projects are distinguished by a diversified array of stakeholders whose interests may be influenced favourable or unfavourable, by the project's outcome. The identification of stakeholders and their role have attracted interest, and been widely researched (Eyiah-Botwe, *et al*., 2016). Mok *et al*., (2013) opine that a connection exists between the culture of a country and the construction industry setup, the national culture inevitably impacts on the stakeholder management process and the project outcome.

Ofori (2012) argues that for a variety of reasons, the nature and outcomes of a country's construction industry are important, with contributions to the nation's socioeconomic growth, supply of physical infrastructure for necessary production, housing, education, health, and civic responsibilities being some of the examples of these. The construction industry significantly contributes to a country's Gross Domestic Product (GDP). Without considering stakeholders, construction projects cannot be initiated, rolled out and benefits gained The realisation of the strategic role of the construction sector in socio-economic growth in South Africa was a trigger or antecedent to the establishment of the Construction Industry Development Board (cidb) whose mandate is to regulate the industry and promote stakeholder collaboration. It is notable that meeting stakeholders' needs and satisfaction is a key project success measure (Project Management Institute (PMI), 2017).

The South African construction industry has been invaded by ostensibly community groups who demand a stake in construction projects throughout the country. This group is often colloquially referred to as business forums. These groups more often resort to violence or coercive power to achieve a stake in a project. Their expectations range from demanding the main contractor to spend 30% of the project budget with them, either using their workers or subcontractors, or through the procurement of building materials provided by them. Surprisingly, the supply cost through the business forums is uncompetitive, and often, at exorbitant rates (Pockok, 2018).

The community members that are followers of the business units consider them to be legitimate representatives of 'radical economic transformation' (RET). However, it is often challenging to draw a line between armed violence, and legitimate demands for access to economic opportunities (Donnelly, 2019). According to the South African Forum of Civil Engineering Contractors (SAFCEC), approximately R63 billion in projects have been obstructed by violent disturbances orchestrated by entities posing as members of the local community or business forums, demanding a 30 percent stake in construction projects. This has had a negative effect on both public and private sector projects.

In other instances, the main contractor may have already subcontracted 30% of the works to black emerging contractors in the community, if not more. Apart from legal options, another option is for construction companies or main contractors to withdraw as expenses rise and losses accumulate. According to Pockok (2018), the business forums method originates ostensibly in the provisions of the regulations revised recently in relation to the Preferential Procurement Policy Framework (PPPFA) Act 5 of 2000). The demands for a 30% cut in projects emanate from confusions in relation to the PPPFA and its associated regulations, promulgated in 2017. The revisions required bidders of projects valued at R30 million and above to subcontract at least 30% of the value of the contract to Qualifying Small Business Enterprises (QSEs) or Exempted Micro Enterprises (EMEs). Small business defined within the National Small Business Act (NSBA) No 102 of 1996 were also included in this requirement. The regulations were intended to promote the inclusion of designated groups in government contracts, including black South Africans, females, and persons with disabilities, through subcontracting on government tenders. However, the business forums argument is flawed as the PPPFA applies to public enterprises only and remains not applicable to private business. This sentiment was long-established in several notices circulated by the Master Builders Association (MBA) to all its members in the Gauteng Province. Accordingly, there is no statutory requirement for private businesses to allocate 30% of their works to subcontractors from the local area (Pockok, 2018).

Conflict is inextricably linked to construction projects and gives the impression of problems including increasing project cost, project delays, reducing productivity, loss of profit, and damage to business relationships (Jaffar et al., 2011). Cheung and Yiu (2007) identified human behaviour sources of conflict as negotiators lacking experience, too many issues for discussion, both parties not being prepared for negotiations, both parties seeking to control proceedings, both parties not taking an interest in reaching a settlement, parties having unreasonable expectations, no leadership within project teams, no trust between the parties, and no trust in the mediator.

The predominant question is what steps can private businesses take to contest the onslaught of protests, whilst also safeguarding their commercial interests, and more importantly, the H&S of their employees? The paper seeks to examine the impact of business forums on construction H&S in South Africa with a view to designing a management framework to manage business forums, policy formulation and good project governance. It is notable that when coercive power is used by business forums to gain a stake in a project, and H&S legislation and regulations are flouted.

According to the cidb (2009), construction H&S is influenced by all project stakeholders across the project life cycle. Therefore, decisions made at a certain point in the life cycle have an impact on H&S at later phases. Clients, project managers, designers, quantity surveyors, and other stakeholders, including the surrounding community, all have an impact on H&S, and they all have H&S functions and roles. According to Masood et al. (2012), stakeholders' awareness of construction H&S culture is critical to making construction sites healthier and safer.

Sieberhagen, Rothman and Pienaar (2009) maintain that policy makers, politicians, labour unions, and employers still need to be convinced of the proportional relevance of H&S. Workers' H&S priorities, according to Rantanen et al. (2004), as cited in Sieberhagen et al. (2009), included stress, aging, the right to H&S information, informed consent, and transparency. The paper unpacks the steps that the client can take, and the policies, procedures, and regulations that the industry must implement with a view to managing stakeholder involvement on construction projects.

The objectives of the study are to determine: the impact of business forums on project cost, timelines, and the economic damage; the impact of business forums involvement on H&S compliance and the health and wellbeing of project stakeholders; if the involvement of business forums have an impact on subcontractor development and training; the level of stakeholder management and engagement needed to ensure smooth running of projects, and which laws and regulations are already in place, and if they are enforced against the business forums.

2 Literature Review

Researchers and professional bodies do not have a common definition of stakeholders. Some argue that certain definitions are too confined, while others maintain that some of the definitions are too widespread (Molwus, 2013). The PMI define stakeholders as persons, groups, or entities who can influence and / or are influenced by a project resolution, task, or outcome.

Winch (2010) categorises stakeholders with regards to their characteristics and dispositions towards the project. Furthermore, he divides construction project stakeholders into two groups based on their affiliation with the client, namely internal stakeholders and external stakeholders. Internal stakeholders have legal contracts binding them to the client, whereas external stakeholders have a direct interest in the project but do not necessarily have direct contracts with the client. Other researchers define project stakeholders as groups or entities, persons with a stake in or expectations of the project's performance, such as clients, project managers, designers, contractors, subcontractors, suppliers, investors, users, and the community, who have power and are directly and indirectly affected by the development (Zanjirchi & Moradi, 2012).

According to Yang et al. (2011), construction has failed miserably in terms of effectively dealing with stakeholders over the last ten years. Studies have revealed that the challenges of managing stakeholders in construction projects' stakeholders were inadequate engagement of stakeholders, project managers with unclear stakeholder management objectives, difficulty identifying the 'invisible' stakeholder, and inadequate communication with stakeholders.

Prabhu (2016) states that the following constitute the significant principles of stakeholder management: consultations with stakeholders at an early stage and regularly ; engaging with stakeholders in a thoughtful and respectful manner; be attentive to stakeholders' needs and requirements; satisfactory and well-timed planning of stakeholder management is vital; create an environment of trust and credibility within the project atmosphere; communication and feedback in a manner that all messages are understood by the intended audience and hence the feedback will be expressed; manage stakeholders as risk and opportunities, which have probabilities and impacts; sacrifice through the set of stakeholders differing requirements and needs; conduct an widespread inquiry to comprehend the importance of the project to the stakeholder, and take accountability of the whole project and process as project governance is vital to project success.

Community stakeholders, according to Ekung et al. (2014), are divided into three categories: Social group which are individual household groups that make up the majority of unskilled labour in the production environment; economic group who are community kingmakers with the authority to rally resources or halt the flow of resources into project organisation, and political groups who are the recognised agency of government in the communities, local councillor's chambers, and youth organisations. Effective engagement of these groups is thus a vital element in securing successful project outcomes, given their uniqueness and the degree of opposition they provide to projects.

Mnaranara (2010) identifies three characteristics of communities: a community is a legally or illegally organised group structure in which members play roles that are amalgamated around objectives associated to the challenges that arise from the shared occupation and usage of occupied space; members of the community have some level of communal identification with the occupied space, and a community has an amount of indigenous sovereignty.

The South African government has incorporated policies, which ensure community participation on construction projects in the country. Some of those policies include the Expanded Public Works Programme (EPWP), which encourages public sector projects to be built using labour intensive methods, and political promises that 25% of any project implemented within a community must be unpacked for the community's small medium and micro enterprises (SMMEs) (Rathernam and Dabup, 2017).

According to Rathernam and Dabup (2017), it is sometimes challenging for a professional to participate in grassroot's involvement unless there are immediate political talks including local talks with structures over control concerns. The importance of community ownership in a project's success and acceptance cannot be overstated. According to Mitchel et al. (1997, cited in Mathebula, 2015), stakeholders are identified in terms of three features, namely power, legitimacy, and urgency. The example given was that where urgency and power characterise stakeholders who lack legitimacy, they would be coercive and possibly violent or dangerous to the project. Stakeholders who have power, legitimacy, and urgency, qualify as salient or definitive stakeholders.

According to Njobeni (2006), Minister Stella Sigcau announced the start of the development of a charter for the construction industry in October 2004. During April 2005, an Indaba was attended by many industry stakeholders to deliberate the structure and the scorecard requirements for a charter in a diverse and uncertain industry sector (Constructing a Charter, 2005). The intentions of the charter were to: achieve a considerable change in the racial and gender composition of ownership; address skills development; enhance entrepreneurial development; end the malpractice of fronting; encourage devotion to triple bottom-line accountability for labour practices and principles of good corporate governance, and lay the foundation for the integration of construction societies.

3 Research Method

3.1 Sample frame and method

The study employed the quantitative method, which entailed the use of a structured questionnaire to collect data in an endeavour to understand the concepts, opinions, and experiences of the respondents. According to Leedy & Ormrod (2010), the quantitative method is used to acquire data on some variables of interest to a problem. It also measures variables by commonly accepted statistics or measurement methods. The population included multiple stakeholders which includes principal contractors, subcontractors, community representatives of communities surrounding projects and business forums who demand a stake from the project in South Africa in the Gauteng region. The use of a structured questionnaire was prompted by the advantages that they bring which are as follows: it is simple and straight forward to use; respondents have time to think about their responses; it is easy to direct and analyse, and discretion and anonymity is usually conserved. A population size of 60 respondents was targeted. Due to time constraints and thus a limited response time, exacerbated by the COVID-19 pandemic, a questionnaire consisting of demographic questions and sub-questions was administered to fifteen stakeholders. A link to a questionnaire was emailed to respondents. A total of eleven responses were received and included in the data analysis, which equates to a response rate of 73.3%. Responses were received from Construction Managers, Project Managers, Health and Safety Managers/Officers and community representatives.

4 Findings and Discussion

Data analysis comprised of the calculation of descriptive statistics to illustrate the frequency distribution and central tendency of responses to response questions to determine the extent of agreement with the statements. Close ended questions with five-point Likert scales, which included an 'unsure' response option were used. Mean scores (MSs) were calculated as follows:

$$MS = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{(n_o + n_1 + n_2 + n_3 + n_4 + n_5) - n_0}$$

Table 1: Definition of Likert scale points and related variables

Code	Likert scale point	Variable
U	Unsure	n_o
SD	Strongly disagree	n_1
D	Disagree	n_2
N	Neutral	n_3
A	Agree	n_4
SA	Strongly agree	n_5

Table 2 below shows the extent to which respondents agree with twenty-three statements relative to construction H&S in terms of percentage responses to a scale of strongly disagree to strongly agree, and mean scores (MSs) between 1.00 and 5.00. Notably most of the statements have MSs > 3.00, which shows that in general, the respondents concurred with the statements. It is notable that the MSs of 5 / 28 (17.9%) statements are > 4.20 ≤ 5.00, which shows that the concurrence is between agree to strongly agree / strongly agree. In summary: effective communication is a pre-requisite for healthy and safe workplaces; stakeholder engagement is a pre-requisite for successful projects; clients provide project specific H&S specifications, and inadequate stakeholder engagement and H&S affects the other project parameters such as the environment, productivity, quality, cost, and project schedule.

Table 2. Degree of concurrence relative to twenty-three statements

Statement	Response (%)						MS
	U	SD	D	N	A	SA	
Effective communication is a pre-requisite for a healthy and safe workplace	0.0	0.0	0.0	0.0	33.3	66.7	4.67
Poor stakeholder management results in project delays and possible project stoppages	0.0	0.0	8.3	0.0	16.7	75.0	4.58
Clients provide project specific H&S Specifications that inform contractors with respect to H&S	0.0	0.0	0.0	8.3	33.3	58.3	4.50
Inadequate H&S negatively affects other project parameters such as the environment, productivity, quality, cost, and schedule	0.0	0.0	0.0	8.3	50.0	41.7	4.33
Stakeholder engagement in the construction industry enables the understanding of the complex business environment, including market developments, and the identification of new strategic opportunities	0.0	0.0	0.0	16.7	41.7	41.7	4.25
No contract is commenced unless all the H&S requirements have been complied with	0.0	8.3	8.3	0.0	25.0	58.3	4.17
Stakeholder engagement in the construction industry nurtures the relation of trust amongst stakeholders	0.0	0.0	8.3	16.7	50.0	25.0	3.92
Clients consider H&S when deciding upon project duration	0.0	0.0	16.7	25.0	25.0	33.3	3.75
Meeting stakeholder satisfaction and needs on construction projects are a key project performance measure	0.0	8.3	0.0	16.7	58.3	16.7	3.75
Stakeholder engagement in the construction industry enables better management of risk and reputation	0.0	8.3	16.7	0.0	50.0	25.0	3.67
Law enforcement agencies are reluctant to prosecute business forums	16.7	0.0	0.0	8.3	33.3	41.7	3.67
Business forums impact negatively on the health and well-being of other project stakeholders	8.3	0.0	0.0	16.7	66.7	8.3	3.58
Clients ensure that contractors have made adequate financial provision for H&S	0.0	0.0	33.3	16.7	33.3	16.7	3.33
Clients facilitate financial provision for H&S in tender documentation without consideration of business forums	0.0	8.3	16.7	33.3	16.7	25.0	3.33
Stakeholders' needs from the project are properly explored before commencement of the project	8.3	0.0	25.0	8.3	33.3	25.0	3.33
Stakeholder engagement on construction projects allow for the pooling of resources to solve problems and reach objectives that cannot be reached by a single organisation	0.0	16.7	8.3	16.7	41.7	16.7	3.33
Potential conflicts and coalition among stakeholders are analysed and addressed timeously	0.0	8.3	25.0	16.7	33.3	16.7	3.25
Project stakeholders are familiar with the H&S roles and responsibilities accruing from their appointment	0.0	25.0	8.3	8.3	41.7	16.7	3.17
Project stakeholders are properly identified in terms of power, legitimacy, and urgency	0.0	8.3	16.7	33.3	33.3	8.3	3.17
There is open communication between the client and the project stakeholders	0.0	16.7	25.0	8.3	25.0	25.0	3.17
Business forum's involvement on construction projects is purely for economic transformation	0.0	16.7	16.7	33.3	8.3	25.0	3.08
Business forums have the interest of the community at heart when they approach construction projects	0.0	33.3	8.3	16.7	25.0	16.7	2.83
Business forums understand the importance of H&S on construction projects	16.7	25.0	16.7	16.7	25.0	0.0	2.08
Business forums are competent in terms of the construction process and its activities	0.0	33.3	33.3	25.0	8.3	0.0	2.08
Business forums have a history of involvement in the construction industry	8.3	41.7	16.7	16.7	16.7	0.0	1.92
Business forums are committed to H&S on construction projects	8.3	33.3	33.3	16.7	8.3	0.0	1.83
Business forums have awareness in terms of project H&S	0.0	58.3	8.3	33.3	0.0	0.0	1.75
H&S is not of value on construction projects	0.0	83.3	16.7	0.0	0.0	0.0	1.17

The MSs of 7 / 28 (25.0%) of the statements are > 3.40 ≤ 4.20, which shows that the concurrence is between neutral to agree / agree. In summary: clients consider H&S when deciding upon project duration and before awarding contracts; stakeholder engagement nurtures trust on projects and enables better management of risk and reputation; business forums impact negatively on the health and wellbeing of other project stakeholders and meeting stakeholder satisfaction; meeting stakeholder satisfaction and needs is a key project performance measure, and law enforcement agencies being reluctant to prosecute business forums.

It is notable that the MSs of 10 / 28 (35.7%) of the statements are > 2.60 ≤ 3.40, which indicates that the concurrence is between disagree to neutral / neutral. In summary: clients ensure that contractors have made adequate financial provision for H&S; business forums are not flagged in H&S documentation; stakeholder engagement is initiated early during projects and is effective in terms of investigating available resources; business forums involvement on construction projects is purely for economic transformation; business forums have the interests of the community at heart when they approach construction projects; project stakeholders are properly identified in terms of power, legitimacy, and urgency.

The MSs of 4 / 28 (14.3%) of the statements are > 1.80 ≤ 2.60, which indicates that the concurrence is between strongly disagree to disagree / disagree. In summary, business forums understand the importance of H&S on construction projects, are competent in terms of the construction process and its activities, have a history of involvement in the construction industry, and are committed to H&S on construction projects. The concurrence relative to these statements confirms the negative connotations attached to business forums. The MSs of 2 / 28 (7.2%) of the statements are ≤ 1.00 ≤ 1.80, which indicates that the concurrence is between strongly disagree to disagree. In summary, business forums are aware in terms of project H&S, and H&S is not of value on construction projects. The former constitutes a further indictment of business forums, and the latter is supported by a range of literature, which documents the synergistic benefits of H&S on projects.

5 Conclusions and Recommendations

It can be concluded that projects must be adequately scoped in terms of identifying the stakeholders in a broad sense. Stakeholders vary during the project implementation phase, changing the stakeholders' interests. Conflicting priorities, political and stakeholder relationships can influence project performance if not managed. The importance and influence levels of these stakeholders should be evaluated, and therefore strategies should be developed to manage stakeholders' expectations from a project. Although the local community is considered a stakeholder of a project, minimal consideration and engagement is given to the local community as a stakeholder, and therefore there is a need to consider and consult the local community relative to a pending project. Since communities are complex, the consultation process should be undertaken through a legal or local authority, or selected community representatives.

Respondents agree that business forums have contributed to the 'brain drain' in the construction industry, with professionals opting to rather move overseas where there is a healthier and safer work environment. They are believed to have a negative impact on construction sites, and have led to many sites being closed, damage to property, threat to the H&S and security of workers, and job losses to the local community.

It is recommended that the South African government, as well as other associations and boards regulating the construction industry such as the cidb, join forces and ensure that the involvement of business forums in the industry is managed through project stakeholder management and engagement, as this is a structured process incorporating arrangements to negotiate, negotiation standards, and reaching a negotiated agreement. Due to the small sample size, the results cannot be deemed representative of the industry's perceptions, but indicative, and therefore further research into the topic is required.

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Sustainable Construction Project delivery: A Skills Availability Assessment in the Eastern Cape Province of South Africa

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Abstract:
The purpose of this paper is to evaluate factors affecting skills availability in the Eastern Cape Province for construction firms to achieve sustainable construction project implementation. Both the quantitative and qualitative research approaches were used in this study. A questionnaire was distributed to construction firms listed under general building Grade 5 to 9 in the Construction Industry Development Board (CIDB) register of Contractors within the Eastern Cape (EC) Province were surveyed. Validation of the questionnaire survey was conducted by data sourced through semi-structured interviews. The findings revealed factors affecting skills availability within construction firms are mainly two-fold: The first is retaining of skilled workers as most of employees are moving away from the industry and secondly the lack of adequate training in the sector. Findings from the qualitative study reveal that workers that possess constructions skills are moving away, some of construction workers have no interest in working in the construction industry and there is a lack of job availability. This study is limited to factors affecting skills availability on construction firms within the EC. The results obtained from this paper present factors affecting skills availability in the construction industry towards achieving sustainable construction project delivery. The practical implications are that the industry should be more diligent towards employee training and retain their skilled employees who are lost to another field which offer better remuneration. This was based factors affecting skills availability in the Eastern Cape Province for construction firms´ to achieve sustainable construction project implementation and recommend areas of improvement concerning factors affecting skills availability on construction firms.

Keywords: Construction skills, skills development, skills shortage, sustainable construction and training.

1 Introduction

Variables of a construction project are labour cost, labour time utilized, material cost and plant cost. For this study, much attention is given to skilled labour availability that might affect construction project delivery (Stefan, 2011). In additions, Bilau, Ajagbe, Kigbu and Sholanke (2015) claimed that craftsmen in the construction industry plays a significant role towards the development and the existence of the construction firm as they are more involved in organisational operations. The construction industry offers mostly national and global employment opportunities (Oseghale, Abiola-Falemu & Oseghale, 2015). However, considering the high demand, the Construction Industry is experiencing with a skills shortage in traditional and new developments

(Mackenzie, Kilpatrick & Akintoye, 2000). Moreover, Zaki, Mohamed and Yusof (2012) pointed out that the skilled labour shortage is not peculiar to the Eastern Cape of South Africa, but it is a worldwide tendency given the overall high demand of limited skilled labourers. In addition, the attraction of the construction industry to the youth is problematic, as most of young people prefer other opportunities than the construction industry (Haupt & Harinarain, 2016). The result is that the government strategy to attract young people towards the industry to deal with the skills shortage issue is not effective (Zaki *et al.*, 2012). Additionally, Makhene and Thwala (2009) noted that the current generation of young people sees the industry as an unattractive industry and uninteresting for several reasons such as being dirty, a physical challenge, moving around when performing duty and most dangerous industry, leading most of the youth to pursue other careers.

There is high number of human resources available in the industry. However, the shortage of skilled tradesmen like plumbers, carpenters and electricians, whose skills requires effective training, persist (Windapo, 2016). Thus, there is a link between the skilled labour shortage and the nature of the building construction industry. Ademeso and Adekoya (2011) concluded that the construction industry in the Eastern Cape Province has continued to experience a skills shortage and the quality of work decreases because of inexperienced workers available in the industry. Mateus, Allen-lle and Iwu (2014) pointed out that the construction industry unlike other sectors requires more knowledgeable workers, an integrated working environment, and effective technology. As a result, most construction workers are resisting the adoption of new skills (Mallo & Espinoza, 2015). These requirements impose a serious challenge between the industry and the current curriculum in both institutions and colleges regarding terms of the focus to mitigate the labour shortage in South Africa. Furthermore, Nzimande (2009) argued that the effect of education and training could not by itself resolve the challenges related to skills shortages in the construction industry. There is a serious need for skilled workers in the construction industry to enhance the development of the country´s economy. Hence, the problem investigated is on the availability of skills in the Eastern Cape to enhance sustainable construction project delivery. This study is organised into six sections. The first section introduces sustainability and skills availability, followed by an overview regarding the concept of sustainable and skills availability in the construction industry. The methodological approach employed to achieve the aim of this study is discussed in section three. The subsequent sections present the results emanating from the study, followed by the conclusions and limitations of the study.

2 Literature review

2.1 Sustainable construction in the Eastern Cape Province

According to Du-Plessis (2007), sustainable construction is the ability to serve the present generation without compromising the ability of the future generation to meet their own needs. Moreover, Ebsen and Ramboll (2000) referred to sustainable construction as serving the current generation aspect of sustainable development that includes economic issues. However, over the years, sustainable development refers to macro-economic development (Corona, Shen, Reike, Carreon & Worrell, 2019). The current research within the built environment development indicates that sustainable construction aims to achieve project goals (Choguill, 2007). Hence, the purpose of this study is to investigate factors affecting skills availability in the construction industry.

2.2 Construction Skills issue in South Africa

Schultz (2003) suggested that over the past decade, South Africa has experience high rate of decrease in the number of skilled individuals, trained in both public and private sector training. This is confirmed by a large decrease of registered contracts by the department of labour. Notwithstanding, the new generation is moving away and leaves the industry with a lack of professional skills and competent labours are moving to different fields or locations (Jide, Xincheng & Liangfa, 2017: Bosetti, Cattaneo & Verdolini, 2015; Bednarikova, Bavorova & Ponkina, 2016). This caused the South African government to aim at the implementation of skills training projects for newly employed workers in the environment are in place as a support, as it will improve production and provide a long-term investment on the skills shortage in South Africa. According to Bilau, Ajagbe, Kigbu and Sholanke (2015), construction skills is the ability to perform specific productive activity to a certain level of competence. Construction worker's skills are the most important aspect of sustainable construction practices (Zaki, Fikri, Mohamed, Yusof, 2012). Among other things, skilled construction workers perform the actual construction activities, by ensuring that the quality and standard of construction products are achieved. The handling and the use of materials, plant and machinery, preparing the site for construction purposes, manage the supply chain on the project site and ensure the completion and delivery of the project (Alzahrani and Emsely, 2013). In other words, the quality of a construction project is directly proportional to the skill and the effectiveness of training of construction labour. As a result, clients are always satisfied with a high standard of work, which leads to the client´s continuous support (Windapo, 2016). On the other hand, skilled worker shortages, cause poor quality, delay the delivery of projects, cause client dissatisfaction, and damage the firm's image (Tshele and Agumba, 2014). Hence, contractors need to have skilled and qualified workers to increase production.

Furthermore, the productivity of construction worker´s can be measured to determine the ratio of increase or decrease in comparative terms (Stefan, 2011). In addition, the project outputs of any construction activity rely on the amount of work done, quality of work done, and the value of work produced by construction workers. As part of the organisational support and skills improvement, Goldstein and Ford (2002) mentioned that there must be an assessment of the need for a specific skill, which must be an integrated decision of the company. Moreover, Goldstein and Ford (2002) and Green and Mclntosh (2007) argued that the training conducted by the construction contractor needs an assessor who will be able to ensure that the training objectives are met and to validate the training expense. Organisational support consists of two fundamental factors: establishing the relationship between top management and operational management (Bello, Ahmad and Yusof, 2018). Thus, for the construction contractor to resolve the skills availability challenge there must be an integrated management system to assist and implement sustainable construction in the Eastern Cape.

2.3 Factors Affecting Construction Skills Availability

There is a relationship between skills availability and training programmes within the industry (e.g. Further Education and Training FET Collage) (CIDB, 2007). However, Modisaotsile (2012) argued that skills availability is determined by the educational system currently available in high institutions or training centres, and a significant decrease in the pass rate of matric/ grade 12 to meet the minimum requirements for higher education. Moreover, Mutereko and Wedekind (2015) showed poor matric results in both major subjects related to the construction industry

(Mathematics and Physical Science), thus leading to a shortage of certified trades, such as electrical and plumbing. Nonetheless, Silva, Warnakulasuriya and Arachchige (2018) hypothesized that the causal factor leading to skills shortage in South Africa is the inadequate number of trained personnel coming out from training institutions joining the construction industry with inadequate skills. AbdulAzeez, Etubi and Umar (2019) argued that inadequate skills management within the industry affects the skills shortage in construction industry. Johanson and Adams (2004) noted that informal training and education have been shared amongst young people, who then fail to progress in the academic environment to improve their skills and gain admission to vocational training institutions. Nevertheless, Mazzucato and Penna (2016) claimed that lack of funding on firms´ side contributes to unavailability of skilled workers in the construction industry.

Additionally, an investigation performed by Barasa and Kaabwe (2001) found that there is more training on school leavers than all formal vocational training institutions combined, making it a significant contributor to skills development. Moreover, Akomah, Ahinaquah and Mustapha (2020) claimed that skills shortage is the result of low remuneration and motivation for skilled workers, such that young people are not interested in vocational training. This indicates that there are many persons with some skills within the industry, but the skills are not meeting the minimum requirements for employment. CIDB (2011) suggested that a guide to the skills development is to improve workers access to job opportunities that never existed in the past and this benefits contractors' in the foreseeable future in terms of project quality improvement. Bednarikova, Bavorova and Ponkina (2016) and Hauptfleisch (2006) showed that most government projects are used to transfer skills that encourage and improve the skills of those who were historically segregated before 1994. Moreover, Van Heerden, Mashatole and Burger (2014) agreed that government has numerous initiative programmes, which seek to encourage the growth and development of construction quality and improve sustainable project implementation. Thus, the above literature makes a strong case for the development of workers to have the specific skills required by the construction industry. However, apart from the future skilled workers' shortages, the problem of fast change needed to adopt green construction loom large and remain unsolved (Hampson & Brandon, 2004).

3 Methodology

This study adopted a combined research methodology approach of quantitative and qualitative methods to respond to the research questions and achieve the research objectives, including overcoming the challenges of validity and bias of the research study. The mixed method approach constructs a broader view of the research, as the quantitative approach present the gathered information in a numeric manner (Baxter, Hughe & Tight, 2006). The quantitative data were obtained with the aid of a structured questionnaire survey from contractors (directors, project managers, quantity surveyors, engineers, construction managers and site agents), who were purposively selected. This approach assists the research in selecting the relevant participants in the study and improving the research study´s quality. O'leary (2010) describes sampling as the process of breaking a large group of respondents into sections with the purpose of deriving results concerning the larger group. The population for this study was purposively selected comprising construction firms who previously completed a construction project or currently busy with a construction project. These construction firms were listed under CIDB general building Grade 5 to 9 in the Register of Contractors in East London, a metropole of the Eastern Cape Province. Two participants were purposely selected from twenty construction firms. This equates 40 participants in total. Soft copies of the survey questionnaires were administered to participants through emails, while hard copies were administered to the firm´s management team available on construction sites. It is noteworthy that this study focused on the quality of the results rather than the quantity of the population. A five point Likert scale questionnaire survey was employed in data gathering; while 5 the highest rating is in relation to how skill shortages is affected. Fellows and Liu (2008:182) suggested that after completing the rankings of the variables, these ratings indicate the degree of being affected and ranking displays the hierarchy. Seventeen (17) questionnaires were returned and completed correctly, representing 43% response rate.

Shortly after the main questionnaire survey was completed, two semi-structured interviews (qualitative method) were administered to validate the quantitative results. The results of the quantitative data were analysed descriptively using a Statistical Package for the Social Sciences (SPSS) version 25 software. These results were summarised and organized using tables. On the other hand, the data collected using semi-structured interviews, was analysed using content analysis. In addition, Flick (2011) explained that content analysis enables the researcher to omit any irrelevant information and terms and summarise accounts.

4 Analysis of Results

4.1 Summary of the Profile of respondents

In terms of age group distribution of the 17 participants, it was found that the age group of 41 to 50 (64.7%0 dominated. Forty-seven point zero seven (47.07) percentage of respondents have relevant experience ranging between 1 to 5 years. Concerning educational qualification, the largest number of the participants 52.94% hold Bachelor's degree qualifications. Regarding the role of the respondents in the firm, about 41.17% of the respondents were construction managers.

Table 1. Profile of participants

	Category	No. Participants	Percentage %
Age group in years	18 – 25	1	5.88
	26 – 40	3	17.64
	41 – 50	11	64.71
	50 – 60	2	11.76
Total		**17**	**100**
Experience of the participants in years	0 – 5	3	17.64
	6 – 10	4	23.53
	11 – 20	8	47.07
	20 – Above	2	11.76
Total		**17**	**`100**
Educational qualification	Matric	5	29.41
	Diploma	2	11.76
	Degree	9	52.94
	Post Graduate	1	5.88
Total		**17**	**100**
Role of the participants	Site agent	3	17.64
	Construction manager	7	41.17
	Quantity Surveyor	0	0
	Director	5	29.41
	Others	2	11.76
Total		**17**	**100**

4.2 Factors affecting construction skills availability

Table 2 presents the statements pertaining to factors affecting construction skills availability in the Eastern Cape. The respondents indicated to what extent they agreed with the given statements using a 4-point Likert scale where 1- Strongly disagree, 2- Disagree, 3- Agree, 4- Strongly agree. First, findings signified that most workers, after obtaining specific skills, change their employers to seek a better income and the lack of funding to invest in workers. Both had the same mean score of 3.53. This is followed by the industry´s lack of attractiveness to young people, with a mean score of 3.47. Next, most construction workers move to other provinces to seek better lives together with workers who are not motivated to work in the Eastern Cape Province, with a mean score of 3.41, which is the cause of the unavailability of skills in the Eastern Cape. Others are workers who possess skills are not meeting the minimum requirements of employment (3.55), most job adverts requires specific experience and education in the construction industry (3.29), and Labourers are not allocated based on their skills (3.24). The average mean score is (3.43) indicating that all these factors have a significant contribution in skills availability in the Eastern Cape Province.

Table 2. Factors affecting construction skills availability

Factors affecting skills availability	*Response*						
	No	1	2	3	4	Mean	Rank
Most workers after obtaining specific skill turn to change their employers to seek better income.	17	0	0	8	9	3.53	1
Skills shortage affect contractors planning and result in inadequate resource planning.	17	0	1	6	10	3.53	1
Lack of funding to invest in workers training.	17	0	1	6	10	3.53	1
The industry is affected by a lack of attractiveness to young people.	17	0	0	9	8	3.47	2
Workers are not motivated to work in the Eastern Cape Province.	17	0	1	8	8	3.41	3
Workers who possess the skills are not meeting the minimum requirements of employment.	17	0	2	7	8	3.35	4
Most job adverts require specific experience and education in the construction industry.	17	0	2	8	7	3.29	5
Labourers are not allocated based on their skills.	17	0	1	11	5	3.24	6
Average	**17**					**3.43**	

4.3 Qualitative interviews

Table 3 present the profile of the respondents who took part in interviews. Table 3 indicates that the respondents were construction manager and site agent respectively. Both respondents were from contractor's listed on Grade 6 cidb Register of Contractors within the Eastern Cape Province.

It is noteworthy that respondent A was from a company that is doing general building contracts, whilst, respondent B was from a firm doing alterations and renovations.

Table 3. Profile of the respondents

Interview participants´	**Position**	**Company Grade (cidb)**	**Type of Service**
Respondent A	Construction manager	6	General building
Respondent B	Site agent	6	Alterations and renovations

4.4 Qualitative results on factors affecting skills availability

Respondent A revealed that in the construction industry around 30% of construction firms in the province employs skilled workers. However, due to lack of project, firms´ are forced to retrench these employees. *Respondent A* further stated that most of workers employed in construction industry are not passionate to succeed in the construction industry and they use their employment as the source of income. *Respondent B* argued that most of skilled workers are willing to learn and pay attention in details. Similarly, *Respondent B* noted that construction contractors allocate workers based on their skills and expert. Lastly, *Respondent B* revealed that lack of project availability affects worker's willingness to lean and lead to skills shortage in the industry.

5 Discussion of Results

The quantitative results obtained indicate that from a ranking perspective, the factors affecting construction skills availability in the Eastern Cape Province include the fact that: Most workers, after obtaining a specific skill, change their employers to seek a better income. This statement aligns with the opinion of Bosetti, Cattaneo and Verdolini (2015), who reveal that the diversity imposed by the change in the building fraternity pushes employees to seek employment in other industries to earn a better income and work in a conducive environment.

The lack of fund to invest in training workers is recognise as one of the most significant factors affecting skills availability in the Eastern Cape. In support, Mazzucato and Penna (2016) argued that lack of project funding for skills development, particularly in privately owned construction projects. The second most significant factor affecting construction skills availability in the industry is the lack of attractiveness of construction to young people. Haupt and Harinarain (2016) who postulated that although the construction industry is important for economic development, the construction industry has been affected by a poor image for a long time, support this finding. Lastly, workers are not motivated to work in the Eastern Cape Province. This finding aligns with that of previous research by Bednarikova, Bavorova and Ponkina (2016), which mentioned employee job satisfaction, health care and personal expectations, as driver's employee´s attitude, which improves productivity at the project level. Concerning the qualitative findings, Mallo and Espinoza (2015) showed that construction employees are willing to change to and learn new technologies that are related to the industry, to improve production. The findings presented in Table 2 aligns with the literature, that workers who possess construction skills are willing to learn new skills. Similarly, the findings revealed that firm´s allocation is effected on a basis to benefit employees who require specific skills. This finding corroborate the finding of Green and Mclntosh (2007), who declare that most skilled workers are allocated with senior job vacancies and assisted by unskilled workers in order to fulfil the labour shortage on a job site. Finally, it is worth noting that the quantitative findings were consistent with the qualitative findings.

6 Conclusion and recommendations

A review of literature on availability of skilled workers in the Eastern Cape Province was performed and an assessment to enhance sustainable construction project delivery was carried out. The mixed-method research approach was adopted to evaluate factors affecting skills availability in the Eastern Cape Province. Regarding the quantitative analysis, the study found from the ranking perspective that the most important factors affecting skills availability in the Eastern Cape include: Most workers, after obtaining a specific skill change their employers to seek better income together with lack of funding to invest in worker´s training, and the lack of attractiveness to young people. Concerning the qualitative findings, the results align with the quantitative analysis, as the respondents agreed on the factors affecting skills availability in the Province. This includes workers who possess construction skills and are willing to learn. In addition, the respondents revealed that firms allocate employees to benefit those who require certain skills. The findings indicate that the lack of attractiveness of the construction industry is a major concern within the industry. It was found that the training of employees during project delivery improve production and the firm’s sustainability. Regarding the skills availability in the Eastern Cape Province, construction firms should ensure that they remunerate employees reasonably to retain their service. In addition, there is a need to train employees on new technologies to improve production and change the image of the industry through the effective adoption of technology.

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Effective Material Management Practices Adopted by SMEs to Achieve Project Success: A Perspective of Construction Industry in the Eastern Cape Province

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Abstract:
This study investigates the effectiveness of material management practices adopted by construction SME firms at the project level to achieve sustainable construction project success. A mixed-method research approach that involved a questionnaire survey was distributed to purposively selected management personnel of SMEs construction companies listed in Grade 1 – 4 of the cidb Register of Contractors and based in the Eastern Cape Province of South Africa. Also, semi-structured interviews of purposively selected contractors who took part in the survey were undertaken. The quantitative data were analysed using descriptive statistics, and content analysis was used to analyse qualitative data. This paper discovered effective material management practices to promote SMEs sustainable success using specified material for construction project, effective utilisation of construction materials, and effective material recording strategy. The qualitative findings revealed effective material management practices and effective monitoring and control of material and effective material procurement practices. The study focuses on emerging contractors registered under CIDB grade 1 and 4 in the Eastern Cape province. However, the findings have practical significance to big firms and the construction industry because projects will be successful when materials are effectively monitored, controlled and procured. This study focuses on SMEs effective material management strategies and provides more comprehensive effective material management practices for enhancing sustainable project implementation.

Keyword: Material management, project delivery, SMEs, sustainable construction

1 Introduction

Material management during the construction of a project has been viewed as the effective practices which result in the success of Small Medium Enterprises (SMEs). Smit and Watkins (2012:6325) referred to SMEs as a business based on yearly turnover and the number of workers or employees. The South African development and the country's economic growth within the lower grades of CIDB are significant to build the capacity required to produce high-quality infrastructure (Yokwana, Ndihokubwayo & Windapo, 2016). Among SMEs project success, Ofori-Kuragu, Baiden and Badu (2016) and Chan and Chan (2004) argue that SMEs project success is measured based on project performance and adoption of profitable and competitive business. Ulubeyli, Kazaz and Sahin (2018:655) and Labuschagne and Brent (2005; 159) indicate that SME businesses constitute one of the pillars of the country's economy and that SMEs have the responsibility to prioritise the significance of sustainability in the construction industry. Hence, construction growth mostly relies on home-based sustainable growth, brought through effective performance by the firm in the industry. Islam, Keawchana and Yusuf (2011) note factors that SMEs can adopt concerning sustainable business, namely management and know-how. For instance, Khyomesh and Vyas (2011) note that construction material management is influenced by numerous factors, including inadequate material handling and material management during construction project delivery. It can be concluded that contractor’s effective material management practices contribute to quality, time, and a socio-economic transformation of sustainable construction. Also, construction material contributes largely to construction project cost; hence, SMEs need to invest in effective material planning and control to minimise wastage which invariably affects the organisation's organisation's performance (Gulghane & Khandve, 2015).

Nonetheless, Kasim, Anumba and Dainty (2006) suggested that the sustainability performance of a construction contractor on projects is mostly influenced by the strategies adopted by contractors regarding material management, which then affects the delivery time of construction project at large. According to Adedeji, Afolabi, Ojelabi and Ayim (2017), contractors need to understand the logistics related to procurement, transportation, handling, storing and efficient use of materials on site. Based on the above literature, the problem to be investigated is stated as follows: it is not evident to what extent effective adoption of material management practices during construction project delivery enhances SMEs’ business performance in the Eastern Cape province. Therefore, the study aims to investigate and determine the most effective material management practices that can be adopted by construction SMEs at the project level to achieve sustainable construction project success. The purpose of the study is pursued by analysing both quantitative and qualitative data from selected SMEs’ management team in the general building category listed in Grade 1 – 4 of the cidb Register of Contractors.

2 Literature Review

2.1 SMEs Material Management Practices

Management of material in construction is the main element, as it is applied to construct the structure of the building. When materials are not effectively managed, they add to the cost of the project from the contractor's perspective (Gulghane & Khandve, 2015:60). Kasim, Anumba, and Dainty (2006:794) point out that materials management is the process that includes planning and quantifying construction material, supplier evaluation and selection, effective purchasing of construction material, expenditure, transportation, material receiving, storing and material recording, and material distribution. Also, Kasim (2011:48) points out that when the material is not properly managed during a construction project, this will have a negative impact on the project performance. Furthermore, Kasim (2011:48) points out that materials make up the bulk of the costs on a construction project between 30% and 80%. During construction project delivery, poor materials management leads to largely unavoidable variation costs that the contractor must consider (Fapohunda, 2014:25). Thus, inappropriate materials management will result in construction project failure. There is a need for emerging contractors to develop an effective material procurement system. The impact of procurement includes planning, ordering and scheduling (Gulghane & Khandve, 2015:60).

Stoilkovska, Hanak and Pancovska (2015:723) reveal that the lack of materials management is the leading factor in increased cost and time overruns. Donya and Flanagan (2009:12) argue that for a contractor to achieve cost reduction, special attention is required on the management of materials, which include the following: effective procurement strategy, shop fabrication, effective material logistics, effective resource management, production on-site, and effective field servicing, which promotes cost reduction. To properly manage production times in construction projects, SME contractors have to ensure proper scheduling of material delivery (Fapohunda, 2014:25). Opoku, Cruickshank and Ahmed (2013) believe that sustainable construction practices are achieved through effective contractor's leadership skills to encourage and influence sustainable practices. Moreover, Korkmaz, Riley and Horman (2011) argue that sustainable construction project delivery is not only the contractor's responsibility but also includes the client's decision making. The sustainable management of project material is the key factor in achieving sustainable construction project delivery. Solanke and Fapohunda (2016:497) opine that sustainable material management requires an integrated approach concerning reducing material wastage during construction projects, thus increasing the company's profit and environmental protection. Hence, extra costs on construction sites are caused by delays which may be unavoidable where there is an inadequate material ordering system within the company. It is necessary for the growth and sustainable use of available materials that construction managers ensure a proper flow in the administration of materials on a project.

2.2 Material Procurement Practices

Kasim, Anumba and Dainty (2005:795) and Tunji-Olayeni, Afolabi, Ojelabi and Ayim (2017) refer to procurement as the term that includes a wide range of activities such as procurement and management of materials, manpower and services required for construction project delivery. According to Patel and Vyas (2011), materials procurement is the primary objective of materials management in any project management system used in a construction project. Similarly, according to Kasim (2011:32), material procurement is the process of purchasing materials from external suppliers to support the project operations. The current interest of construction firms mainly focuses on the resource acquisition relationship concerning SME contractor sand material suppliers and construction subcontractors. In most construction organisations, material procurement activities are the responsibility of the buying department or estimating department. Practically, procurement officers or buyers perform vital functions to ensure that the materials required for a project are provided (Hadded, 2006). Consequently, the material procurement strategy scheduled for a construction project as large as an industrial plant requires a complex and integrated management system, which could be determined by considering the above-mentioned selection factors. It is worth noting that selecting an unsuitable material procurement strategy for a project could result in unsatisfactory project outcomes in terms of quality and cost.

2.3 Construction Material Scheduling

The management personnel decisions are mainly based on programmes and schedules developed during the planning stage of a project, but there is still a lack of material scheduling that needs to be done, among many scenarios that could be considered at the project level (Ashby & Johnson, 2013). Although most SMEs uses CPM (Critical Path Method) to do scheduling of materials, this technique has been used since the 1950's and benefited most SMEs in many areas of construction projects, such as the planning and controlling of materials, communicating plans, and training management (Ashby & Johnson, 2013; Farhikhteh, Kazemi, Shahin & Shafiee, 2020). Hence, Risku and Karkkainen (2004:4) conclude that materials can be managed effectively by focusing on two factors; namely, the planner needs to have access to effective, comprehensive information regarding materials required on the project, and the materials should be reliable in terms of the required quality, without excessive record build-up at the project site. Consequently, SME material routing is still heavily dependent on the level of experience of the construction site manager. Hence there is a need for SMEs to develop sustainable material scheduling for construction projects. Cost, quality, time, client, supply chain and project size are drivers of strategic material procurement selection, which is usually also influenced by the legislation of any country (Baloi, 2002).

2.4 Selection of Sustainable Building Material

According to Haddara and Elragal (2014), most construction activities worldwide use billions of tons of raw materials in a single year, contributing to more than 40% of the global use. Thus, Ljungberg (2007) opines that the objectives of sustainable construction can be enhanced through effective consideration of environmental impact, economic impact, client's requirements and the demand within the market. Nevertheless, Abeysundara, Babel and Gheewala (2009) divulge that contractors can select material based on the fundamentals of sustainable construction practices for contractors to achieve economic benefits. Thus, ineffective material selection affects the contractors' desire to achieve sustainable project goals. Moreover, Abeysundara *et al*. (2009) conclude that an appropriate approach adopted from the design to the construction of the sustainable project is fundamental in the sustainable construction project delivery.

3 Research Methodology

This study adopts a mixed-method research approach consisting of both quantitative and qualitative research approach was adopted in this study. Zou, Sunindijo and Dainty (2014:317) argue that a mixed-method enhances the validity and reliability of the study outcome. The sample frame for the study is from emerging SME contractors listed in Grade1 to 4 of the general building (GB) category of the cidb Register of the Contractors. It is important to highlight that the population comprises construction managers, site agent, and quantity surveyors. The purposive techniques were adopted to select participants for a questionnaire survey.

Construction SMEs situated in East London, Port Elizabeth, Mthatha and Butterworth in the Eastern Cape Province were grouped into clusters of thirty-two (32) in which participants were selected using a purposive sampling approach with a total of one hundred and twenty-eight (128) firms. Out of the 128 questionnaires administered to the respondents, 59 were duly completed and returned, representing a 46% response rate. Closed-ended questions were formulated to obtain data from all the participants. The survey instrument adopted in collecting the quantitative data was divided into two sections. The first section solicited information regarding the participants´ demographic details, whereas the second section collected information about the effective material management practices adopted by construction SMEs. A 5-point Likert scale where SD = Strongly disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly agree was adopted to evaluate respondents´ perceptions regarding the most effective material management practices adopted by construction SMEs. Concerning qualitative data gathering, semi-structured interviews aided the data collection to understand effective material management practices at the project level. Statistical Package for the Social Sciences (SPSS) version 25 was used to analyse the quantitative data. SPSS was adopted to summarise, organise, and reduce large numbers in the research study using descriptive statistics. Whereas qualitative data was analysed using content analysis.

3.1 Reliability Testing

The scaled questions used were tested on Cronbach's alpha coefficient to check the reliability of questions. Statistic Package for Social Sciences Software (SPSS) was used to examine the reliability of the Likert scale questions. According to Maree (2007:216), the Cronbach's alpha test is interpreted as follows: values that are lower than 0.6 are considered as unacceptable; values with a coefficient of 0.70 are considered as having low reliability; while values with a coefficient of 0.80 are considered as moderate, and values hovering around 0.90 are considered as possessing high reliability. The results of the Cronbach's alpha co-efficient tests presented in Table 1 were found satisfactory in terms of the reliability test requirements.

Table 1 Reliability Testing

Question No.	Headings	No. of items	Cronbach's alpha coefficient value	Rank
12	Effective material management practices	14	0.84	Moderate
Sum	All questions combined	14	0.84	Moderate

4 Analysis of Results

4.1 The Profile of Respondents

A total of 59 respondents from different SME firms. 54.2% of respondents fell in the age group between 26 and 39, 23.7% were aged between 40 and 49, with only 11.9% between the age of 50 and 59 years. At the same time, 10.2% were in the age group between 18 and 25. 89.8% of the respondents were aged between 26 to 59, which suggests respondents had sufficient maturity. Regarding the relevant experience of the respondents in the industry, it is evident that 37.3% had experience ranging between 1 to 5 years, 25.4% of respondents had worked in the industry between 6 to 10, while 25.4% had 11 to15 years of industry experience. Furthermore, 6.8% of respondents had worked in the industry between 16 and 20 years, and only 5.1% had worked in the industry ranging for more than 20 years. Concerning the educational qualification of the respondents, 47.5% held a National Diploma qualification, followed by respondents with degree qualification 25.4% and others with 13.6%. It can be deduced from the findings that an overwhelming 72.9% have obtained tertiary qualification. Regarding the role of respondents, 37.3% of the respondents were site agent, and 20.3% of respondents were project managers. Also, 32.2% of respondents have other roles, 10.2% are Quantity Surveyors. Concerning the gender of the respondent, it was found that 62.7% and 37.3% of the respondents were male and female, respectively. This implies that both genders participated in the study.

4.2 Effective Material Management Practices

Table 2 presents the findings related to effective SME material management practices adopted by construction SMEs to achieve sustainable construction project delivery in the Eastern Cape province. Table 2 indicates that the use of specified material for a construction project is ranked peak, with MV=4.25. This is reinforced by the fact that 90% of the respondents agreed that using specified material for a construction project is significant for SMEs to achieve sustainable construction projects. 8.5% of the respondents were neutral, and 1.6% of the respondents disagreed. Managing material through effective utilisation of construction material is ranked second, with MV=4.19. 89.9% of the respondents agreed that the effective utilisation of construction material is an effective material management modality for construction SMEs to achieve sustainable project success. However, 10.2% of the respondents were neutral, and Table 2 indicates that none disagreed. Notably, 84.5% of the respondents agreed on adopting an effective material strategy, which ranked third with a mean value of 4.12. 15.3% of the respondents were neutral on this factor, and none of them disagreed. In addition, the least recognised factor by construction SMEs is worker awareness of budgeted material against available material, with a mean value of 3.48. Nonetheless, it can be noted that these modalities proved to be significant for construction SMEs to achieve sustainable construction project success, with an average mean value of 3.97.

Table 2: Effective Material Management Practices

Statements	**No**	**SD %**	**D %**	**N %**	**A %**	**SA %**	**Mean**	**Std.**	**Rank**
The use of specified material for construction project	59	1.7	0.0	8.5	52.5	37.3	4.25	.68464	1
Effective utilisation of construction materials	59	0.0	0.0	10.2	61.0	28.8	4.19	.60099	2
Effective material recording strategy	59	0.0	0.0	15.3	57.6	27.1	4.12	.64553	3
Adequate scheduling of construction materials	59	0.0	0.0	16.9	55.9	27.1	4.10	.66163	4
Availability of materials	59	1.7	0.0	13.6	55.9	28.8	4.10	.75874	4
Integrated material management approach among the team on site	59	0.0	0.0	27.1	42.4	30.5	4.03	.76488	5
Effective leadership on-site to avoid material wastage	59	0.0	3.4	27.1	33.9	35.6	4.02	.88066	6
Materials stored in safe areas	59	0.0	1.7	30.5	35.6	32.2	3.98	.84060	7
Effective management of materials by the use of requisitions	59	1.7	0.0	20.3	55.9	22.0	3.97	.76488	8
Building relationship with construction material suppliers	59	0.0	1.7	30.5	42.4	25.4	3.92	.79412	9
Sustainable procurement system	59	1.7	1.7	25.4	54.2	16.9	3.83	.79117	10
Effective processes for purchasing material from external suppliers	59	1.7	3.4	28.8	47.5	18.6	3.78	.85234	11
Material is ordered and delivered on time	59	13.6	0.0	11.9	47.5	27.1	3.75	1.25387	12
Worker awareness of budgeted material against available material	59	1.7	15.3	28.8	42.4	11.9	3.48	.95332	13
Average	59						3.97		

4.3 Qualitative Interviews

4.3.1 Profile of Respondents

The first interview (*with respondent A*) was conducted with the firm's director on 05 September 2019 in King William's Town, a suburb of East London in the Eastern Cape Province. The second interview (*with respondent B*) was conducted with the firm´s director on 06 September 2019 in the Southernwood suburb of East London at 14:45 in the meeting room of the SME contractor during office hours. The third interview (*with respondent C*) was conducted with a firm's director, who was the sole management executive of the firm.

Respondent A declared that material was managed through material recording of the material coming in and material going out. The respondent also suggested that construction SMEs have a buying department in their organisational structure responsible for overseeing what is needed on site. The respondent also recommended that after recording the material, the project manager does the material reconciliation. *Respondent B* stated that at the beginning of each project, a storeman would oversee the material recording on-site, although the director quantifies the material to order. The storeman kept the record of the available material. The material was ordered based on the quantities taken from the drawing, not from the BOQ, and the material was stored in the safe area and a lockable area for small materials (door locks) for safety reasons. The respondent also indicated that the storeman was strictly responsible for the storeroom and kept the material´s record. The storeman was to check the delivery notes of the material to ensure that the correct material was delivered on-site, and the storeman was given the necessary training to read the delivery notes. Lastly, *Respondent C* opined that a 0% waste initiative was implemented on construction sites to reduce the cost of materials, which made up the lion´s share of costs on a project. The respondent recommended that material be managed through effective site security on construction sites and that orders be managed and controlled by the site manager, including ordering materials.

5 Discussion of Findings

Among the effective resource management practices, the effective use of materials for the construction project contributes to sustainable material management. As presented in Table 2, the quantitative findings indicate that the use of specified construction material in construction projects is the most important material management practices adopted by SMEs in sustainable construction projects, with MV=4.25. The specification on the construction project forms the basis of the contract, which the SME has to comply with. This finding is justified by Lam, Chau, Chau and Poon (2011), who note the significant material specification and promote the effective use of project specification by SMEs, as this forms the basis of contractual documents concerning achieving project goals. The effective utilisation of materials during construction project delivery is the second important effective material management practice. It is significant to note that SME contractors who adopt effective utilisation of construction material in construction projects minimise project cost and increase production (Safiuddin, Jumaat, Salam, Islam & Hashim, 2010; Ahmadi & Al-Khaja, 2001). Effective material recording strategy ranked third, with MV=4.12, and is a notable material management practices adopted by SMEs. Mikulakova, Konig, Tausche and Beucke (2010) support this finding, arguing that most material management system utilises material recording techniques.

Quantitative analysis suggested that SMEs adopt material recording, safe storage of material, and monitor and control material and material procurement strategies to achieve sustainable construction project success. As indicated in quantitative analysis, material recording is significant for SME contractors´ effective material management strategy, indicated in Table 2 with MV=4.12. Qualitative findings also revealed effective monitoring and controlling of materials as a tool used by SME contractors to manage material. This result aligns with the findings of previous research by Omar, Mahdjoubi and Keder (2018). They point out that monitoring and controlling systems assist construction managers in seeing the project's progress, identifying potential delays, and taking corrective action to prevent risks. The qualitative findings in Table 2 indicate effective material procurement as the effective strategy adopted by SMEs. Arbulu, Ballard and Harper (2003) and Tabrizi (2018) reveal that material procurement includes identifying, acquiring, distributing, and disposing materials on construction projects.

6 Conclusion and Recommendations

Based on the quantitative analysis, the most effective material management practices adopted by construction SMEs to achieve a sustainable success rate include the effective use of specified material for a construction project (MV=4.25), effective utilisation of construction material (MV=4.19) and effective material recording (MV=4.12). Qualitative findings were consistent with the quantitative analysis, as the respondents revealed that effective material management practices adopted by construction SMEs include effective material recording, as discussed in quantitative findings, and reconciliation of the material. Also, the qualitative findings revealed that construction SMEs could adopt materials stored in safe areas, material ordering as per issued construction drawings, adequate site security, monitoring and controlling construction material, effective material procurement and effective utilisation of material to achieve sustainable construction project success. The study provides information on effective material management practices to enhance sustainable construction project delivery by SMEs. It is recommended that SMEs should ensure that they utilise the available material effectively and avoid waste on construction sites. Also, SMEs need to keep a record of available material on-site to minimise waste. Construction SMEs should adopt an effective procurement strategy to order material according to the specification and ensure that the ordered material is as per drawings. This study is limited to the Eastern Cape Province of South Africa and focuses on Small to Medium Enterprise (SME) contractors listed in Grade 1 to 4 of the cidb Register of Contractors. However, the findings have practical significance to big firms and the construction industry because projects will be successful when materials are effectively monitored, controlled and procured.

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The effect of Incubation Programme Small, Micro and Medium Enterprises Development: A cross-sectional survey

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Abstract:
The research examines the effect of business incubation on the Small-Medium, and Micro Enterprises (SMMEs)' growth and development as perceived by incubatees in a South African context. The study addresses the challenges SMMEs had before joining the incubation programme, the entrepreneurial skills required for SMMES success, and the entrepreneurial skills delivered on business incubation programs. The research was carried out in the province of Gauteng in South Africa. The study adopted a quantitative research methodology and a cross-sectional research design. A purposive sample of 32 Incubated SMME from 6 incubators was selected within the public incubation program of the Small Enterprise Development Agency (SEDA), evaluating the effect of business incubation on SMME development and growth. Three key outcomes were assessed to measure growth and development: increase in turnover, job creation and expansion either in markets, products and incubation programmes, and the perceived value-added of incubation support services to black-owned businesses. For the incubation program to be successful, its service offerings should be aligned with the needs of the SMMEs. Through incubation, the challenges which SMMEs identified before joining the incubation program should be eliminated. Business Advisory, Business Development, Funding and Lack of access to infrastructure are the most prevalent barriers faced by SMMEs before to joining the incubation program.

Keywords: Business incubation, enterprise development, enterpreneural skills, SMMEs

1 Introduction

SMMEs in South Africa are pivotal drivers of job creation, alleviating high levels of unemployment and poverty. However, many start-ups and SMMEs do not make it through

the first two years of their existence, despite government's intervention through the rollout of incubation programmes. Challenges faced by SMMEs are broad and vary by the area where these SMMEs operate and by the industrial sector. Some of these SMMEs include the inability to access market opportunities, lack of sponsorship, and poor business strategy (Lose and Tengeh, 2015). Poor business strategy may be induced by a lack of managerial skills and competencies of SMME owners and limited institutions to offer financial intermediary and support (Asah et al., 2015 and Marivate, 2014). As a result, many SMMEs do not reach their full potential, with the lost economic growth opportunity, job creation and poverty alleviation. It is against these challenges that the worldwide economic climate identified the need for effective assessment and support in the SMME sector. Among the interventions needed to increase SMME effectiveness are support to upskill, empower, and bring about the turnaround for SMME development, growth, and success. The effectiveness of business incubation in enhancing entrepreneurial skills and improving access to finance and markets to SMME's organisational success and development needs to be evaluated. This will ensure that success in the business incubation programme is properly measured.

2 Literature review

Some of the key challenges facing SMMEs' growth in developing countries include meeting local and global competition from well-established businesses (Urban and Naidoo, 2012). In addition, SMMEs competitiveness in developing countries is hindered by a lack of human resource and development skills and access to adequate finance (Urban and Naidoo, 2012). The sustainable profitability of the SMMEs that are in their start-up phases is undermined by inadequate business, managerial, auditing, networking and accounting skills, lack of collateral, difficulty in securing a loan, poor vocational training, and poor mentorship support from various agencies whose duty is to promote and monitor the SMME sector of the economy (Asah, Fakoti & Rungani, 2015; Marivate, 2014). Business incubation is one of the strategies that support entrepreneurs by promoting the creation and growth of entrepreneurial venture (Choto, 2015).

Incubators are most successful when their mission and goals are aligned with the entrepreneur's needs and sponsoring organisations (Isabelle, 2013). To maximise the benefits of incubator programs, entrepreneurs need to consider the BI (Business Incubators) core offering before signing up (Isabelle, 2013). Incubation should not be an exercise taken within the agenda of a corporate social investment initiative but a significant intervention to drive economic growth. Business incubators (BIs) have to overcome several challenges to equip SMMEs with relevant skills (Lose and Tengeh, 2015). Despite these studies on the valuable contribution this can bring to economies, the effectiveness of these organisations is not sufficiently documented.

Enterprise development has emerged as a vehicle to achieve sustainable economic growth and development (Scillitoe and Chakrabati, 2010). However, in South Africa, there has been limited initiatives by both private and public organisations aimed at mainstreaming the participation and role of SMMEs within the country's economy. Business incubators can provide incubated companies with a conducive work environment to enable emerging businesses to survive (Tilana, 2015). In South Africa, business incubators are considered to significantly impact economic growth and development (Lose, 2016).

The studies by Bengesi and Le Roux (2014); and Wiklund and Shepherd (2005), assessing the impact of entrepreneurial orientation (EO) on SMME firm performance, used profit as a performance measure. Some studies used sales turnover growth, profits, number of jobs created and market share to measure the relative performance of SMMEs (Lukes, Longo and Zouhar, 2019). The challenge with the measure in revenue is that there are still operating costs associated with running a business that may or may not make the business profitable. To assess the outcome of incubation, the services offered by business incubators and how they address the challenges faced by the entrepreneurs should be reviewed.

3 Data and Methodology

The study used secondary data descriptive cross-sectional survey of incubated SMMEs owners, utilising quantitative techniques in collecting the data at a particular- point in time. Data was collected from the Small Enterprise Development Agency (SEDA) in annual reviews where details of their incubators and post-incubation entrepreneurs were recorded. This study included incubated business mainly in the publicly administered programmes. It was a challenge to estimate the population size as there is limited monitoring of business incubators post the incubation program as most incubators do not keep contact with incubatees after graduation.

A cross-sectional approach was applied focusing on the independent change variables measured in terms of change in the number of employees between two points in time: start-up time and survey, similarly with change in turnover the SMME's realised. The sampling comprised of SMMEs owners in the province of Gauteng who had been through an incubation program. This sampling frame comprises a list of public incubators as obtained from the SEDA publications and other reliable sources. This study included incubated businesses mainly in the publicly administered programmes. Since the study is cross-sectional, it considered entrepreneurs who have completed an incubation program. This approach comprised a mix of black-owned and non-black-owned incubated companies, thus limited generalisability is mitigated, given broader insight sourced from different business incubation programs and groups.

The SMME incubation program in Gauteng is based on a high number of incubation centres concentrated in Gauteng. A sample size of 32 incubated SMMEs was sourced using the purposive sampling technique. These SMMEs went through the incubation program responsible for providing financial and non-financial assistance, business incubation, and quality support services. An attempt was made to split further the sample size of 32 SMMEs incubated across different industry sectors.

The data was put through Minitab software after it was coded. In addition, a program such as Pareto and ANON was used to test themes, such as barriers that SMMEs faced before joining the incubator. These statistical tools were also applied to test the SMMEs' test skills to be important for business survival, success, and growth-related to the support received. A one-way analysis of variance (ANOVA) is also adopted within this study. The ANOVA t-test statistic of $p \leq 0.05$ indicates significant results, meaning that the groups differ significantly (Diamantopoulos and Schlegelmilch, 2000). On the other hand, when $p \geq 0.05$ indicates that the results are not significant, there is no difference in the mean scores of the groups or organisations.

4 Results and Discussions

The data sourced from SEDA's 32 incubated SMMEs have shown the age of only two owners, equivalent to 0.06% from the sample. This implies that there is less focus placed on age according to SEDA selection and criterion applied. Therefore, no further analysis was done on age as a factor.

The test performed on the racial representation of the business owners was to determine whether SEDA is providing service according to target as per acceptance criteria in the program. The study revealed that racial groups within the black categories make up the largest group of participants, almost 80%. It can therefore be assumed that this percentage is representative of the sample size.

In terms of the character of businesses sampled, the findings revealed that the Manufacturing sector had the highest representation rate at 37.5%. Engineering 12%, Services 9.38% and Motor, Agro-processing and Food and Entertainment all with 6.25% representation. All the other remaining sectors had a representation of below 5% from the sample.

4.1 Analysis of barriers faced by SMMEs before joining the incubation program

Figure 1 below shows the analysis of the barriers faced by SMMEs before joining the incubation program.

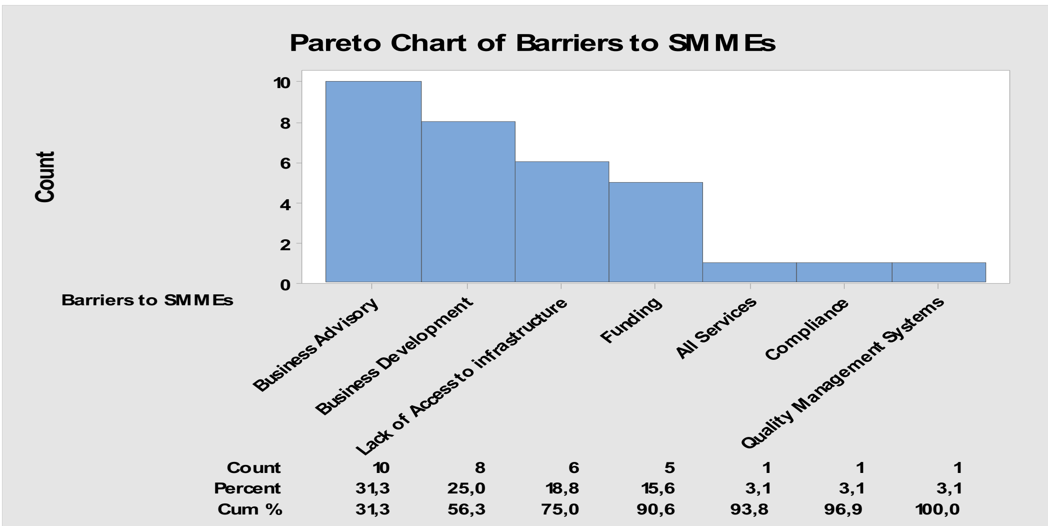

Figure 1. Barriers to SMMEs before joining SEDA

The most common challenges faced by SMMEs that entered the SEDA incubation program include Business Advisory, Business Development, Lack of Access to Infrastructure and Funding. These four challenges contribute to 75% of the common challenges raised by SMMEs when they enter the incubation program. Further tests on the barriers of SMMEs before joining the SEDA incubation program, analysis of the data in terms of revenue growth and the barriers to SMMEs was conducted. The results show that lack of access to infrastructure, funding and quality management systems have a high revenue growth than the other factors. In addition, the SMMEs that faced these barriers to the growth experienced high growth in revenue post the incubation program. Business incubators experience negative sales revenue during the earlier stages of the incubation and positive sales revenue in the long-term post incubation programme (Lukes et al., 2019).

Analysis of barriers to SMMEs and the impact on growth and development of SMMEs post-incubation program was also conducted. An interaction plot ANOVA test was conducted to test whether there is a relationship between SMMEs and background skill level barriers. The objective of the test was to determine whether the relationship between the two factors results in high revenue growth for the SMMEs. With this test, the barriers and the level of skill of the SMMEs and their growth can be isolated. The results of the test show that: semi-skilled SMMEs that experienced a lack of access to infrastructure, funding and quality management systems had very high growth in revenue post the incubation; skilled SMMEs with funding as a barrier to growth and development before incubation experienced very high levels of revenue growth; unskilled

SMMEs experienced the lowest growth in revenue (below average), and the only interaction with the barriers was Business Advisory and did not have a significant impact on the revenue growth.

Figure 2. Barriers to SMMEs and Background Skill Level

4.2 Analysis of background entrepreneurial skill level

In order to establish the background skill level of the SMMEs before joining the incubation program, a Pareto analysis was conducted. The results of the Pareto analysis are presented on the graph below (figure 3). There were 19 semi-skilled level entrepreneurs, ten skilled level entrepreneurs, two unskilled entrepreneurs and one unclassified. The percentage contribution of each level of skill is shown on the graph, with semi-skilled and skilled level entrepreneurs contributing 93% of the total skill level of all entrepreneurs.

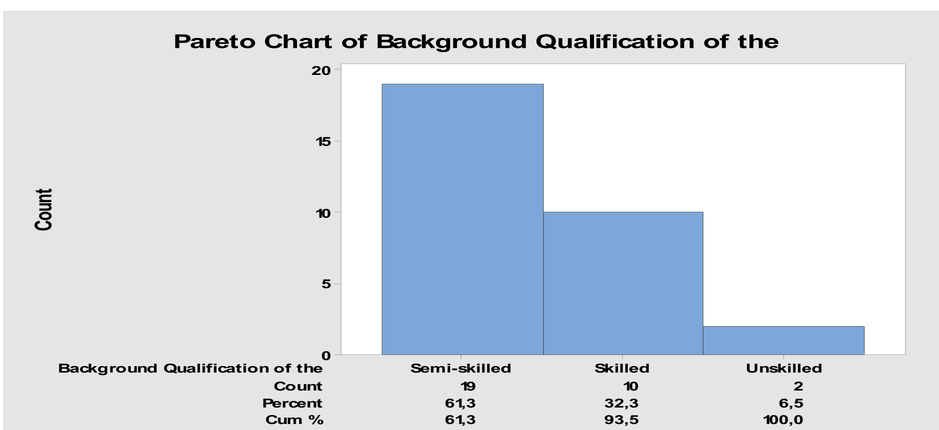

Figure 3. Background Qualifications of the SMMEs

The Main Effects graph (see Figure 4) plots Revenue Growth as an output variable (Y) versus the background skill level as an input variable (X). This is to test the impact of the background skill level on the growth and development of SMMEs. The Pareto analysis (Figure 3) indicates that the entrepreneurs were mainly semi-skilled (61.3%) and skilled (32.3%) before joining the incubation program. The results (see Figure 4) support the Pareto analysis above and show that SMMEs with entrepreneurs with Semi-skilled and Skilled level have a higher growth ratio than unskilled entrepreneurs. Therefore, it can be inferred that semi-skilled and skilled entrepreneurs can grasp the business advisory and business development support functions provided by SEDA to help SMMEs grow and develop. However, to further explore and test this hypothesis, an ANOVA test was conducted to test the interaction of the two factors.

The ANOVA test reveals that the level of education and prior experience in the sector do not positively influence the growth and development of SMMEs. This poses a new challenge to business incubators to ensure that they provide relevant skills and impart acumen to bridge the gap already identified.

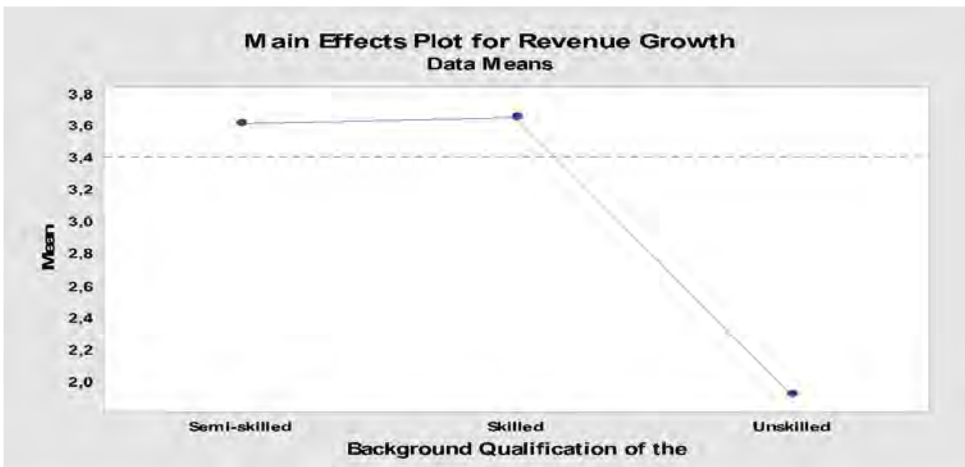

Figure 4. Revenue Growth and Background Qualifications

4.3 Analysis of entrepreneurial skills delivered through business incubation programs

A review of SEDA's support functions provided to SMMEs was analysed using a Pareto chart (see Figure 5). The Pareto analysis shows which support functions were frequently provided to the SMMEs. For example, funding, Business Development, Access to Infrastructure, Business Advisory and Compliance contributed 66% to the total 32 incubation support functions provided to the SMMEs. This would infer that these functions are critical factors that contribute to the growth and development of SMMEs.

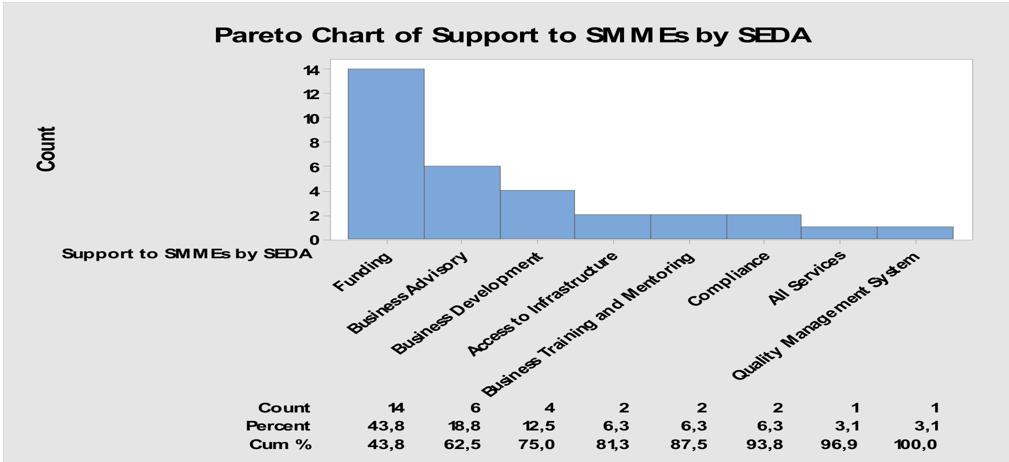

Figure 5: Support to SMMEs

A Main Effects Plot test (figure 6) was conducted to test which support factors significantly impacted Revenue Growth. The results of the Main Effects Plot are presented below. The Main Effects Plot factors highlighted to significantly impact Revenue Growth are Business Training and Mentoring, Funding and Quality Management Systems.

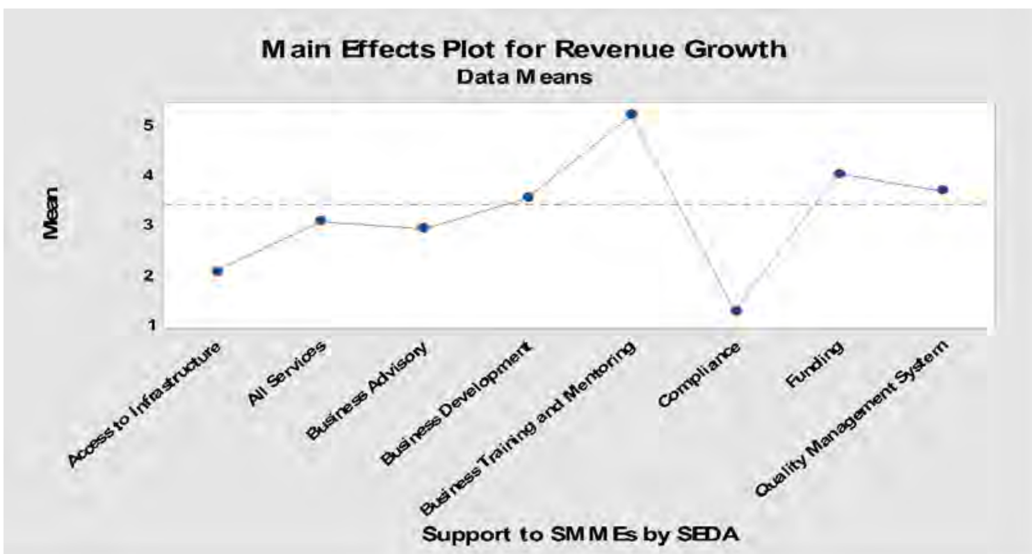

Figure 6: Supports factors and Revenue Growth

An interaction plot ANOVA test was conducted to test whether there is a relationship between SMMEs and background skill level barriers. The objective of the test was to determine whether the relationship between the two factors results in high revenue growth for the SMMEs. With this test, the barriers and skill level that contribute to the SMMEs' growth can be isolated. The ANOVA test reveals that: semi-skilled SMMEs that faced a lack of access to infrastructure, funding and quality management systems had very high growth in revenue post the incubation; Skilled SMMEs with Business Development and Business Training and Development as the barriers to growth and development before incubation experienced very high levels of revenue growth; Unskilled

SMMEs with compliance as a barrier to growth and development experienced moderate revenue growth.

Entrepreneurial skills such as training can influence of the revenue growth. SMMEs can improve their managerial skills such as financial management, strategic planning and human resource management through training and seminar (Asah, Fatoki and Rungani, 2013). Training and seminar provide a platform for collaboration between incubates and incubator management, increasing the likelihood of raising capital (Rubin, Aas and Stead, 2015). Thus, the barrier of financial support will be minimised. Business advisory constraint can be mitigated through coaching and mentoring. Business mentorship is long-term business counselling relationship between an experienced business advisor and a client throughout the various stages of a business venture's growth (Nieman and Nieuwenhuizen, 2009). Entrepreneurial skill such as financial management will assist the incubatees in measuring and controlling of sales/revenue growth. The commonly used growth indicators include sales/revenue, employment, performance, market share, asset, profit (Wiklund and Shepherd, 2005). Managing these constraints, business incubators can be an effective tool for developing new ventures and contributing to job creation and economic development (Chandra and Fealey, 2009).

5 Conclusions and Further Research

For the incubation program to be successful, its service offerings should be aligned with the needs of SMMEs. Through incubation, the challenges which SMMEs identified before they joined the incubation program should be eliminated. The most common challenges faced by SMMEs that entered the SEDA incubation program include Business Advisory, Business Development, Lack of Access to Infrastructure and Funding.

Lack of access to infrastructure, funding and quality management systems contribute to high revenue growth than other factors. The semi-skilled and skilled SMMEs who experienced barriers such as funding before incubation can achieve high growth in revenue post the incubation program. The entrepreneurial skills required for SMME success are post-matric qualification and industry experience (Semi-skilled and Skilled SMMEs). SMMEs that are recruited into the incubation programme should be provided with relevant training during the incubation process. The growth and development of the SMMEs post-incubation program can be measured by revenue growth. Business Advisory, Business Development, Funding and Lack of access to infrastructure are the most prevalent barriers faced by SMMEs before to joining the incubation program. The entrepreneurial skills required for SMME success are a post-matric qualification and an industry experience.

The implication of the findings on key challenges faced by the SMMEs recruited into the incubation program is that government needs to re-examine the operating model of incubators to amend it to sustain the SMMEs in contributing to the economic growth. The implication to policymakers is to address the barriers experienced by the SMME before joining the incubation program, and the barriers post the incubation program. The operating model of the business incubators should be aligned with their mission and vision to remain economic hubs able to sustain job creation.

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Management Tools and Techniques Impacting On-site Labour Productivity

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Abstract:
The aim of this research was to investigate the implementation of the various Management Tools and Techniques in the execution of construction projects in the South African Construction Industry as a means to improve the current low levels of On-site Labour Productivity. An in-depth literature review was conducted in order to obtain a collection of current Management Tools and Techniques potentially utilised by Construction and Project Managers in South Africa's Construction Industry. This collection of Management Tools and Techniques was used to develop the questionnaire that was used in identifying those Management Tools and Techniques utilised with varying levels of emphasis by construction personnel in the South African Construction Industry. The research adopted a quantitative research approach that employed a questionnaire survey administered to randomly selected respondents using the SurveyMonkey web-based tool. The study used descriptive statistics - Frequency Analysis to identify the Frequency and level of emphasis placed on the respective Management Tools and Techniques and inferential statistics - Correlation Analysis to test the relationship between the Management Tools and Techniques and On-site Labour Productivity. Based on the findings, the study concludes that there is a Significant Positive Relationship between the particular Management Tools and Techniques implemented on construction projects, and the resultant levels of On-site Labour Productivity. Additionally, this research recommends future researchers to investigate particular Management Tools and Techniques that have been used with lower levels of emphasis but proved to have considerable correlation to On-site Labour Productivity.

Keywords: Construction, labour productivity, management, tools, techniques

1 Introduction

Literature suggests that the major problem with On-site Labour Productivity in the South African context, is that it is by no means optimal, and in fact, is at its lowest in 46 years according to Naicker (2014). Although some authors have alluded to the fact that management is a significant factor which impacts On-site Labour Productivity, few have touched on the relationship between the two. This creates a gap in the literature in establishing a well-defined relationship, either positive or negative, between management and On-site Labour Productivity. If the low levels of On-site Labour Productivity in South Africa's construction industry are to be addressed, the level of emphasis placed on those Management Tools and Techniques identified to have Significant Positive Correlation should be reconsidered.

The aim of this research was therefore to investigate the Management Tools and Techniques implemented on construction projects, by construction and project managers, and to determine whether or not they contribute to the improved levels of On-site Labour Productivity. As such, the objectives of the research were to; Investigate the current Management Tools and Techniques implemented on construction projects within the South African Construction Industry, Establish how contractors determine the success of a project, Establish the relationship between the Management Tools and Techniques implemented on projects, and their effect on On-site Labour Productivity, and lastly, to Establish which of the Management Tools and Techniques implemented have the most significant impact on On-site Labour Productivity.

To achieve the aim and objectives of this research the methodology that was adopted involved a critical review of the current literature pertinent to construction management in order to provide a collection of the tools and techniques implemented by management on construction projects. From this, a questionnaire was distributed to various contractors in the South African construction industry. The results obtained from these questionnaires provided non-parametric data, which was then used to perform the appropriate correlation analysis in order to establish the relationship discussed in the objectives.

The findings identified those Management Tools and Techniques currently used in the South African Construction Industry. Furthermore, time performance was identified as one of the key indicators of project success, and as such was used to evaluate the relationship between the Management Tools and Techniques and On-site Labour Productivity. The Management Tools and Techniques identified by this research to have significantly positive correlation to the time performance of the respective projects provide useful insight into potential solutions to the current levels of On-site Labour Productivity. As such, these findings provide a platform for future research.

2 Literature Review

2.1 Labour Productivity Defined

Labour productivity is defined by the International Labour Office (ILO) as the amount of output per unit of input (labour). Output is measured as gross domestic product (GDP) for the aggregate economy, and input referring to the labour (ILO, 2016). The ratio through which Labour Productivity can be considered can be seen below.

Equation 1: Labour Productivity

Labour Productivity = Output (GDP) / Input (Labour).

2.2 On-site Labour Productivity in Context

On-site Labour Productivity is a significant factor affecting the success of construction projects, and is therefore of immense importance for the economic growth of a country (Naoum, 2016). According to Barbosa *et al.* (2017), the construction industry on a macro level, has been at a standstill regarding productivity, in comparison to other sectors of the economy. Globally, the construction industry has only managed to average an annual growth rate of 1% over the last twenty years Barbosa *et al.* (2017). This underperformance relative to other industries implies that labour productivity in the construction industry is of great concern and needs to be investigated to understand the phenomenon giving rise to this lack of efficiency, and ultimately overcome this standstill.

2.3 Management and its Relation to Levels of On-site Labour Productivity

Throughout literature, management is considered as one of the primary factors affecting On-site Labour Productivity on construction projects. Management at various levels, from supervisors through to coordinators, site managers, construction managers or project managers is cited as being a major contributor to the levels of On-site Labour Productivity (Allmon *et al.*, 2000; Fischer, 2009; Durdyev and Mbachu, 2011; Attar *et al.*, 2012; BIS, 2013; Bierman *et al.*, 2016; Barbosa *et al.*, 2017).

Furthermore, this affiliation between Management and On-site Labour Productivity is prevalent through the work of various authors (Kagioglou *et al.*, 2001; Dubois and Gadde, 2002; Harris and McCaffer, 2013; Windapo, 2013).

2.4 Management Tools and Techniques applicable in the South African Construction Industry

During the Planning stage, the collection of Management Tools utilised by management include: The Project Brief; the Scope of Works; the Budget; the Work Breakdown Structure; The Construction Program; The Method Statement; Network Analysis; the Organogram; the Procurement Strategy Documentation for Subcontractors; The Health and Safety Plan; The Site Establishment Plan and the Quality Assurance Plan.

The Management Techniques on the other hand, include Forecasting and Predicting the construction activities, Planning the various activities and expenditure, Organising the various resources, and communicating the plan of action to the various subordinates (Windapo, 2013; SACPCMP, 2018).

During the Construction stage, management is more focused on the implementation of the tools and thus there are more Management Techniques that prevail. The few Management Tools that are implemented include the Health and Safety Plan; Net Work Analysis; Financial Reports and Budgeting, and Quality Control (implementation of the Quality Assurance Plan). The Management Techniques include: the Monitoring & Controlling of the various resources; the Co-ordinating of construction activities; the Motivation of the labour force; conducting Site Meetings and Tool Box Talks; the implementation of structured communication lines through the Organogram; Supply Chain Management; Materials Management; the regular updating of the Construction Program and Progress Reports; Cost Control and Financial Reporting; Quality Control through the implementation of the Quality Control Plan and lastly, Risk Management (Windapo, 2013; SACPCMP, 2018).

3 Research Methodology

The selection of a research approach is based on the nature of the research problem according to Creswell (2009). Seeing that the research question reads: “Which Management Tools and Techniques implemented on construction projects in South Africa have an impact on the levels of On-site Labour Productivity?” it was clear that this research required a quantitative approach.

3.1 Questionnaires as the Primary Tool for Data Collection

Questionnaires are a method, among several others, of extracting information and opinion from a sample of participants. In this particular method, questions are laid out in such a manner as to extrude the required information from the participants. The reason for this research having made use of the questionnaire method of data collection, was heavily based on the advantages outlined by Drever and Munn (1990). These advantages include; an efficient use of time, anonymity of respondents, possibility of a high return rate, standardising of questions (Drever and Munn, 1990). Furthermore, the use of a Likert Scale in the questionnaire provides non-parametric data (Pell, 2005), which warrants the use of Spearman Rho test to calculate correlation (Murray, 2013).

3.2 Population and Sample Size

Given the broad spectrum of the population of construction management personnel, the researchers were limited to the sample available to them, through the SurveyMonkey database created through the Department of Construction Economics and Management at the University of Cape Town. Drawing from a sample of 7535 management personnel in the industry, at a 95% Confidence Level and Margin of Error of 5%, the number of responses required equates to 366 respondents. At the end of the survey period, 64 responses were received which equates to a response rate of 17.5%. The low response rate was attributed to the prevalent time constraints, as well as the reluctance of construction management personnel in the industry to respond to questionnaires. The 64 responses comprise of all questionnaires that were fully completed. This gave the research a richer and core number to work with as evidenced by the number of respondents that engaged with the questionnaire. Additionally, these responses represent an array of specialists in the construction industry that use and employ tools and techniques that allow the smooth running of managing labour to get the intended output. This falls above the threshold of 30, as outlined by the Central Limit Theorem, and as such, the findings can be generalised.

3.3 Methods of Data Analysis

3.3.1 Mean Item Score

For various questions in the questionnaire, respondents were provided with a 5-Point Likert Scale in which they could respond to questions. The responses were then allocated a Mean Item Score (MIS), which provided a mean for the responses obtained from the Likert Scale

3.3.2 Frequency Distribution

Other portions of the responses were analysed by means of Frequency Distributions. Frequency Distributions summarise data by converting the raw data into percentages and grouping this data into respective categories. This provides useful descriptive statistics. The higher the percentage frequency of a particular response, the more important the response is deemed to be.

3.3.3 Correlation Analysis

The analysis of the data through the use of Statistical Package for Social Sciences (SPSS) confirmed that the data was indeed non-parametric, and thus warranted the use of Spearman Rho test to calculate correlation (Murray, 2013). The Correlation Analysis was used to establish the relationship between the various Management Tools and Techniques and the project's performance with respect time. The completion of a project within the specified time, is highly dependent on the productivity of the on-site labourers. Therefore, the performance of a project with respect to time corresponds with the level of On-site Labour Productivity.

3.4 Reliability and Validity of Findings

The internal reliability of the main findings pertinent to Management Tools and Techniques utilised by respondents was achieved by means of achieving an acceptable Cronbach's Alpha. The use of Low Inference Descriptors, Peer Examination, Multiple researchers and Mechanically Recorded Data were also used to ensure reliability of the research. The means by which this research aimed to achieve validity was through examinations of the research by experienced industry professionals, in the Department of Construction, Economics and Management at the University of Cape Town, as mentioned above.

4 Findings and Discussion

4.1 Profile of Respondents

The majority of respondents (62,50%) were Managing Directors of their respective companies, whilst Project Managers constituted the second highest responses (9,38%).
The majority of respondents were highly experienced, with 73,44% of the respondents having more than ten (10) years of experience within the construction industry.
It was also found that the majority of respondents proved to have a Construction Industry Development Board (cidb) Grading that fell within the Grade 4 – 7 Categories in both General Building and Civil Construction.

4.2 The Relationship between Management Tools and Techniques and On-site Labour Productivity

4.2.1 Management Tools

All Management Tools as outlined in the Literature Review were adopted by the various respondents. Using a weighted average out of a possible 1-5 rating, the level of emphasis placed on the various Management Tools were identified and can be seen in Figure 1. It can be seen from Figure 1, that the Management Tool utilised with the most emphasis were the Scope of Works and Health & Safety Plan.

Through conducting a Spearman Correlation Test, the Management Tools identified to have moderate positive correlation to the time related performance were that of the Project Brief (0.435), Method Statement (0.546), Work Breakdown Structure (0.536) and Gantt Chart / Project Schedule (0.484). The analysis conducted shows that there is a significant relationship between management tools and the on-site labour productivity (see Table 1). All the management tools displayed a strong correlation and as a result, this is empirical to the understanding of the fact that each management tool to govern the operation of labour on site, there is a direct relationship between how it also allows productivity to be improved.

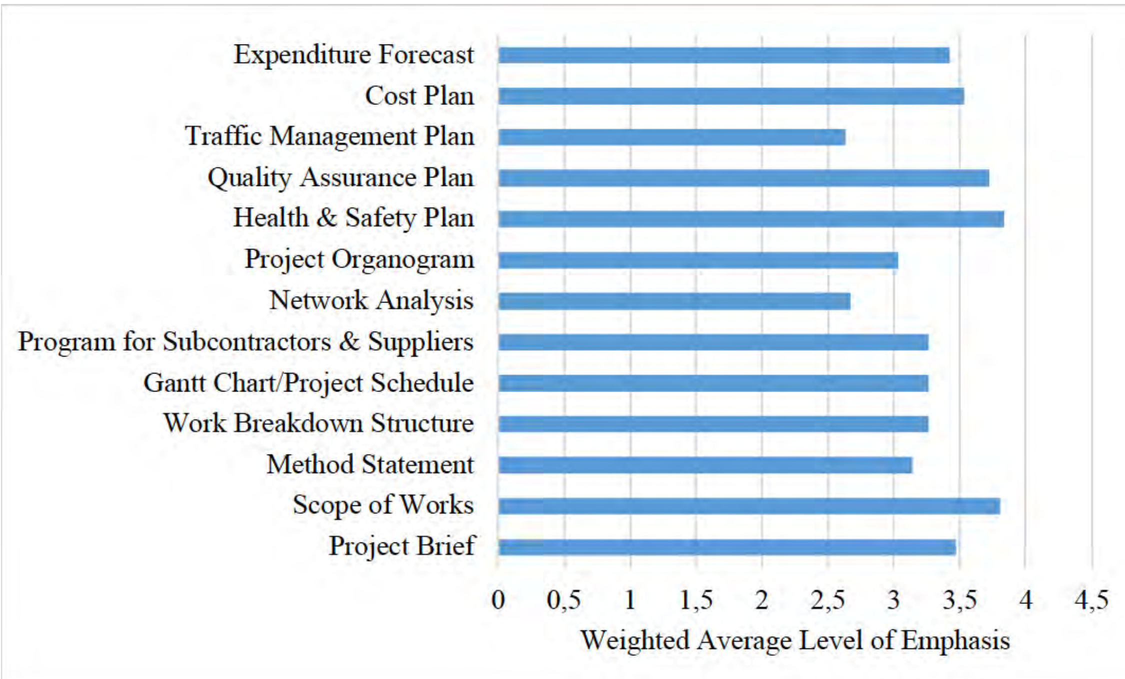

Figure 1: Level of emphasis placed on Management Tools

Table 1: Management Tools Correlation to Time

Management Tools Correlation to Time (On-site Labour Productivity)			
Management Tools			TIME
Spearman's rho	Project Brief	Correlation Coefficient	.435*
	Method Statement	Correlation Coefficient	.546*
	Work Breakdown Structure	Correlation Coefficient	.536*
	Gantt Chart / Project Schedule	Correlation Coefficient	.484*
*. Correlation is significant at the 0.05 level (2-tailed).			

4.2.2 Management Techniques

Through conducting a Spearman Correlation Test through the SPSS software package, the incorporation of Incentive Strategies for the Labour Force was identified as the only Management Technique having the highest correlation (0.571) to time-related performance.

Table 2: Management Techniques Correlation to Time

Management Techniques Correlation to Time (On-site Labour Productivity)			
Techniques			Time
Spearman's rho	Incentives Strategies for Labour Force	Correlation Coefficient	.571*
*. Correlation is significant at the 0.05 level (2-tailed).			

4.3 Discussion on the Relationship between Management Tools and Techniques and On-site Labour Productivity

4.3.1 Management Tools

Through the extraction of data points pertaining to particular questions of the Questionnaire, the variables pertaining to time-related performance and the level of emphasis placed on the various Management Tools were analysed in SPSS Software Package. This provided the various correlation coefficients, which allowed for a correlation analysis to be performed. The Management Tools identified to have the highest positive correlation to the time-related performance were that of the Method Statement, Work Breakdown Structure, Gantt Chart / Project Schedule and Project Brief, ranked from highest to lowest correlation with respect to time performance. The Method Statement is a tool used by management for the control of various aspects of a project, as well as the required resource allocation. This resource allocation considers both manpower and plant, which are consequently used in the development of the Project Schedule. As such, failure to implement a suitable Method Statement may result in the inability to effectively allocate and control resources, particularly with respect to On-site Labour.

The Work Breakdown Structure is a planning tool which organises the work to be done into more manageable work packages, and in turn contributes to development of the Project Schedule. During the execution phase, if a project is falling behind schedule for example, referring back to the Work Breakdown Structure can help identify major deliverables impacted by failing work packages. The Project Schedule is arguably one of the most important Management Tools implemented on projects, to help plan, track and monitor the progress of the project. The Project Schedule sets the benchmark against which on-site labourers ought to perform, and as such, can be expected to have a positive correlation with respect to time performance. The Project Brief is an essential tool used in outlining a project's core objectives, scope, deliverables and other essential project details. It is the document upon which many of the other tools are based on and sets the precedent for the planning of the project.

The Scope of Works proved to have no significant correlation to On-site Labour Productivity. This is somewhat counter-intuitive, as it is cited as one of the most prevalent Management Tools. Construction projects tend to be highly complex and can often experience scope-creep. Changes in the scope of works can result in the requirement for additional time, cost and resources. Additionally, this may result in lack of clarity and demotivating the labour force due to having to re-execute the works.

The Management Tools with the most emphasis placed on them in South Africa's construction industry were found to be the Project Brief; Scope of Works; Health & Safety Plan; Quality Assurance Plan and the Cost Plan. Of these Management Tools, the Project Brief was proven to have the highest positive correlation to a project's time performance. Furthermore, the Project Brief, Method Statement, Work Breakdown Structure and the Gantt Chart / Project Schedule were found to have a significant positive correlation to a project's performance with respect to time. This supports the work of Maserang (2002).

Since literature alluded towards a positive relationship between project performance and the implication of various Management Tools, it was to be expected that the remaining Management

Tools identified in the questionnaire would yield a positive correlation to On-site Labour Productivity. This was not found to be the case; however, it is to be noted that this may be due to the sample size in comparison to the population.

4.3.2 Management Techniques

Through the extraction of data points pertaining to relevant questions of the Questionnaire, the variables pertaining to time-related performance and the level of emphasis placed on the various Management Techniques were analysed in SPSS Software Package. This provided the various correlation coefficients, which allowed for a correlation analysis to be performed. The incorporation of Incentive Strategies for the Labour Force was found to be the only Management Technique with significant correlation to On-site Labour Productivity.

Incentive Strategies for the Labour Force are strategies which encourage labour to perform better, in return offering rewards for improved performance with respect to productivity and quality. This is the very reason why Incentive Strategies have proven to show a significantly positive correlation to On-site Labour Productivity.

Interestingly enough, Site Meetings, Progress Reports and Progress Meetings have proven to show negative correlation to On-site Labour Productivity. The reason for this is not certain, however may be due to these three Management Techniques not being directly related to the labours on site. Additionally, supervision of site activities also proved to have a negative correlation to On-site Labour Productivity. This may be due to the reluctance of labourers wanting to be monitored on a continuous basis. On the contrary, one would expect that the supervision of labourers would compel them to remain productive.

Quality Control also proved to have a negative correlation to On-site Labour Productivity. Quality Control can at times result in the works on site being halted for inspections, as well as result in reworks having to be carried out. This creates time delays and thus hinders On-site Labour Productivity. Literature suggests that middle management needs to co-ordinate the site activities required in order to carry out the work in a well thought out way that optimises the sequence of construction ensuring that the time taken for each work package is minimised while still meeting the quality requirements. This can be achieved if the site manager practices appropriate forms of supervision, control and motivation over the labour force. Furthermore, Murphy and Ledwith (2007) conclude that having clear project objectives and top management support are crucial success factors.

5 Conclusion and Further Research

Given the concerning levels of On-site Labour Productivity in the South African Construction Industry and the affiliation between Management and On-site Labour Productivity, the aim of this research was to investigate the Management Tools and Techniques implemented on construction projects, by construction and project managers in South Africa, and to determine whether or not they contribute to the improved levels of On-site Labour Productivity. Through a critical review of the current literature pertinent to construction management and the distributed questionnaire, the Management Tools and Techniques that are currently implemented in the South

African Construction Industry were identified. In order to establish whether or not a relationship exists between the Management Tools and Techniques implemented on construction projects and On-site Labour Productivity, the level of emphasis placed on the implementation of the various Tools and Techniques were analysed in terms of their correlation to the project's Time Performance. The Spearman Correlation Test provided the correlation coefficient between the respective Tools and Techniques and Time Performance, identifying those that are significant at a 95% confidence level.

The Management Technique identified as having the lowest level of emphasis placed on them, was that of implementing incentive strategies for the labour force, however, this was identified to have the most Significant Positive Correlation to a project's performance with respect to time. Supply Chain Management was also one of the less emphasised Management Techniques utilised by respondents which proved to manifest a negligible positive correlation to a project's performance with respect to time. While of the queried Management Techniques, the Supervision of Site Activities was found to have a negative correlation to time performance. This also proves to be contradictory to what is outlined in literature.

All things considered, literature alluded to a positive relationship between Management Tools and Techniques and On-site Labour Productivity. However, the findings of this research portray otherwise with particular Management Tools and Techniques. Such variances may be due to the scale of the Sample Size in relation to the Population. This inhibits statistical inferences to be made across the population. The findings established that the level of emphasis placed on the implementation of Incentive Strategies for labourers was low, however, the findings also established that Incentive Strategies proved to have a Significant Positive Correlation to On-site Labour Productivity. As such, further research should aim to investigate alternative, cost effective incentive strategies for labourers, as this could result in improved levels of Onsite Labour Productivity.

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Requirements for the application of data sciences in construction

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Abstract:
This paper investigates the use of data sciences in construction project management. A literature review identified limited use and application of data sciences in construction project management compared to other industries. Therefore, the paper addresses this gap by demonstrating the benefits of using data mining as a project management tool. It identifies the requirement for structured data capturing, facilitating the widespread application of data sciences in construction with demonstrated benefits. Following a description of the data mining methodology used, two cases are presented of the practical application of data mining on construction projects. In one case, predictions are made for the number of employment opportunities created in a project. In the other case, the total project duration is estimated/predicted. It is shown that improved results (in comparison with previously published cases) can be obtained from large databases with a 62.3% accuracy in one case study and 88.8% accuracy in the other. It also shows that the accuracy depends on the chosen algorithm. Similar to previous studies, the two cases identified the effort required to prepare suitable databases. This is a result of the current unstructured and uncoordinated capturing of data in the construction industry. It is recommended that companies develop standardised processes to capture data. It will be even more beneficial if such data can be stored in an industry-wide database to improve management processes and predictions. A current limitation to its application is the lack of knowledge in the industry about data sciences techniques.

Keywords: Data sciences, project efficiency, rework, project parameters

1 Introduction

Construction projects are prone to time and cost overruns and often suffer from delays due to various reasons (Mukuka, Aigbavboa and Thwala, 2015; Senouci, Ismail and Eldin, 2016; Niazi and Painting, 2017). Other demands are also sometimes placed on construction projects, such as creating employment opportunities (McCutcheon, 1995).

Data mining is effectively used in the communication, retail, insurance and medical sectors (among others) to reduce costs and improve business efficiency (Mcafee and Brynjolfsson, 2012; Pospieszny, 2017). A study by Bach, Bertoncel, Meško, Vugec and Ivanči ć (2020) amongst 3 European country clusters shows that the construction industry has some of the lowest usage of big data sources (6 - 15%) from a variety of other industries surveyed, with information and communication (22 - 41%) and electricity, gas, air conditioning and water supply (14 - 36%) being the highest usage.

This paper aims to demonstrate the benefits of data sciences in managing construction projects and highlights the requirement for companies and the industry to standardise data capturing. The contribution of this paper is a recognition that structured data capturing and analysis is required to improve the management of construction projects. This can only be done if high volumes of data, which is mostly unstructured, are captured systematically.

The objectives are addressed by the paper layout as follows:

The paper first provides examples from the literature of data mining in construction project management and thereby identifies the need for further investigation. It then presents the methodology followed in two case studies, summarising the process of data mining. The paper concludes with a presentation of the outcome of two case studies completed as MEng research projects, where data mining is used effectively as project management tool to address employment creation and time management on projects.

2 Literature review: limited applications of data mining in construction

Fan, Abourizk and Kim (2008) determined the residual value of heavy construction equipment in the USA by using a national database of construction equipment auction results (LastBid) together with data mining techniques. They thereby developed a data-based decision support system which enables the better management of construction assets (equipment).

Lee, Hsueh and Tseng (2008) used a data mining process to obtain new knowledge from historic actions. They used a data mining algorithm to identify causes of poor quality in the building work of a large construction company to reduce ongoing maintenance costs. They successfully identified the three most important factors that caused leakage and concrete cracking in their buildings. The investigation therefore showed the benefits of using data mining to solve problems using existing project information.

Chaovalitwongse et al. (2012), used data mining and machine learning to create an application that would select the bid closest to the actual price of the project using project bid policies. By using bid data from the Texas and California Departments of Transport and a dataset of approximately 4000 projects, it was shown that data mining can be used for the evaluation of tender-selection policies. They also showed that data mining benefits are not limited to predictions or to knowledge generation only. A critical insight from the project highlighted the importance of normalising data or using data ratios to prevent overweighting of some features.

Williams and Gong (2014) used text mining together with numerical data to predict construction project cost overruns. The data was obtained from the California Department of Transport. It included numerical bid information but also a short, worded description of each project and its major cost items. Their investigation showed that more accurate predictions can be achieved if both numerical and text data is used in the database, as it allows for a more complete model to be constructed through the data mining. It was found that poor accuracy in predicting cost underruns on projects is possibly due to the complexity of the construction environment or due to insufficient data that was used in the study.

Alsubaey, Asasi and Makatsoris (2015*)* used 46 files of project site meeting minutes to develop an early warning system on project outcomes by mining the unstructured text. They used the Naïve Bayes classifier to identify early signs of project risks materialising. Unfortunately, 86.95% of the outcomes were classified as "no-signal," which was attributed to the classifier not being suited for the analyses of full sentences. Their case study does however show the potential of unstructured text as a data source. Text mining thus allows for the identification of valuable information that project personnel might oversee.

2.1 Synthesis:

The five examples above each demonstrated the potential of using data mining algorithms to support decision making and predictions in the construction industry. It is shown that data mining allows for the prediction of future outcomes, but also develops new knowledge from historic data.

A common thread from all studies was the recognition of the value of data, but also the need to develop practical and usable data sets. Limited data results in poor accuracy of prediction. Each study required considerable effort from researchers to prepare clean data sets from the available material. This crucial step might not happen in industry (no time), which highlights the requirement for correct data capturing the first time.

While the lessons learned from the five examples could be useful for construction project management, it was not the specific aim of these cases. Of the example studies presented above, there are limited cases of data mining being used to directly improve construction project management. The gaps identified in the existing literature which this article therefore seeks to address are the value of large data bases, the application of data sciences in construction project management and the nature of available data.

3 Methodology of the study

The process of data mining considers the use of large datasets from which computer algorithms recognise patterns and relationships between variables which may not be easily recognisable by the human mind. This process provides support for decision making based on the data (Syvajarvi and Stenvall, 2010). The methodology described below was used in two case studies to investigate the process, the possible application and/or benefits, and finally the requirements for data sciences in construction project management.

Throughout the different phases of a construction project, large amounts of data are generated and stored in a variety of ways and formats. This could include drawings, bills of quantities, contract documents, meeting minutes, instructions, requests for information, Building Information Models and a multitude of other sources.

For each of the two data mining studies below a clear definition of the goal was defined. In the first case it was to determine the number of employment opportunities created, and in the second case it was to determine final project duration during the execution of the project.

For each study pre-processing of the available data was required to produce a clean dataset. The process started with a thorough examination of the goals of the application based on the available data. This was then followed by three steps:

- Extracting of data that can model the system accurately;
- Cleaning of data from omissions, errors, and inconsistencies;
- Removal of excess data and/or transformation of data where needed.

The choice of the data mining model and data mining technique was made by a specialist with knowledge of statistics and machine learning. While data mining applications do not typically use all the available methods, the choice of application was dependent on the type of data and the goal. Aspects considered for the choice of the application included (as identified by Aggarwal, 2015):

- Similarity and distance functions;
- Association pattern mining;
- Cluster analysis;
- Outlier analysis;
- Classification and regression;
- Text mining.

The accuracy of the results either were validated or evaluated, depending on the nature of the process used, being either supervised or unsupervised. Clustering and outlier analyses were validated, whilst classification processes were evaluated. Criteria were defined with items such as coefficient of determination, mean absolute error, and root mean square error (see also Lee, S., Kim, C., Son, H., and Kim. C., 2011; Han, Kamber and Pei, 2012; Srivastava, 2014). For each study the data was divided into a training data set (80% and 67% of the data respectively for the two studies) and a testing data set (remainder of the data).

Several software packages are available that assist with the application of data mining. This allows a user to apply the techniques with relative ease. In the first case the Scikit-Learn Python module was used with the application of six data mining algorithms. In the second case Orange and Rapid Minor were chosen with similar algorithms to create prediction models. The outcome is described below.

4 Two case studies

Under the next two headings case studies are presented where the above methodology was applied to different aspects of construction project management. It is shown that there are real-life benefits for applying data mining methodologies to construction projects. More importantly however it also identifies the requirements that are needed for the widespread adoption of data sciences in construction.

Both of these case studies formed part of two MEng research projects (referenced below) for the qualification.

4.1 Predicting the employment opportunities in South African construction projects

South Africa had an official unemployment rate of 32.5% in the 4th quarter of 2020 (Stats SA, 2021). The South African government continues to address the problem by providing/regulating temporary employment opportunities in the construction industry.

To assist projects in successfully meeting the requirement of unskilled employment opportunities, Botha (2018) used data mining techniques to estimate at the initiation and/or planning phases of a project, the total temporary employment opportunities that would be created.

Botha (2018) used project details from 755 different road construction and rehabilitation projects of the Construction and Maintenance Directorate of a provincial government body.

Whilst the data base consisted of much more information, for the specific study he selected the following features:

- District (one of the districts in the Western Cape Province in South Africa)
- Project objective (such as 'resurfacing' which could be one of thirteen objectives)
- Tender cost estimate
- Number of created employment opportunities

Botha (2018) created a dataset after pre-processing the available data by normalising, cleaning and transforming data from 475 road construction or maintenance projects. Considerable effort was required to clean the available data. Cleaning of the data improved the $\boldsymbol{R^2}$ value from 0.377 for the uncleaned data to 0.427 for cleaned data. The opportunities created versus the tender cost estimate is shown in Figure 1 for the cleaned dataset.

Using the above dataset, he evaluated six popular data mining algorithms as found in the Scikit-learn module of Python. The evaluation consisted of randomly splitting the dataset into training (80%) and testing (20%) parts. The process was repeated ten times on different random splits of the data.

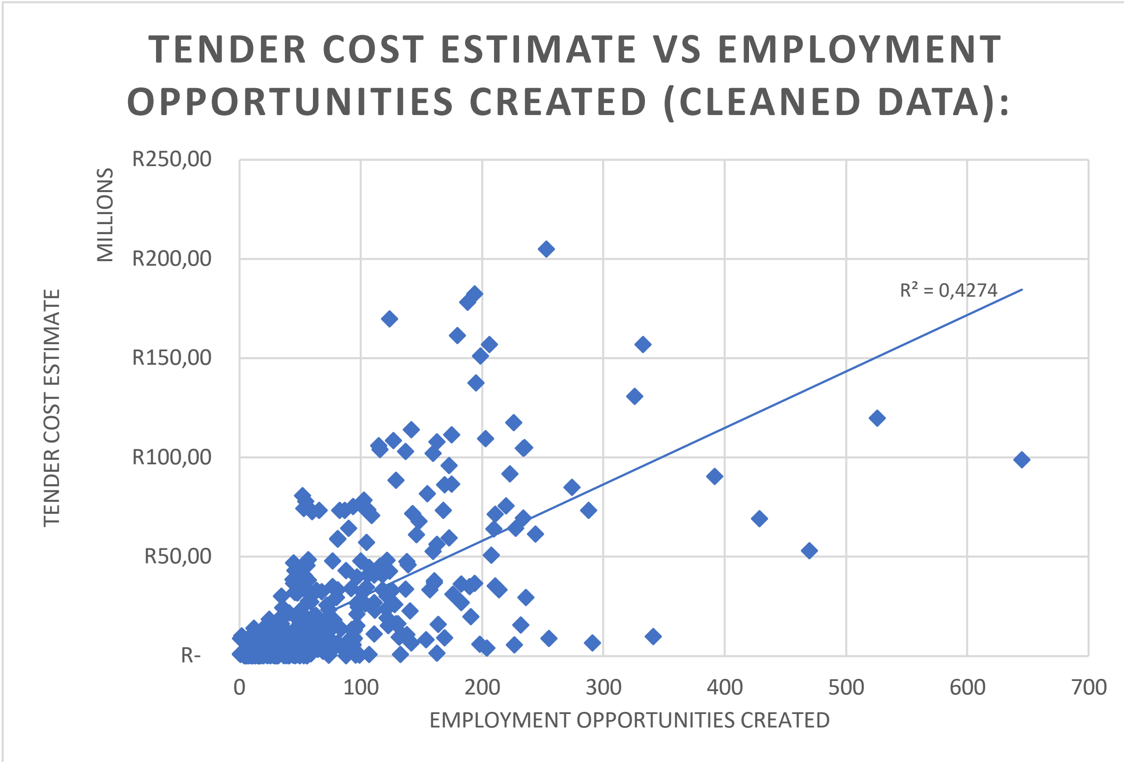

Figure 1. Tender cost estimate versus Employment opportunities (after cleaning dataset)(Botha, 2018)

Results from the four best performing algorithms are shown in Table 1. Botha (2018) found that the Naïve Bayes (Gaussian) classifier was the most accurate for his case study, predicting the correct class with 62.3% accuracy. His results compare favourably with the results of Williams and Gong (2014), who only managed to correctly predict the cost overrun of projects 44% of the time (probably due to their limited dataset).

Table 1. Prediction accuracies of different algorithms (Botha, 2018)

Algorithm	**Total Accuracy**
Naïves Bayes (Gaussian) Classifier	62.3%
K Nearest Neighbour Classifier	60.7%
Support Vector machine Classifier	58.3%
Neural Network Classifier	55.9%

The outcome of the study was that reasonable "ball park" estimates of employment opportunities can be made from sufficiently populated historic data. It also showed that cleaning of the data requires considerable effort, thus highlighting the requirement of having a well-structured data collection method to improve prediction accuracy but also reduce cleaning time. Lastly, the study found that some specialist knowledge is needed for the application of the various data mining algorithms.

4.2 Using project site meeting minutes to predict project duration

A study was performed to investigate data science's ability to timely predict the total project duration of construction projects.

The data for this study was obtained from construction project site meeting minutes (Van Niekerk, 2020). For this purpose, meeting minutes from 27 construction projects were obtained from a South African contractor. The projects were carried out over the last 10 years. Considerable effort was required for creating a suitable database for this study given the relatively unstructured nature of site meeting minutes. The data shown in Table 2 was manually extracted from the documents and entered into +500 rows of data in an Excel database.

Table 2. Time related factors recorded in the data warehouse (Van Niekerk, 2020)

Time related factors	**Non-time related factors**
% Progress	Meeting number
% Progress planned	Date
Expected completion date	Number of contractor employees at the meeting
Progress notes	Number of client representatives at the meeting
Original/contractual completion date	Health, safety, environment and community
Days ahead or behind programme	Security and IR
Class of progress	Quality
Weather delays	Contractual/commercial
Design delays	Number of FEQ's
Planning	Number of SI's
Project complete late	Early warning from contractor
	Early warning from client
	Number of compensation events
	Project man-hours
	Rework mentioned
	Repeat items on the minutes
	Meeting number

The data mining process was executed by applying the methodology as presented under Section 3 above, in conjunction with two freely available data mining applications. The objective was to determine the prediction accuracy of the two applications.

Training and testing datasets were set up by splitting the original dataset into 2/3 and 1/3 groups respectively. One hundred repetitions were performed during the model's training, each time splitting the dataset randomly between training and testing groups.

A variety of data mining algorithms were evaluated from each application. Table 3 shows the best results obtained for both applications, which used the same algorithms and yet gave different results for the two applications. It can be seen that the accuracy of the results is better than that of the investigation by Botha (2018), probably due to the larger dataset.

Table 3. Accuracy of results for Datasets A using Orange and Rapidminer (Van Niekerk, 2020)

	Orange	**RapidMiner**
Model type	**Accuracy for Dataset A**	**Accuracy of Dataset A**
Random Forest	88.8%	81.7%
Neural Network	85.3%	79.2%
Tree	78.6%	72.5%
Naïves Bayes	72.6%	72.5%

The outcome of the study demonstrated the benefit of using large amounts of data to make predictions of project outcomes (project programme). However, it was again realised that the process can only be practically implemented if data is captured systematically and in a well-defined structure. It was learned that without a defined structure for capturing data on construction projects, the widespread application of data sciences will most likely not happen.

5 Conclusion

This paper investigates the practical application of data mining, a sub-set of data sciences, as a management tool for the construction industry.

The cases identified in literature applied data sciences on industry data (equipment) and on project data. It is shown that data mining allows for the prediction of future outcomes, thereby developing new knowledge from historic data. In cases where the technique was applied to project data, it was seen that limited data resulted in relatively poor accuracy of prediction.

The first case demonstrates the value of historical data to find trends in and to predict job creation in public projects. It shows that a large database is needed, but when available it can be of much value to make suitable predictions.

The second case shows how project site meeting records can be used to predict project duration. The practical implication of the study is that with early warning information, project teams can take corrective actions at any time during the project.

Together with the cases from literature, the two studies emphasised that data sciences is a powerful technique that can be used by project teams for predictions or for improving overall project efficiencies. It is shown in this paper that the accuracy can be considerably better when having a database with large volumes of data. As in literature, it also identifies the effort in creating suitable databases from unstructured data, and thus emphasises the need for construction organisations to develop systems for capturing large volumes of structured data.

The real contribution of this paper is a recognition that the benefits of data mining in the construction industry is restricted by the current unstructured capturing of data.

At present the construction industry is shown to make little use of data sciences when compared to other industries, most probably due to the effort needed to create usable databases. Well-structured data is essential for the successful application of data mining techniques.

It is recommended that organisations standardise the format and data of items to be captured in their projects, starting with project site meetings minutes. A lack of expertise in data science techniques can however be a current restriction to the widespread application. This may require further investigation.

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INDEX OF AUTHORS

INDEX OF KEYWORDS