JCBM

ISSN 2521-0165

Volume 2, Number 2, December 2018

JOURNAL OF CONSTRUCTION BUSINESS & MANAGEMENT

http://journals.uct.ac.za/index.php/jcbm/index

JCBM

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ABOUT JCBM

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

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

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

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Editorial

Welcome to the fourth issue of the Journal of Construction Business and Management. The themes covered in this issue are related to information technologies, building materials, risk factors and practices used in the procurement of construction projects. These papers expose the readers to innovative technologies, career advancement, risk factors, alternative building materials and cost analysis that fills the key gaps in knowledge. The issue contains five articles that were written by authors based in Nigeria and South Africa. Overall, twelve authors produced these articles aimed at strengthening the debate in and improving research undertaken in the area of the management of construction project organizations and delivery processes.

The first paper by Olugboyega and Aina examines the Levels of Details of Building Information Models being generated by two hundred and eighty-two construction professionals in Lagos State, Nigeria using respondents driven sampling techniques. The authors found that the levels of generating BIM visualization purposes were very high in the study area. Paper two by Dada investigates the progression of Quantity Surveyors towards developing a career path framework for Quantity Surveyors in private practice in Nigeria. The proposed framework demonstrates the benchmark necessary for resolving common problems about career progression towards promoting harmonious working relationship and quality service delivery in Quantity Surveying practice. Leo-Olagbaye and Odeyinka's paper assessed the risk factors encountered in the delivery of road projects in Osun State, Nigeria. The study results revealed that the risk factors on these projects with a high likelihood of occurrence are the scope of work, defective design, error and rework and change in design, in order of magnitude. Paper four by Alade, Oyebade and Nzewi examines the availability and level of usage of Local Building Materials (LBM) in Ado-Ekiti, South Western Nigeria. Based on information provided by One Hundred and Fifty construction professionals, the research found that LBMs such as stone, timber, laterite, clay and bamboo were available in sufficient quantities in the study area for building construction. The final paper by Windapo, Moghayedi, Oliphant and Adediran explored the components of cost on construction projects in South Africa using a qualitative research approach. The study found that the primary cost constituents of construction projects were building materials and sub-contracted work, accounting for 63.69% and 74.6% of the value of renovation and new construction work respectively, and recommends that the sub-contractor and building material inputs in construction projects should be carefully managed to ensure that construction projects are completed effectively and efficiently.

Lastly, I wish to acknowledge all authors who submitted papers for consideration, members of the JCBM Editorial Board and panel of reviewers for their support, timeous review and comments that have helped in defining and improving the quality of manuscripts submitted to the JCBM for review. In conclusion, we welcome feedback and suggestions from readers towards improving the quality of the journal and in maintaining the integrity of the findings published.

Abimbola Windapo *PhD*
Editor-in-chief

JCBM (2018) 2(2). 1-14

University of Cape Town

Journal of Construction Business and Management

http://journals.uct.ac.za/index.php/jcbm

Examination of the Levels of Development of Building Information Models in the Nigerian Construction Industry

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Received 21 June 2017; received in revised form 25 August 2017, 18 July 2018; accepted 20 July 2018
https://doi.org/10.15641/jcbm.2.2.2018.99

Abstract

BIM can be used to illustrate the entire building lifecycle, from cradle to inception, design and demolition and materials reuse; quantities and properties of materials, which can be easily extracted from the model; and the scope of works, including management of project targets and facilities management throughout the building's life. The implementation of BIM in projects or organization is in phases and building information models can be developed as 2D, 3D, 4D, 5D and 6D BIM depending on the stage of BIM implementation and level of details required. This study examined the levels of details of building information models being generated by two hundred and eighty two construction professionals in Lagos State, Nigeria using respondents driven sampling technique. Frequency distribution and percentage, clustered bar chart, mean ranking, Kruskal Wallis test and Fisher exact test were used to analyse the data obtained from the respondents. The study found that the implementation of BIM in the study area is for visualization purpose. The findings also revealed that the levels of generating 2D and 3D BIM were very high in the study area; and that 3D architectural model, 3D architectural and structural model, and 3D architectural and building services model were the most developed variants of 3D BIM. It was concluded that that the status of BIM adoption in construction industry in Lagos State, Nigeria is at the visualization phase.
Keywords: BIM details, BIM, BIM development, 4D BIM, federated BIM.

1. Introduction

Building information modelling (BIM) is an accurate parametric and 3D geometrical representation of a building or any structure digitally (Bhargav, 2014). In BIM, the three-dimensional (3D) model of a building can be combined with change management information to give a four-dimensional (4D), five-dimensional (5D) or six-dimensional (6D) model of the building. Sebastian (2010) and Simpson (2013) describe this practice as a process that gives meaning to the building information models through relationships. BIM is regarded as the future and the solution to the construction industry's problems (Lu and Li, 2011).

BIM as a process, is significantly altering the way that the construction industry creates and cares for its assets; mostly because it allows the identification and reduction of errors and design conflicts before they actually happen as well as reduces process waste by eliminating rework (Scott, Chong and Li, 2005). The body of knowledge has shown the extent of implementation and levels of development of building information models among construction professionals in the developed countries, for example, Australian Institute of Architects (2014), BIMforum (2015), UKBIM alliance (2016), and UK National BIM Report (2017). In Nigeria, a number of studies have recently been done on BIM. Ede (2014) reported a case study of usage of BIM on a modest duplex building project in Enugu. Although, the study did not report the level of details of BIM used for the project, but it reinforces the need to investigate other BIM-based projects that have not been reported. Dare-Abel, Igwe and Charles (2014) studied the usage of software technologies by architectural firms in Abuja, Enugu, Maiduguri,

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Kaduna and Lagos. The usage of software technologies among construction professionals is bound to vary and a study focused on only the architects cannot be said to have evaluated the usage of software technologies among the construction professionals.

Besides, knowledge on the building information models being generated from the software technologies is more important than the software technologies that they are using. A desktop study of the change process associated with BIM implementation on projects as carried out by Dim, Ezeabasili and Okoro (2015) reviewed literature on how the use of BIM for projects will impact the design and construction process. In whatever way, these studies did not provide adequate insight on the level of development of building information models. The examination of the extent of BIM-enabled collaboration improvement among AEC consultants in Nigeria, as conducted by Onungwa and Uduma-Olugu (2017) did not consider the importance of contents of the federated building information models being generated by these consultants. The consideration of this would have provided information on the extent of collaboration and the details of the building information models being exchanged and integrated. Collaboration among consultants is not a stand-alone issue; it is affected by the numbers of the consultants and the knowledge they are contributing. Therefore, examining collaboration practices among the consultants is an unrepresentative way of examining the adoption of BIM in a construction industry. Sawhney (2014) affirmed that the usage of BIM must be evaluated in order to provide the construction industry with timely and clear understanding of the status of BIM adoption in comparison with global developments. As noted by Jung and Lee (2015), a study on the usage of BIM should examine its level of implementation and details. Moreover, the existing literature on the level of development of building information models globally cannot be said to have captured the level of development of building information models in Nigeria; as the conditions in the Nigerian construction industry are different due to geographic location, size and complexity of projects, and contractual arrangements.

Smith (2013) maintained that BIM can be used to transform the construction industry into an efficient and value-oriented sector that can successfully deliver the clients' requirements, and that, BIM can transform the construction industry to a data-rich environment and knowledge-intensive industry which can enable virtual and automated design, analysis, construction and communication. However, these are untested assumptions. For a gainful deployment of BIM in Nigeria, It is therefore important to study the levels of development of building information models by construction professionals in Nigeria. In order to understand the status of BIM adoption in Nigeria, this study examined the phase of BIM implementation and extent of generating building information models by construction professionals in the construction industry in Lagos State, Nigeria.

2. Literature Review

BIM is the process of developing an intelligent building model which can be more easily modified, and which can accurately represent the final building product (Computer Integrated Construction Research Group [CICRP], 2012). In BIM, virtual designs are built in 3D before work proceeds on site; the attributes of all the elements of the building can be found in the model; and spatial 'clashes' can be identified and resolved in the model instead of on site (CPA, 2013). As observed by RIBA (2012) and Sebastian (2010), BIM is more than 3D, it could be 4D when time or work schedule information is added to the project model or 5D when cost or quantity schedule information is given in the model or 6D when facilities management information is added to the model. BIM provides an integrated system that can be used to simulate the behaviour of buildings in a real-world system, provides information about quantities and properties of building elements, and documents design information in an integrated database (Sabol (2008), Ian and Bob (2010) and Royal Institute of British Architects [RIBA], 2012). Additionally, BIM can be used to illustrate the entire building lifecycle, from cradle to inception, design and demolition and materials reuse; quantities and properties of materials, which can be easily extracted from the model; and the scope of works, including management of project targets and facilities management throughout the building's life (NBSBR, 2014). As noted by Shelden (2009), BIM is the most promising recent development in the construction industry and an important tool for the growth of the construction industry. Similarly, Newton and Chileshe (2012) affirmed that BIM is imperative to the efficiency and competitiveness of the construction industry. Succar (2009) argued that BIM can stimulate the process of information exchange and interoperability among project stakeholders. This supports the view of Panuwatwanich, Wong, Doh, Stewart and McCarthy (2013) that the need for BIM stems from the lack of integration along the construction supply chain. Also, BIM Guide (2013) asserted that BIM would change the traditional process of working in the construction industry over a wide range of its typical characteristics, including those of people, processes, communication and work culture.

The level of development of building information models can be classified as 2D, 3D, 4D, 5D and 6D BIM depending on the level of details required and on the ability of the construction supply chain to operate and exchange information (Engineering News Record, 2014; Sawhney, 2014; Smith, 2014). The level of development of building information models is used to define the level of information required for modelling and maturity of the necessary IT technology, supporting infrastructure, collaboration and integration required at each level of capacity and is expected to be used by the BIM project strategy team to prioritise development of the BIM infrastructure (RIBA, 2012; Practical BIM, 2012; BIM Guide, 2013; Bolpagni, 2013; Eadie et al., 2014; British Standard Institute [BSI], 2013; Porwal and Hewage, 2013; BIM Planning Guide for Facilities Managers, 2012).

A 2D BIM is a conventional building model created using computer aided design (CAD) software technologies where building geometry is represented by lines between defined points. 2D based modelling evolved from pencils to ink, to overlay drafting, and to CAD technologies. It does not provide visualization, thinking and documentation, but leaves building information to imaginations (Arcadis, 2015). 2D BIM is the starting point for BIM implementation and it involves the use of CAD software with 2D files to design and produce only traditional drawings. In 2D BIM, information is often sent as Portable Document Format (PDF) and files are printed off on paper (RIBA, 2012; BIM Guide, 2013; Smith, 2014). According to Eadie et al. (2014), Oakley (2014) and BSI (2013), 2D BIM is document oriented and involves drawings in 2D CAD software technologies, calculation in Excel and processing of information using Microsoft word. The information from 2D BIM can be described as 'non-intelligent' information as no digital objects are utilized and professionals only employ texts, lines and arcs to prepare and communicate data. However, the information models created by project participants at 2D BIM require coordination in order to detect and correct information clash (Building Information Council, 2014). CAD software technologies employed in 2D BIM merely automated the process of drawing, design and documenting building information; but cannot represent the relationships between building elements; for example, the architectural information model is represented by 2D geometry of a building via graphical elements such as lines, arcs and symbols (Autodesk, 2002; Ian and Bob, 2010).

3D BIM is an object oriented models of buildings where virtual abstract representations of real life known as objects are used to represent components such as doors, windows or columns. Unlike 2D BIM that uses a collection of lines to represent building components on a drawing, 3D BIM gives a model consisting of virtual objects with a homogeneous geometrical description. It brings an immediate and understandable representation of the available design of a building and makes it easier to make changes in the design (Engineering News Record, 2014). Where only the information about the geometry of a building is required, the model can be developed as a 3D model, and this type of federated building information models is known as 3D BIM with visualization as the level of detail. Examples of software technologies that can be used in generating 2D or 3D BIM are MS Project, MS Outlook, Orion, ROBOT, Magi CAD, AutoCAD Architecture, AutoCAD MEP, Autodesk REVIT, Graphisoft ArchiCAD and Bentley Architecture (Royal Architectural Institute of Canada [RAIC], 2007; CICRP, 2011). 2D or 3D objects in 3D BIM usually have geometric description to which intelligence can be linked to create a federated building information model. The coordination of disciple-specific information models is also required for 3D BIM in order to avoid error and defective works (Eadie et al., 2014; BSI, 2013; Oakley, 2014).

The increased usage of both 2D and 3D CAD software technologies has been reported in a number of studies (Smith, 2014; BIM Guide, 2013; Ian and Bob, 2010; Building Information Council, 2014; and RIBA, 2012). For example, Building Information Council (2014) reported that 3D BIM primarily gives visualizations, concepts of designs and plans of project team members by creating geometry of buildings in support of visualization, realistic rendering and lighting effects. In 3D BIM only one party, usually the architects and engineers, develop a 3D information model for the project and other project team members only employing CAD software technology to develop building information without necessarily collaborating with one another. A level of collaboration could be done though to provide a common data environment for the project team by exchanging information models on compatible BIM software platforms. Other dimensions can be added to a 3D BIM by way of increasing the database with other information, and where time is added as the fourth dimension, the model is known as 4D BIM, 5D BIM when cost analysis and management information are added and when maintenance information is added, the model becomes a 6D BIM. Although, other dimensions can be added to BIM to generate 'nD BIM' depending on the project requirements; but the major benefit of BIM is achieved at 6D BIM (also known as integrated BIM [iBIM]) because it supports collaborative use of project information, provides a single or master model and provides greater use for the information in the model (Sabol, 2008; RAIC, 2007).

The level of details in BIM is very important to understand the construction process because elements in a 3D BIM model have to be in accordance with the schedule. The fourth dimension is an extra feature that provides the model with more dynamism in terms of representing the behaviour of the building elements along time, extending in this way its usage for other purposes. A 4D BIM takes the level of details in a BIM to another dimension by simulating the construction process of the 3D models using construction planning software technology. 4D BIM enables the team to introduce the construction sequence into the model, simulating the process, checking for mistakes and looking for optimizations. It increases the quality of the design and the cost effectiveness of construction and construction logistics (Velasco, 2013). Examples of software technologies that can be used to generate 4D, 5D or 6D BIM are Navisworks, Tekla structures, Bentley Navigator, Dinamo, DAYSIM among others (BIM Handbook, 2011; Velasco, 2013).

Conversely, VicoSoftware (2015) argued that 2D BIM still remains the cornerstone of construction contracts as 2D vector-based software technologies are still required to produce and document contract information and that 3D BIM is a collection of objects such as walls, slabs, columns, doors, and windows. In 5D BIM, 'quantification' is required only to integrate quantity take-off, location-based quantities, resources, productivity rates, and labour costs information into the 3D model and time dimension. As an estimating dimension, it gives the cost of the item, the cost of the crew to install it, the tools and materials necessary to install it, and its quantities per location (Arcadis, 2015). The sixth dimension in the level of BIM details is the operation and maintenance or sustainability information. This level analyses the models for maintenance or sustainability criteria (Velasco, 2013). VicoSoftware (2015) noted that 6D BIM is impossible to develop without interoperability and data exchange standards.

The classification for the level of development of building information models was mainly based on geometrical information and other dimensions of building information such as cost, time, maintenance, and sustainability. This classification is not apt for developing construction industries, for example, the Nigerian construction industry, where there exists no framework for the level of development of building information models for varied sizes of projects, types of clients, and diverse project delivery systems. For BIM implementation rationale in the developing construction industries, the numerals of building information models in a federated building information model could be used to classify the level of development of building information models, regardless of the geometry and dimensions of the constituent building information models in the federated building information models. This will trim down the level of intricacies, cost and information required in the development of building information models. This will in no way diminish the benefits to be derived from BIM process, but will bring down the cost of BIM process, and make BIM adaption easier in small projects, small firms, and developing construction industries.

3. Method

Primary data required for the study was obtained through the administration of structured questionnaire. The study population composed of construction professionals who have substantial involvement and responsibilities in BIM and who have generated building information models at any level of details for projects in Lagos State. These included the Architects, Quantity Surveyors, Facilities Managers, Civil and Structural Engineers, Building Services Engineers (Mechanical and Electrical) and Builders. At present, the comprehensive lists of these professionals are not available and this justified the adoption of purposive sampling for selection of the respondents for the study. Purposive sampling was adopted for the study. The selection of respondents for the study was done using Respondent Driven Sampling (RDS) technique. RDS is a sampling technique based on the principle of 'six degrees of separation', with the potential to reach any member of a population in six waves and involves a network-based methods that start with a set of initial respondents (driver respondents) who refer their peers; these in turn refer their peers up to the sixth wave.

A list of construction professionals who had generated building information models at any level of details in project was compiled using contacts list from social media based on the recommendation of Kossinets and Watts (2006). The construction professionals were divided into professional groups and the contacts list for each professional group was taken as the Personal Network Size (PNS) for the group. PNS for this study is the number of known professionals who had generated building information models at any level of details and it is required to determine the target population. The PNS for each of the professional group is as shown in Table 1.

Table 1: PNS and RDS Respondents Estimate and Target Population

Professional group	**Personal Network Size (PNS)**	**Estimated number of respondents**	**Minimum Target Sample Size (MTSS)**
Architects	16	96	77
Builders	11	66	57
Building services engineers	9	54	48
Facilities managers	4	24	23
Quantity surveyors	4	24	23
Structural/Civil engineers	8	48	43
Total MTSS for the study		**282**	

The RDS target population required for the study depends on RDS respondents estimate and this was determined by calculating the degree of person (di) and degree of distribution (Pdij) for the PNS using the summation method proposed by McCarthy et al., (2001). The RDS respondents estimate is presented in Table 1. The potentials of the PNS to name other respondents in six waves were summed to yield an overall estimate. The degree of person (di) was calculated using the formula given by McCarty et al. (2001).

$$di = \sum Pdij \qquad \text{(Equation 1)}$$

Where:
di = the degree of person i;
Pdij = 1 (if person i knows person j); and
∑Pdij= 6 (for six degrees of separation).

RDS target population was then determined by calculating the minimum target sample size (MTSS) for each of the professional group using the formula given by Glen (2013).

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

Where:
n = sample size;
N = population size; and
e = level of precision.

RDS target population for the study is as presented in Table 1. MTSS is required to compensate for differences in homophily and PNS across group and also to determine when the RDS should be stopped. The RDS for this study was stopped when the MTSS for each professional group was reached. Information obtained from the respondents included the levels of details and phase of implementation of BIM. Frequency distribution and percentage, clustered bar chart, mean ranking, Kruskal Wallis test and Fisher exact test were used to analyse the levels of BIM in use and degree to which the professional groups vary in their level of BIM usage. Where the ratings of the professional groups for a question were formed into contingency tables, Fisher exact test was used to determine if there were significant differences in the ratings indicated by the professional groups. The hyper-geometric probability function to determine significance value in Fisher exact test was calculated using the following formula as given by Weisstein (1999):

$$P = \frac{(R_1!R_2!\ldots\ldots R_m!)(C_1!C_2!\ldots\ldots C_n!)}{N!\prod_{ij} aij!} \qquad \text{(Equation3)}$$

Where:
N = total number of values in all the groups = $\sum iRi = \sum jCj$
Ri = row sums
Ci = column sums
aij = number of observations in which x=i and y=j

To determine if the ratings for a set of questions on the objective originated from the same professional group and to show if there are statistically significant differences among construction professional groups, Kruskal Wallis test was conducted on the responses owing to its sensitivity to unequal means. The discrepancies among the rank sums were combined to create a single value called Kruskal Wallis statistic using the formula given by National Institute of Standards and Technology (2015):

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{ni} - 3(n+1) \qquad \text{(Equation4)}$$

Where
ni = sample sizes for each of the k groups
Ri= sum of the ranks for group i

4. Results

4.1 Profile of respondents

The total MTSS of two hundred and eighty two construction professionals (282) as determined from the RDS target population guided the total number of respondents surveyed for the study. Seventy-eight responses were from Architects, representing 27.7% of the total respondents. Fifty-nine responses were from Builders (20.9%), fifty-one from Building Services Engineers (18.10%), forty-six from Structural Engineers (16.3%), twenty-four from Quantity Surveyors (8.5%) and twenty-four from Facilities Managers (8.5%). This shows that all the construction professional groups were represented in the survey and the conclusions from this study won't be biased.

Regarding the academic qualification of the respondents, 38.3% of respondents were BSc. holders, followed by respondents holding M.Sc. Degree accounting for 34.0% of the total respondents. Respondents who were HND holders accounted for 27.0% of the respondents; while respondents who were PhD holders accounted for 0.7% of the total respondents. This suggests that the respondents are well educated and would be able to respond to the questions with understanding. The distribution of respondents according to number of projects they had been involved in was also surveyed. Respondents who had been involved in at least 16 projects accounted for 26.2% of the total respondents, followed by respondents who had been involved in at least 11 projects, representing 25.5% of the total respondents. 20.6% of respondents have been involved in at least 5 projects, while 12.8% of respondents have been involved in more than 21 projects. This shows that the average respondents had participated in about seven projects. This shows that the respondents have enough working experience to provide the required information for this study.

On the subject of the experience level of the respondents for this study. Only 50.4% of the surveyed respondents had at least 5 years of experience in the Nigerian construction industry. 32.6% of the total respondents are professionals with at least 11 years of working experience. No more than 8.5% participants have less than 5 years' experience. While 2.1% of the total respondents have worked in the construction industry for 21 years and above. This suggests that there was great depth in the experience possessed by the respondents and that the information provided by these professionals can be considered reliable.

4.2 Phase of BIM implementation adopted for work processes in the study area

To achieve the objective of this study, it was noted that implementation of BIM in projects or organizations is in phases; and that BIM could be developed as 2D building information model (2D BIM) and federated building information models (3D, 4D, 5D and 6D BIM) depending on the stage of BIM implementation and level of details required for the project or applicable in the organization. Respondents were therefore asked to identify the phases of BIM implementation that they had adopted for their work processes.

The phases of BIM implementation employed by the respondents were analysed using frequency distribution and percentage and clustered bar chart, this is as presented in Figure 1. A significant number of respondents (19.9% and 18.4%) were still at visualization phase of BIM implementation and visualization with coordination phase of BIM implementation respectively, as shown in Figure 1. Only 11.3% of the respondents indicated that they were sharing digital information among project team members. However, BIM models were still not being shared collaboratively among project team members, as only 4.3% of the total respondents indicated that they shared information models collaboratively. While, 12.8% of the total respondents indicated that they were adjusting the work process towards BIM process.

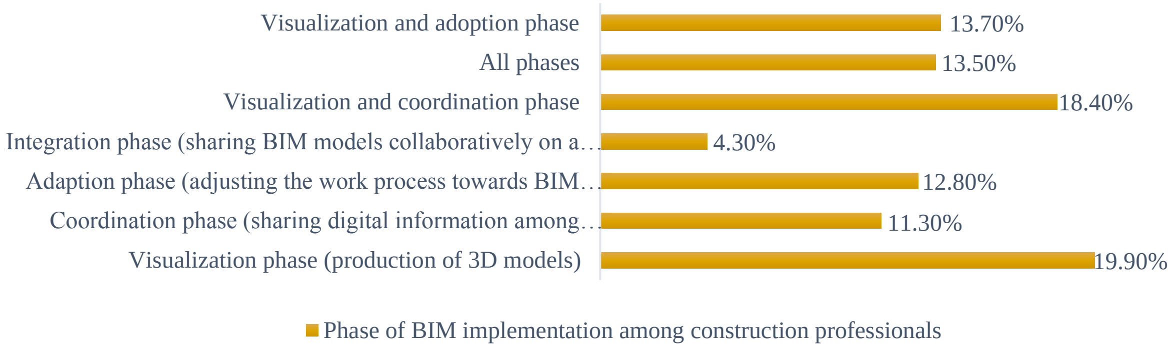

Figure 1: phase of BIM implementation among the surveyed construction professionals.

4.3 Generation of 2D BIM in the study area

Professionals had adopted Computer Aided design (CAD) and were using it in so many forms, such as 2D and 3D CAD. CAD adoption is often described as the starting point for BIM adoption. Therefore, the study examined the level of generating 2D BIM among the construction professionals. A 5-point Likert scale was adopted for the study, where 1 = very low level of generation, 2= low level of generation, 3=average level of generation, 4=high level of generation, and 5= very high level of generation. It can be seen from Figure 2 that, 34% of the respondents indicated high usage of 2D BIM for projects, 31.9% indicated very high level of generation of 2D BIM; while 9.9% indicated average level of generation of 2D BIM. No more than 4.3% and 19.9% of the total respondents indicated very low level of generation of 2D BIM and low level of generation of 2D BIM respectively.

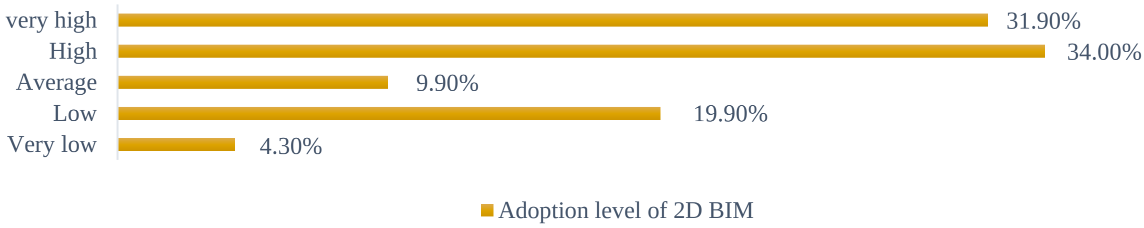

Figure 2: Level of generating 2D BIM among Construction Professionals.

A test of significance difference and ranking of the level of generation of 2D BIM among construction professionals was conducted using Kruskal Wallis test and mean score. As shown in Table 2, the variance in the level of 2D BIM being generated among construction professionals is significant. Builders accounted for the majority of those with high level of generation of 2D BIM with a mean score of 4.27. Facilities managers and quantity surveyors also have high level of generation of 2D BIM with a mean score of 4.00; while architects and structural/civil engineers have average level of generation of 2D BIM with mean scores of 3.97 and 3.08 respectively. Only building services engineers recorded low level of generation of 2D BIM with a mean score of 2.08.

Table 2: Mean score and Kruskal Wallis Test on Levels of generating 2D BIM among Construction Professionals.

Construction Professionals	Very Low	Low	Average	High	Very High	Total	Mean Score	Rank	Significant value
Architect	0	0	28	24	26	78	3.97	4	0.001
Builder	0	7	0	22	30	59	4.27	1	
Building service Engineers	0	49	0	2	0	51	2.08	6	
Facilities Manager	0	0	0	24	0	24	4.00	2	
Quantity surveyor	0	0	0	24	0	24	4.00	2	
Structural/Civil Engineer	12	0	0	0	34	46	3.08	5	
Total				282					

4.4 Forms of 3D BIM being generated in the study area

In order to obtain information on the level of details of 3D BIM in use among the surveyed construction professionals, 3D BIM dimensions were broken up into different variants by describing them according to possible numerals of the building information model contained in the federated building information models. Respondents were then asked to indicate the rate of generating 3D BIM dimensions and their variants. The standard form of 3D BIM is 3D architectural and engineering (structural and building services) models. However, most professionals develop 3D BIM in some other form than the standard 3D BIM. Table 3 shows the forms of 3D BIM being generated by the surveyed construction professionals, together with the level of generating standard 3D BIM. Forms of 3D BIM with high level of development by the surveyed construction professionals were 3D architectural model, 3D architectural and structural model and 3D architectural, electrical and mechanical model. Standard 3D BIM (architectural, structural, electrical and mechanical models), 3D structural model and 3D structural, electrical and mechanical model were rated as having low level of generation.

Table 3: Level of generating 3D BIM and its variants by construction professionals

3D BIM and its variants	Very Low	Low	Average	High	Very high	Mean Score
Standard 3D BIM (architectural, structural, electrical and mechanical models)	24.80%	21.30%	18.40%	15.60%	19.90%	2.84
3D architectural model	24.80%	0.00%	6.70%	28.70%	39.70%	3.59
3D architectural and structural model	24.10%	0.00%	13.50%	48.90%	13.50%	3.28
3D structural model	29.80%	21.30%	4.30%	24.80%	15.60%	2.62
3D structural, electrical and mechanical model	46.10%	16.30%	18.40%	9.90%	9.20%	2.20
3D architectural, electrical and mechanical model	29.80%	0.00%	18.10%	27.30%	24.80%	3.17

4.5 Forms of 4D BIM being generated in the study area

Standard 4D BIM can be generated by adding time dimension to standard 3D BIM. Therefore, this study examined the level of generating 4D BIM by construction professionals in the study area. Different forms of 4D BIM were identified and presented to the respondents. As explained in Table 4, 36.9% of the respondents were adding time dimension to 3D architectural model to generate a form of 4D BIM. Similarly, for the standard 4D BIM, 14.9% of the total respondents indicated high level of generation; while 33.3% indicated low level. Among the variants of 4D BIM, only 3D architectural model and time dimension had average level of generation with a mean score of 3.11; while Standard 4D BIM (standard 3D BIM and time dimension), 3D structural model and time dimension, 3D architectural model and cost dimension, 3D architectural and structural model and cost dimension and 3D architectural and structural model and facilities management had low level of generation with an average mean score of 2.34.

Table 4: Level of generating 4D BIM and its variants among construction professionals

4D BIM and variants	Very low	Low	Average	High	Very high	Mean Score
3D architectural model and time dimension	37.60%	0.00%	12.80%	12.80%	36.90%	3.11
3D architectural and structural model and facilities management	23.40%	28.40%	18.40%	0.00%	29.80%	2.84
3D architectural and structural model and cost dimension	25.50%	24.80%	8.50%	23.40%	17.70%	2.83
Standard 4D BIM (standard 3D BIM and time dimension)	33.30%	0.00%	42.60%	9.20%	14.90%	2.72
3D architectural model and cost dimension	58.90%	0.00%	13.50%	9.90%	17.70%	2.28
3D structural model and time dimension	44.00%	0.00%	36.90%	9.20%	9.90%	2.25
3D electrical and mechanical model and facilities management	54.60%	27.70%	12.80%	0.70%	4.30%	1.72
3D structural model and cost dimension	48.90%	46.80%	4.30%	0.00%	0.00%	1.55
3D architectural model and facilities management information	72.70%	22.30%	0.00%	4.30%	0.70%	1.38
3D electrical and mechanical model and time dimension	78.40%	8.50%	13.10%	0.00%	0.00%	1.35
3D electrical and mechanical model and cost dimension	79.40%	7.10%	12.80%	0.70%	0.00%	1.35
3D structural model and facilities management information	70.90%	24.10%	5.00%	0.00%	0.00%	1.34

4.6 Forms of 5D BIM being generated in the study area

Using the same Likert scale, different forms of 5D BIM were identified and used to examine the level of development of 5D BIM by the construction professionals in the study area. The result from Table 5 revealed that 60.3% of the respondents indicated very low generation of standard 5D BIM. Similarly, the usage of other forms of 5D BIM is very low with 29.1% indicating very low level of generation of 3D architectural-structural-time and cost dimension model, and 46.8% indicating very low level of generation of 3D architectural-electrical-mechanical-time and cost model. None of the variants of 5D BIM have high level of generation. The variants of 5D BIM with low level of generation (mean score between 2.00-2.99) were Standard 5D BIM (standard 4D and cost dimension), 3D architectural, structural, time and cost dimension, 3D architectural, electrical, mechanical, time and cost dimension, 3D architectural, time and cost dimension, and 3D architectural, structural, electrical, mechanical, facilities management and cost dimension

Table 5: Level of generating 5D BIM and its Variants among Construction Professional

5D BIM and its variants	Very low	Low	Average	High	Very high	Mean Score
3D architectural, time and cost dimension	46.50%	0.40%	5.70%	4.30%	43.30%	2.98
3D architectural, structural, time and cost dimension	29.10%	9.20%	25.50%	28.40%	4.30%	2.59
3D architectural, electrical, mechanical, time and cost dimension	46.80%	19.90%	5.00%	24.10%	8.50%	2.4
3D architectural, structural, electrical, mechanical, facilities management and cost dimension	9.90%	59.60%	29.10%	0.00%	4.30%	2.38
Standard 5D BIM (standard 4D and cost dimension)	39.70%	27.70%	9.20%	19.10%	4.30%	2.21
3D structural, electrical, mechanical, time and cost dimension	42.60%	45.40%	3.50%	5.70%	8.50%	1.95
3D architectural, structural, electrical, mechanical and time and facilities management dimension	60.30%	7.80%	17.00%	14.90%	0.00%	1.87
3D architectural, facilities management and time dimension	61.00%	15.60%	9.90%	5.00%	8.50%	1.84
3D architectural, facilities management and cost dimension	54.00%	26.20%	5.00%	9.90%	4.30%	1.83
3D structural, electrical, mechanical, time and facilities management	51.80%	44.00%	0.00%	0.00%	4.30%	1.61
3D structural, facilities management and cost dimension	68.10%	19.10%	4.30%	4.30%	4.30%	1.57
3D structural, facilities management and time dimension	71.60%	24.10%	0.00%	0.00%	4.30%	1.41
3D electrical, mechanical, facilities management and time dimension	71.60%	24.10%	0.00%	4.30%	0.00%	1.37
3D structural, time and cost dimension	77.70%	21.60%	4.30%	0.00%	0.00%	1.34
3D electrical, mechanical, facilities management and cost dimension	71.60%	27.70%	0.70%	0.00%	0.00%	1.29
3D electrical and mechanical model and time and cost dimension	74.50%	25.50%	0.00%	0.00%	0.00%	1.26
3D structural, electrical, mechanical, facilities management and cost dimension	78.40%	21.60%	0.00%	0.00%	0.00%	1.22

4.7 Forms of 6D BIM being generated in the study area

The current level of details in BIM is 6D comprising of Standard 5D BIM and facilities management information. However, based on the identified possible numerals and implementation strategies that could be adopted by various construction professionals, it is possible to have other forms of 6D BIM. These forms of 6D BIM were identified and presented to the respondents to rate the level of using them. The level of generation of 6D BIM and its variants among construction professionals is as explained in Table 6. In the Table, 36.9% and 37.6% of the respondents indicated that their level of generating Standard 6D BIM (Standard 5D BIM and facilities management information) were very low and low respectively. Also, as explained in Table 6, only Standard 6D BIM (Standard 5D BIM and facilities management information) had low level of usage with a mean score of 2.06.

Table 6: Level of generating 6D BIM and its Variants among Construction Professionals

6D BIM and its variants	Very low	Low	Average	High	Very high	Mean Score
Standard 6D BIM (Standard 5D BIM and facilities management information)	36.90%	37.60%	12.80%	8.50%	4.30%	2.06
Standard 6D BIM (Standard 5D BIM and facilities management information)	36.90%	37.60%	12.80%	8.50%	4.30%	2.06
3D architectural-electrical-mechanical-facilities management and time dimension	49.60%	24.80%	17.00%	8.50%	0.00%	1.84
3D architectural-electrical-mechanical-facilities management and time dimension	49.60%	24.80%	17.00%	8.50%	0.00%	1.84
3D architectural-structural-facilities management and time dimension	46.00%	36.90%	12.10%	4.30%	0.00%	1.74
3D architectural-structural-facilities management and time dimension	46.00%	36.90%	12.10%	4.30%	0.00%	1.74
3D structural-electrical-mechanical-facilities management and time dimension	70.90%	19.90%	0.70%	4.30%	4.30%	1.51
3D structural-electrical-mechanical-facilities management and time dimension	70.90%	19.90%	0.70%	4.30%	4.30%	1.51

3D electrical-mechanical-facilities management-time and cost dimension	79.40%	20.60%	0.00%	0.00%	0.00%	1.21
3D electrical-mechanical-facilities management-time and cost dimension	79.40%	20.60%	0.00%	0.00%	0.00%	1.21

4.8 Difference in the levels of generating federated building information models among the surveyed construction professionals

It was assumed that the construction professionals might not be developing federated building information models at the same level and level of details. To establish this supposition, a test of difference was conducted on the responses of the surveyed construction professionals and trend line was plotted to show the pattern of level of details of federated building information models being generated by the surveyed construction professionals. Fisher Exact test was conducted to examine the difference in the levels of generating federated building information models among construction professionals (Table 7). Comparing the differences in the mean rank for the professional groups, the significant value (p = 0.001) was less than the alpha threshold value ($p<0.05$). Table 7 also reveals that architect, structural/civil engineers and builders were ahead of other professionals in the generation of federated building information models.

Table 7: Fisher Exact Test to examine the difference in the levels of generating federated building information models by construction professionals.

Construction Professionals	Number of respondents	Mean Score	Rank	Significant value
Architect	78	0.39	1	0.001
Builder	59	0.32	3	
Building service Engineers	51	0.28	4	
Facilities Manager	24	0.20	6	
Quantity surveyor	24	0.23	5	
Structural/Civil Engineer	46	0.34	2	
Total	282			

Figure 3 shows the trend line of details of building information models being developed by the surveyed construction professionals. It can be deduced from the figure that, 2D, 3D and 4D BIM were the commonly generated building information models. Using the trend line to predict the likely advancement in the levels of development of building information models in the construction industry. The level of development of building information models which started with 2D BIM and 3D BIM (3D architectural model), would advance thus: 3D BIM (architectural + structural), 3D BIM (architectural + electrical and mechanical model), 3D (structural model), 3D BIM (3D structural + electrical and mechanical model), Standard 3D BIM (3D architectural + structural + electrical and mechanical), 4D BIM (3D architectural + time dimension), Standard 4D BIM (3D architectural + structural + electrical and mechanical + time dimension), 4D BIM (3D structural model + time dimension), 4D BIM (3D structural model+ cost dimension), 5D BIM (3D architectural + structural + time + cost model), 5D BIM (3D structural + facilities management + cost model), 5D BIM (3D structural + time + facilities management model), Standard 6D BIM (3D architectural + structural + electrical and mechanical + time + cost + facilities management model), 6D BIM (3D structural + electrical and mechanical + time + cost + facilities management model), 6D BIM (3D electrical and mechanical + time + cost + facilities management model), 6D BIM (3D architectural + electrical and mechanical + time + cost + facilities management), 6D BIM (3D architectural + structural + time + cost + facilities management model.

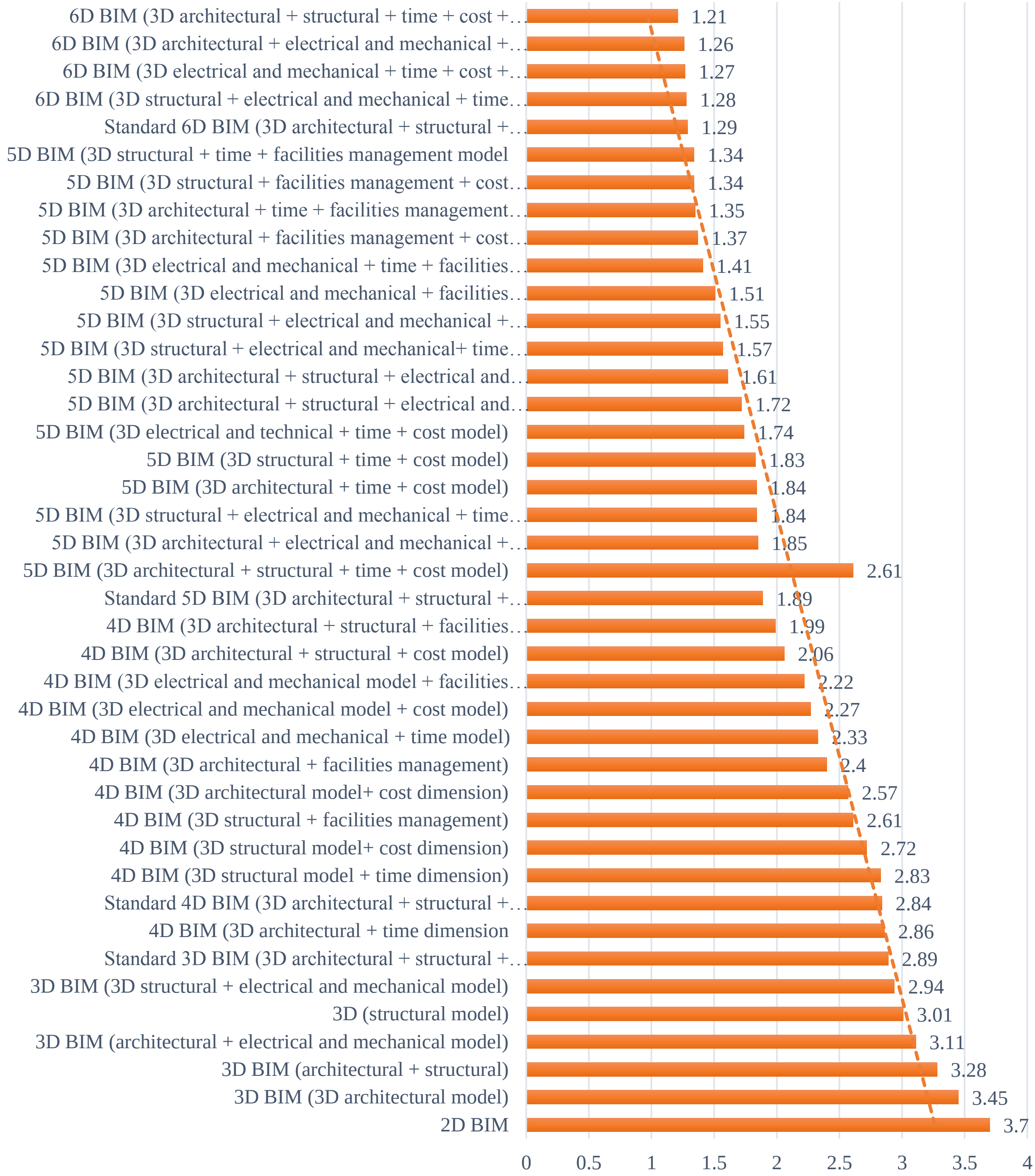

Figure 3: Trend line of details of building information models.

5. Discussion

5.1 BIM implementation in construction projects and organizations

Going by the information presented in Figure 1, it could be inferred that BIM process is gaining ground among professionals owing to competitiveness and availability of BIM software technologies. The results also show that professionals find BIM most useful for producing 3D models. BIM was also used to coordinate the sharing of information model among professionals. This supports and adds to the findings of Building and Construction Industry Productivity Partnership (2014) and Sawhney (2014) which found that BIM is used mostly at the visualization phase of a project and that 3D BIM is the most useful BIM for construction professionals.

The coordination of BIM is usually done by the Architects or Builders depending on the contractual arrangement and the criteria for appointing the project manager, in this case, BIM manager. This could explain why 18.4% of the total respondents were at visualization and coordination phase. An Architect who has adopted BIM for visualization purpose could as well be experimenting with the coordination of sharing of information models among the project team if the Architect is the appointed project manager for the project. Also, a Builder acting as the project or BIM manager on a project where Architect has adopted BIM for visualization may have to implement BIM for the coordination of the information models. This study found that respondents were adjusting their work process towards the BIM process. However, there is no formal adoption of BIM by the Federal Government of Nigeria or the Nigerian construction industry as a whole; therefore the adjustment of work process towards BIM adoption by the surveyed construction professionals only implies that individual organizations operating in the Nigerian construction industry were feeling the competition posed by firms that are well advanced in ICT adoption and CAD utilization for projects, and were therefore adopting BIM to be relevant and competitive in the industry.

The indication of some of the respondents that they were at all phases of BIM implementation shows that the construction professionals were lacking information on the process and framework for BIM adoption. It also suggests that construction professionals were in haste to adopt BIM for projects and work processes without having in-depth knowledge of the intricacies of BIM implementation. BIM could be adopted for projects without the project participants having implemented or adopted BIM in their respective organizations or in their work processes. It is the duty of BIM managers to coordinate BIM implementation and workflows. As pointed out by Ozorhon et al., (2010), BIM could be adopted for a project based on the project deliverables; while in organization, BIM implementation is based on the organizational objectives. For a successful implementation of BIM in a project or in an organization, the phase of implementation should be in stages and not lumped together as a one-time thing. Projects are executed in stages, and the stage where visualization is required was not the same as where coordination is required. Also, in organizations or in work processes, change comes gradually. Time is required to learn BIM processes, design BIM workflows, and integrate BIM application to work process in order to change the old method of work process.

5.2 Level of development of 2D BIM and federated building information models

The findings in Figure 2 shows that the level of generating 2D BIM (CAD adoption) was very high among the surveyed construction professionals and this can be attributed to widespread application of software technologies and advancement in ICT in the construction industry of Lagos State. Builders, Quantity Surveyors and Facilities Managers ranked higher than the other professionals in the generation of 2D BIM. The fact that Builders use and prepare more 2D documents than every other professionals in the construction industry could be responsible for this. 2D documents such as working plan, engineering plan, construction plan, health and safety plan, and work process reports are being required to interpret and construct projects by Builders. The reason for high usage of 2D BIM software technologies such as Masterbill, QS Plus and MS Excel to develop 2D BIM for projects by Quantity Surveyors and Facilities Managers could be attributable to the unavailability of cloud-based cost analysis software technologies and digital cost information in Nigeria. However, 2D software technologies only present building information in 2D and are not so effective for developing federated building information models. This finding is consistent with other studies from Hamil (2013) and Oladapo (2006), which showed that the construction industry has fully adopted CAD and that the use of CAD and software technologies for design, drawing, measurement, estimating and preparation of Bill of Quantities is common among construction professionals in Nigeria.

Findings on the forms of 3D BIM being generated by the surveyed construction professionals revealed that 3D architectural model, 3D architectural and structural model, and 3D architectural and building services model were the most developed variants of 3D BIM. High generation of these forms of 3D BIM suggests that the construction professionals were advancing on the usage of BIM, as 3D BIM depicts the point of departure from CAD to BIM. It also means that architects and builders have ample knowledge of structural design, thereby employing CAD software technologies to analyse and develop 3D structural model. The development of 3D structural and building services model by some architects and builders implies that they have ample knowledge of structural and building services design aided by the availability of building services software technologies. The low level of generating standard 3D BIM among the respondents shows that BIM usage is a new trend among construction professionals in Nigeria and that the construction professionals lack the understanding of the appropriate level of details at which building information models should be developed.

Among the likely variants of 4D BIM, only 3D architectural model + time dimension had an appreciable level of generation by the respondents. This shows that construction professionals were adding time dimensions to 3D architectural model to generate a form of 4D BIM more than other forms of 4D BIM. It could be that Builders were able to add time dimension to various forms of 3D models on account of availability of software technologies such as MS Project and Autodesk Naviswork. Autodesk Naviswork and Dinamo allow Builders to develop federated building information model and simulate construction timeline by adding time schedule model from MS Project or Primavera to the federated model. A standard 3D BIM is an example of federated building information model. This study found the level of integrating standard 3D BIM with time dimension or time schedule model to be low among the respondents and this could be as a result of paucity of information on methods of developing federated building information models.

Findings on the forms of 5D BIM being generated by the respondents indicate low level of development of 5D BIM and its variants in the study area. This is an evidence of non-appreciation of BIM processes by the Quantity Surveyors whose responsibility it is to provide cost information model for extending the level of details of standard 4D BIM to the fifth dimension. If 3D BIM portrays the point of departure from CAD to BIM; then standard 3D BIM represents integration, collaboration and point of departure from fragmentation and traditional work processes in the construction industry. There are BIM software technologies that support automatic quantification and 3D taking-off; thereby enabling the development of federated building information models such as 5D BIM. In order to facilitate the transformation of the Nigerian construction industry, the Quantity Surveyors must switch from traditional method of quantification to automatic quantification. This finding is consistent with low adoption of BIM by the quantity surveyors and with the study by RICS (2011), which found that quantity surveyors still use traditional quantification rather than adopting automatic quantification provided by BIM.

None of the variants of 6D BIM were found to have average level of generation. This shows that facilities management is not well developed yet in Nigeria and the profession is not witnessing intense competition as being witnessed by the established professions in the construction industry. In addition, the findings explain the reasons why Facilities Managers ranked lowest among the surveyed construction professionals in the generation of federated building information models. Nevertheless, early adoption of BIM would transform the facilities management in its cradle of emergence in the Nigerian construction industry. This finding is consistent with the study by Sawhney (2014) in India, which indicated that the Facilities Managers are not adopting BIM for facilities management operations.

The usage of BIM starts from the adoption of 3D BIM which could be generated using object-based parametric software technologies. Quantity Surveyors and Facilities Managers were the top developers of 2D BIM which could not be regarded as a proper BIM, for that reason, this study examined the difference in the levels of generating federated building information models among the construction professionals in the study area. The observed difference in the levels of federated building information models being generated among the construction professionals was statistically significant. This implies that the surveyed construction professionals were not using BIM at the same degree nor generating building information models at the same level of details. The level of generating federated building information models was statistically higher among Architects, Civil/Structural engineers and Builders. This finding shows that Architects have embraced BIM more than any other construction professionals. Similar study carried out in the United States of America by Autodesk (2011), showed that six out of ten Architects use BIM.

5.3 Inclination in the level of development of building information models

The pattern of developing building information models was examined and the result suggests that only 3D architectural and engineering models were being integrated on regular basis. Though, not always to the standard form of 3D BIM. The result also shows that time dimension was being integrated occasionally to various forms of 3D BIM to generate standard 4D BIM and its other forms. Nevertheless, other dimensions such as cost and facilities management, though they were being modelled using 2D CAD, but were not being used in BIM to generate 5D and 6D BIM on account of compatibility and interoperability issues. Interoperability of authoring software technologies is a key issue in BIM processes and this is the main reason why 2D CAD software technologies are not being regarded as BIM software technologies. Likewise, information developed using 2D CAD software technologies could not be taken as a building information model. This finding is consistent with previous studies by NBS-National BIM Report (2012) and (2013) in UK and Sawhney (2014) in India, which indicated that 2D and 3D BIM are still the most prevailing level of BIM being generated among construction professionals.

Furthermore, the trend shows that 2D, 3D and 4D BIM would be generated for a very long time. Going by the information contents of 2D, 3D and 4D BIM, it could be deduced that Builders were collaborating with either Architects or Structural engineers to develop different forms of 4D BIM or develop different forms of 4D BIM by themselves or in-house. It could also mean that professionals were experimenting with various forms of BIM at lower levels of BIM details, that is, 2D, 3D and 4D BIM, depending on the demand and size of the projects for which they were using BIM. However, in complex projects that were more demanding and large in size, and where detailed information are required, professionals were using 4D and 5D BIM. This finding is consistent with study by Laiserin (2010), which indicated that the demand and size of a project should determine the level of BIM to be adopted for projects.

5.4 Implications of the findings of this study

The findings of this study imply that BIM adoption and implementation framework should be developed for the Nigerian construction industry as a result of the low level of development, understanding and adoption of BIM in the construction industry and amongst construction professionals. The framework should describe the level of development of building information models appropriate for various project characteristics. Also, educational and professional institutions should strategize on how to make construction professionals to understand, adopt and implement BIM.

5. Conclusion

Levels of development of building information models is a function of the phase of BIM implementation and the creation of federated building information models. This paper examined the phase of BIM implementation adopted for work processes and the level of generating different forms of building information models by construction professionals in Lagos State, Nigeria. The paper establishes that BIM is used mostly at the visualization phase in project delivery for the production of 3D models. In general, 2D and 3D BIM are still the most prevailing building information models being generated. Although, 4D BIM was barely being created, but the level of details were not consistent with the standard form of adding time dimension to standard 3D BIM. The forms of 3D and 4D BIM being generated in the study area are 3D architectural model, 3D structural model only, 3D architectural and structural model, and 3D architectural and time dimension. The level of development of 5D BIM in Lagos State, Nigeria is very low because Quantity Surveyors are still using 2D CAD for quantification rather than adopting 3D taking-off methods. This connotes that the status of BIM adoption in construction industry in Lagos State, Nigeria is at the visualization phase.

Architects, Engineers and Builders in the study area are generating building information models more than the other professionals owing to the fact that they have knowledge of each other's profession and form the core of design and construction team members. The findings of this paper are limited to the construction industry in Lagos state, Nigeria.

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JCBM (2018) 2(2).15-23

University of Cape Town

Journal of Construction Business and Management

http://journals.uct.ac.za/index.php/jcbm

A Career Path Framework for Quantity Surveyors in Nigeria Private Practice

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Received 1 June 2017; received in revised form 16 August 2017, 21 June 2018; accepted 27 June 2018
https://doi.org/10.15641/jcbm.2.2.2018.94

Abstract

In a typical organization, career path helps employees to understand what is expected of them based on the positions they occupied. This also allows them to participate in managing their career progress. Many quantity surveying firms do not have career development path for their quantity surveyor (QS) employees and this has limited their performance at work. This paper, therefore, develops a career path framework for quantity surveyors in private practice in Nigeria. A combination of survey and interviews were employed to elicit the required data. The study population are in two categories. Firstly, the quantity surveying firms, while the respondents in the firms are the principal partners and their employees. The second category is the chairmen of the state chapters of the Nigerian Institute of Quantity Surveyors. The findings of the study establish the career path progression for a quantity surveyor in private practice which ranges from trainee quantity surveyor, assistant quantity surveyor, quantity surveyor, senior quantity surveyor, principal quantity surveyor, chief quantity surveyor, partner and principal partner/consultant in that order. The proposed conceptual framework signifies and demonstrates the necessary benchmark to resolving common problems about career progression and development among quantity surveyor in private practice. This is seen as having a positive effect on harmonious working relationship and quality service delivery.
Keywords: Career development, Career path, Framework, Nigeria, Private Practice, Quantity Surveyors.

1. Introduction

The world has witnessed and still witnessing massive changes in technology, social, political and economic orders. Many of these changes appear as threats to the quantity surveying profession but only to the pessimist because more significant opportunities have been and are still being created (Ikedionwu, 2016). The Quantity surveyor plays a significant role in the management of construction projects by acquiring and deploying appropriate competencies (Nkado and Meyer, 2001). The exact nature of their role depends on who employs them. The professional quantity surveyor engaged by the client and the contractor's quantity surveyor have different roles to play in any construction project. The contractor's quantity surveyor role is far more than measurement and quantification but extends to administration and commercial management of construction contract (Towey, 2012). VFM Group (2008) summarized the principal role of a Chartered Quantity Surveyor in ensuring that the building client receives value for money. Back in 1971 the Royal Institution of Chartered Surveyors (RICS) defined the traditional role and described the distinctive competence of the quantity surveyor as a skill in measurement and valuation in the field of construction in order that such work can be described, the cost and price forecasted, analysed, planned, controlled and accounted for. However, Phen and Ming (1997); RICS (1993); RICS (1998); BQSM (2004); Arifin and Torrance (2008); AIQS (2004); PAQS (2001) Githaiga (2004) and, Chiu and Ng (2015) explicitly highlighted the role of quantity surveyor in private practice. These include feasibility study, development appraisal, cost planning and control, contract documentation and administration, project management, procurement management, risk management, litigation, arbitration and dispute resolution, technical auditing and valuation for fire insurance.

Growth or progress, in any profession, is expected or made when one climbs from one level to higher one either by having more knowledge, acquiring more skills or having higher output. (Anunike, 2016). Grugulis (2003) opined that qualifications could help employers identify

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suitable employees, provide individuals with portable credentials, and give occupational groups bargaining power. This notwithstanding, there is dichotomy in quantity surveyors' recruitment, placement and promotion in private practice when compared with those in public service in Nigeria. In public service, there exists a regulated scheme of service for all cadres of staff irrespective of their professional affiliation, but this is not the case in private practice primarily for quantity surveying. This makes it difficult for employees to put in their best in such an organization where there is no clear plan on how they will progress on their jobs over the years.

Thus, it is of considerable importance to have in place a formal career path system for quantity surveyor employees in private practice. This is seen to take account of and encourage the career management of prospective employee which is vital to high-quality service delivery. The purpose of this paper, therefore, is to provide a career path framework that could serve as a regulated scheme of service and career pathway metrics for quantity surveyors in private practice. In doing this, a literature review, to clarify the theory and key concepts that provided the background for the study, was first conducted. This is followed by the explanation of the research and analytical methods. The findings and results were thereafter presented and discussed.

2. Literature Review

2.1 The Theoretical Concept

Collins English Dictionary (2012) defined career as a person's course or progress through life. This definition relates career to a range of aspects of an individual's learning and work through life. According to Hrzone (2016), career paths are routes that individuals take from their first engagement into the job market through to their final position before retirement. This definition can be expanded to include even after retirement. National Career Pathways Network (2012) defined career pathway as a coherent, articulated sequence of rigorous academic and career or technical courses, commencing in the ninth grade and leading to an associate degree, baccalaureate degree and beyond, an industry-recognized certificate, and licensure. Simply put, career pathways are a method of developing and organizing curricula across different strands of careers. The teaching, counselling, and assessment that support career pathways are also designed to focus students toward career goals beyond graduation, the result being passports and a portfolio as evidence of work readiness. The objectives of career pathways are to help students or employees to understand and consider career options, discover workplaces and their relationship to curricula, make choices about future education and training, understand the expectations for achieving career goals, maintain portfolios of progress and achievement, and become flexible but focused employees.

Heathfield (2014) defined career pathing as the process used by an employee to chart a course within an organization for his or her career path and career development. It involves understanding what knowledge, skills, personal characteristics, and experience are required for an employee to progress in his or her career laterally or through access to promotion. Society for Human Resources Management (SHRM) (2015) viewed career development as the process by which individuals establish their current and future career objectives and assess their existing skill, knowledge or experience levels and implement an appropriate course of action to obtain their desired career objectives. A career development model facilitates this process by providing pre-defined career paths or ladders which SHRM defines as the "progression of jobs in an organization's specific occupational field ranked from the lowest to the highest hierarchy. Career management describes the active and purposeful management of a career by an individual. Ideas of what comprise "career management skills" are described by the Blueprint model/framework (in the United States, Canada, Australia, Scotland, and England (Hooley, et al (2013)) and the Seven C's of Digital Career Literacy (specifically relating to the Internet skills (Hooley, 2012).

2.2. The significance of career path model or framework in an organisation

Career path frameworks are often used to describe the progress path of an individual in an organization. Hollmann and Elliot, (2006) viewed this as a technical ladder. Once a model or platform is created, the organization has all the information needed to readily create job description and job postings as needed, with assurance that the job posting meets business requirements as well as specific job requirements. The career path approach, according to Centre for Postsecondary and Economic Success (2013), strengthens existing education and workforce services from a myriad of disconnected programmes to a structure that focuses on the individuals in need of education and training and their career paths. It provides clear transitions, strong supports, and other elements critical to the success of participants. Giamalvo (2016) presented a five-level functional career track progression in typical project control and cost management organization with similar credentials and experience. The functional levels are intermediate, professional, advanced, expert and fellow; which roughly corresponds to career progression from being a fresh graduate getting the first job to becoming a senior practitioner. The author stressed further that the approach enables the integration between the needs of employers who are hiring practitioners who hold these credentials and those individuals and organizations who develop and deliver training to prepare practitioners to qualify for these jobs via the certification process.

Love et al. (2001) emphasized the importance of companies recruiting graduates not to view graduates' acquired education as teaching them about their workplace but as a foundation from which industrial experience will be built into them. As the move towards "outcome" or "results based" education and training, where courses are being designed to prepare people for actual jobs when they graduate, continues to grow; it becomes imperative for those developing/delivering training programs focus on those skills and competencies which are in demand (Giamalvo, 2017). Raiden and Dainty (2006) argued that employers have to leverage on their employees' need for development and also their needs in meeting the competitive business environment. In this regard, Chiu and Ng (2015) recommended that quantity surveying firm managers should place more efforts on improving their employee's job satisfaction to enhance their commitment to the organization. This, according to Chan and Moehler (2008), mandates employers to contribute to the career development of their employees and Chan (2007) sees it as very key to ensuring a sustainable skill base. The outcome of Onukwube (2012)'s study, which established a significant relationship between job satisfaction of quantity surveyors and the work itself, buttressed this view. The study recommended that quantity surveying firms' management should provide opportunities for career growth to quantity surveyors in their employment.

2.3. The Quantity Surveyor's Career Path system in Nigeria working environment

Quantity surveyors provide financial and commercial management services on construction projects. They are employed in different working fields within the construction sector. Cartlidge (2009) categorised this, principally, as private practice and contracting organization. Quantity surveyors working in private practice are often described as professional quantity surveyor (PQS) while those in contracting organizations are called contracting quantity surveyors (CQS). They may also work within development companies, commercial organizations, financial institutions and in public sector. As such their involvement in construction projects varies. This is mostly dependent on individual project scheme and mode of procurement (Cunningham, 2014). Traditionally, competence in surveying has been defined by its knowledge base, but the RICS has developed its membership requirements from examination through to a more comprehensive assessment of an acceptable level of proficiency expected of a qualified surveyor, which attempts to be both more carefully defined and also flexible enough to encourage development with changing markets (Westcott and Burnside, 2003).

Due to the vastness of the roles of modern quantity surveyors, a Nigerian graduate quantity surveyor works in different fields and organization with a variety of nomenclature. Nigerian Institute of Quantity Surveyors (NIQS, 2015) categorized these nomenclatures as Public Sector (Federal, States and Local Governments, Ministries, Departments, Agencies and Institutions); Private Sector (Consultancy Practices, Financial Institutions; Oil and Gas Companies; Building and Engineering Firms; Property Development Companies; and so forth). Ikedionwu (2016) summarized the potential employer of quantity surveyors, in Nigeria, into the following categories – consultancy firms; contractors and subcontractors; government and private client organizations. This is illustrated in Figure 1.

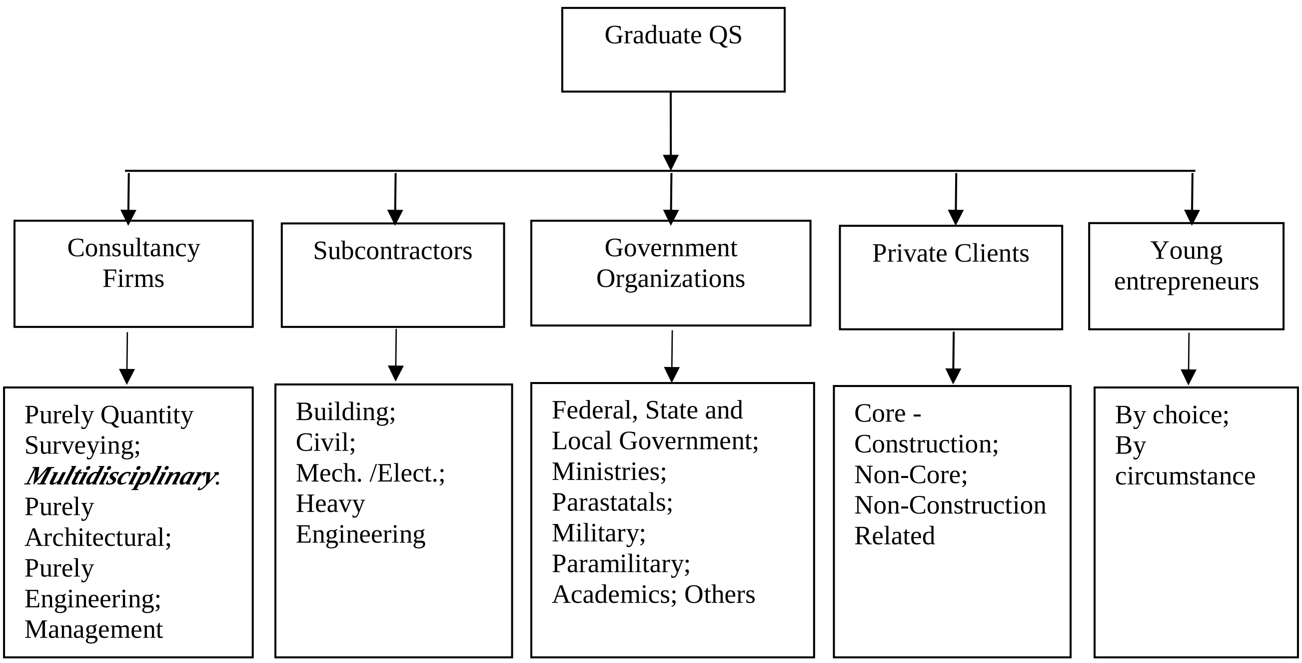

Figure 1: Potential Employers of Quantity Surveyors in Nigeria (Ikedionwu, 2016)

Wherever quantity surveyors work or employed, their roles remain very important in financial accountability, value for money and profitability (Willis et al., 1994) in competitive business environment. The Nigerian Civil (public) Service consists of employees in government agencies other than the military. They progress based on qualifications and seniority. Quantity Surveyors in the Nigeria public service deal with the control of projects in a wide range of sizes as well as maintenance and repair works. Willis et al. (1994) had long given the primary responsibility of quantity surveyors as controlling public money and monitoring the way it is being spent. As earlier reiterated, the key public service for quantity surveyors includes employment in government ministries, departments and agencies. Table 1 gives the scheme of service for quantity surveyors cadre in Nigerian civil service.

Table 1: Nigerian scheme of service for civil (public) servants (Quantity Surveyor Cadre) (Federal Republic of Nigeria, 2003)

S/N	Rank	Entry Qualification	Duties	Salary Scale	Next Rank
1	Quantity Surveyor II	Direct appointment of a candidate possessing 5 O' level credits (WASC/NECO/GCE) including English Language and Mathematics plus a First Degree in Quantity Surveying with a minimum of Second Class Lower Division.	Assisting in the preparation of bills of quantities and estimates of proposed works. Carrying out valuation for interim certificates of payments. Carrying out other duties as may be assigned and providing professional and community service.	*CONTISS 07	
2	Quantity Surveyor I	Promotion of a confirmed and suitable Quantity Surveyor II who has spent at least three years on the grade. Direct appointment of a candidate possessing (a) First Degree plus three years post qualification relevant experience or (b) master's Degree in relevant area.	Same duties as specified above.	CONTISS 08	Senior Quantity Surveyor
3	Senior Quantity Surveyor	Promotion of a confirmed and suitable Quantity Surveyor I who has spent at least three years on the post with satisfactory record of service Direct appointment of a candidate possessing 5 O' level credits (WASC/NECO/GCE/) including English Language and Mathematics plus (a) First Degree plus six years post qualification cognate experience, or (b) master's Degree plus three years post-graduation cognate experience.	Preparing bills, quantities and estimates of proposed works. Carrying out valuation for interim certificates of payments and serve as Quantity Surveyor and Cost Planner on major projects and control costs of construction works. Carrying out other duties as m ay be assigned and provide professional' and community service. Participating in the preparation of bills of quantities and estimates of proposed works. Carrying out valuation for interim certificates of payments and serve as Quantity Surveyor on medium projects. Carrying out other duties as may be assigned and provide professional and community service.	CONTISS 09	Principal Quantity Surveyors
4	Principal Quantity Surveyor	Promotion of a confirmed and suitable Senior Quantity Surveyor who has spent at least three years on the grade. Direct appointment of a candidate possessing 5 O' level credits (WASC/NECO/GCE/) including English Language and Mathematics plus (a) First Degree plus nine years post qualification experience, or (b) master's Degree plus six years post qualification cognate experience	Same as specified in 3 above. Assessing financial implications of project proposals and advise on cost decisions. Carrying out other duties as may be assigned.	CONTISS 11	Chief Quantity Surveyor

5	Chief Quantity Surveyor	Promotion of a confirmed and suitable Principal Quantity Surveyor who has spent at least three years on the grade.	Preparing bill of quantities and estimates of proposed works and carry out valuation for interim certificates of payment. Serving as Quantity Surveyor and Cost Planner, or Major Projects and control cost of construction works. Assessing financial implications of project proposals and advising on cost decisions and assist in annual capital estimates preparations, review of rolling plans and updating fixed assets register. Carrying out other duties as may be assigned and providing professional and community service.	CONTISS 13	Deputy Director
6	Deputy director	Promotion of a confirmed and suitable Chief Quantity Surveyor who has spent at least three years on the post.	Performing at higher level, similar duties specified above. Carries out other duties as may be assigned and providing professional and community service.	CONTISS 14	Director
7	Director	Appointment only.		CONTISS 15	

** CONTISS - Consolidated Tertiary Institution Salary Structure in Nigerian Public Service*

3. Research Method

The research methodology adopted for this study includes Delphi survey method. The method involves conduct of rounds of survey on group of experts in a particular field with the intention of eliciting a consensus opinion on an issue (Yousuf, 2007).

In selecting the experts used for this study, a panel drawn from members of the Nigerian Institute of Quantity Surveyors (NIQS) was constituted. Specifically, the chairmen of state chapters and the head of academic institution offering quantity surveying were targeted in the sampling frame. Fifty percent of the functioning 27 state chapter chairs were randomly selected. Of the twenty-nine public institutions offering quantity surveying in Nigeria; seventy-five percent of the heads of department were also randomly selected. Two members of the National Executive Council of the NIQS – chairman of the education committee and that of professional development committee were purposively included. This is as a result of their peculiar portfolio about the training of quantity surveyors. In all, a total number of thirty-eight members panel of experts were included in the survey. The shortlisted members of the panel were written to inform them of their inclusion and the purpose of the study. This gives them the opportunity to accept or dissent their participation. The letter also intimates them of the procedure and guidelines that would be followed.

Structure questionnaire, highlighting various issues of investigation, was designed for the first round of the survey. This gives the participants the opportunity to affirm or comment on the revised and added comments from the anonymous members of the panel. The survey was conducted via registered courier post with adequate follow-up. Twenty-nine members of the panel responded to the first round. Responses for the first round were analysed, and the feedback was used as basis for the second round. Twenty -seven out of the twenty-nine that responded to the first round gave valid response to the second round. Theoretically, Delphi process can be continuously iterated until consensus is determined to have been achieved (Hsu and Sandford, 2007). Custer et al. (1999) also pointed out that three iterations are often sufficient to collect the needed information and to reach a consensus in most situations. However, in this research, two rounds of iteration were conducted to obtain valid results.

In validating the proposed framework, an interview was conducted on small group of quantity surveyors purposively selected based on their long years of experience in the industry. The selection included five quantity surveyors in private practice and two quantity surveyors in academic. An effort was made to ensure that they were not captured in the earlier survey. Specifically, they were interviewed to comment on the appropriateness of the results produced by the consensus opinion and to give their candid view on the process. The interviewees attested to the credibility of the process and the usefulness as well as the relevancy of the proposed framework.

4. Results, Findings and Discussions

This section presents and discusses the conceptual career path framework developed from the results of the study. The framework design for a typical quantity surveying firm was adapted from what obtains in the public sector (Table 1). The section involves the process of recruitment (including conduct of interview and aptitude tests);

post/cadre to be adopted for private practice; as well as qualification and experience required for the respective posts/cadres.

4.1 Recruitment of Quantity Surveyors

This section discusses the findings on issues relating to the recruitment of quantity surveyors into the profession. The findings were from the outcome of the final results of the Delphi survey (Tables 2 and 3).

Table 2: Summary of Responses to issues relating to Recruitment of Quantity Surveyors

Test	Yes/ (%)	No/ (%)
General Knowledge	27 (100)	0 (0)
Professional Knowledge (specific competencies)	27 (100)	0 (0)
Personal Interview (work experience)	27 (100)	0 (0)

Table 3: Summary of responses to the revised/added comments/suggestions on issues relating to Recruitment of Quantity Surveyors

Comment/suggestion	Agree (%)	Disagree (%)
Spoken/Written English	26 (96.23)	1 (3.77)
ICT	26 (96.23)	1 (3.77)
Industry sector-specific knowledge	19 (70.37)	8 (29.63)
Current Affairs	12 (44.44)	15 (55.56)
Human Relation	25 (92.59)	2 (7.41)

The results indicate that new entrants into any cadre of the profession should involve the conduct of series of writing/aptitude tests and should be made to cover: general knowledge, professional knowledge (which addresses specific competencies) and Personal Interview (which addresses work experience). Interview serve as guide and selection process which enables the evaluation of the core competencies expected of quantity surveyor; professional test questions should, therefore, be structured toward them as much as possible. Other areas found to be highly essential and to be addressed are: Spoken/Written English Language, Information and Communication Technology experience, Industrial Specific knowledge and the issue of Human Relations. The issue of spoken /Written English Language is essential as the official language of communication is the English Language. Other identified areas are the specific knowledge which has to do with the basic technical skill and competency requirements which have been documented by various studies. Also; as quantity surveyors will be relating to different stakeholders in the industry and other groups of people and organizations; the issue of human relation is considered very vital in professional practice.

4.2. Quantity surveyor Career pathway framework for private practice

From the outcome of the final results of the Delphi survey, the criteria for developing the proposed quantity surveyor career pathway framework is summarized and presented in Tables 4 and 5

Table 4: Summary of Responses to the Proposed Quantity Surveyor Career Pathway Framework

Qualification	Post/Cadre	Yes/ (%)	No/ (%)
ND	Junior Quantity Surveyor	13 (48.15)	14 (51.85)
HND	Assistant Quantity Surveyor	24 (88.89)	3 (11.11)
B.Sc.	Assistant Quantity Surveyor	24 (88.89)	3 (11.11)
HND/B.Sc. plus NIQS professional qualification	Quantity Surveyor	26 (96.31)	1 (3.77)
M.Sc. plus five years cognate experience but without NIQS professional qualification	Quantity Surveyor	9 (33.33)	18 (66.67)
HND/B.Sc. plus five years cognate experience and with NIQS professional qualification	Senior Quantity Surveyor	25 (92.59)	2 (7.41)
M.Sc./Ph.D. plus NIQS professional qualification	Senior Quantity Surveyor	26 (96.23)	1 (3.77)
HND/B.Sc./M.Sc. /Ph.D. plus NIQS professional qualification and over 15 years cognate experience	Chief Quantity Surveyor	26 (96.23)	1 (3.77)

Table 5: Summary of Responses to the revised/added comments/suggestions to the Proposed Quantity Surveyor Career Pathway Framework

Comment/suggestion	Agree (%)	Disagree (%)
(ND) Trainee QS	17 (62.96)	10 (37.04)
(ND) QS Assistant	6 (22.22)	21 (77.78)
(ND) Estimator	2 (7.41)	25 (92.59)
(ND) QS Technician	2 (7.41)	25 (92.59)
(HND) Higher Technical Officer	7 (25.93)	20 (74.07)
(HND) QS Trainee	2 (7.41)	25 (92.59)
(B.Sc.) Pupil QS	7 (25.93)	20 (74.07)
(B.Sc.) QS II	11 (40.74)	16 (59.26)
(HND/B.Sc. +MNIQS) QS I	10 (37.04)	17 (62.96)
(HND/B.Sc. +MNIQS) Senior QS	4 (14.81)	23 (85.19)
(HND/B.Sc. +MNIQS+2yrs *exp.) Senior QS	22 (81.48)	5 (18.52)
(HND/B.Sc. +MNIQS+10yrs exp.) Principal QS	23 (85.19)	4 (14.81)
(HND/B.Sc. +MNIQS+15yrs exp.) Partner	22 (81.48)	5 (18.52)
(HND/B.Sc.+MNIQS+20yrs exp.) Consultant QS	12 (44.44)	25 (55.56)

(HND/B.Sc.+MNIQS+25yrs exp.) Principal Consultant	19 (70.37)	8 (29.63)
Candidate to pass NIQS and reg. with QSRBN before called QS	20 (74.07)	7 (25.93)

**exp - experience*

Table 6 presents the developed conceptual framework which detailed the agreed posts/cadres to be adopted in private practice as well as the qualifications and experience to match them. This ranges from the trainee quantity surveyor, assistant quantity surveyor, through principal partner/consultant. A holder of the lowest degree (ND) is to be regarded as trainee, while holder of HND/B.Sc. is to be regarded as assistant quantity surveyors. Any candidate with HND/B.Sc. moreover, who has passed the professional examination and registered with the QSRBN should be regarded as quantity surveyor. From this premise, it is to be noted that before anybody is called quantity surveyor, he/she must have passed the professional examinations and duly registered with the QSRBN. Subsequent cadres have to do with post qualification and years of experience. Adopting this policy in private practice is seen as good development which will engender uniformity among quantity surveying practitioners.

Table 6: Framework for Quantity Surveyors' Career Path in Private Practice

Post/Cadre	**Qualifications and experiences**
Trainee Quantity Surveyor	ND
Assistant Quantity Surveyor	HND/B.Sc.
Quantity Surveyor	HND/B.Sc. + NIQS professional qualification
Senior Quantity Surveyor	HND/B.Sc. + NIQS professional qualification + 5 years cognate experience
Principal Quantity Surveyor	HND/B.Sc. + NIQS professional qualification + 10 years cognate experience
Chief Quantity Surveyor	HND/B.Sc. + NIQS professional qualification + 15 years cognate experience
Partner	HND/B.Sc. + NIQS professional qualification + 15 years cognate experience
Principal Partner/Consultant	HND/B.Sc. + NIQS professional qualification + 25 years cognate experience
Post/Cadre	Qualifications and experiences

Trainee quantity surveyor cadre

For the post of trainee quantity surveyor, the prospective applicant must have at least OND in quantity surveying from an accredited institution. Creation of this cadre in the professional development cycle helps the career development of quantity surveying graduates up to managerial levels.

Assistance quantity surveyor cadre

For the post of assistance quantity surveyor, the prospective applicant must have at least first degree (HND or B.Sc. quantity surveying) from an accredited institution. Fresh graduates will mostly fall into this category. This is because of the limited professional training or experience (as indicated in the framework). This cadre affords an individual while working in a quantity surveying firm, to commence the professional certification process. It also affords the firm to create a platform for sponsoring their employee in this regard.

Quantity surveyor cadre

To be qualified for this post of quantity surveyor, the prospective applicant must have at least HND or B.Sc. in quantity surveying from an accredited institution and must have passed the Test of Professional Competence (TPC)/Graduateship Examination and the Professional Competence Interview (PCI) conducted by the institute. Also, candidates must have a minimum of two years experience after graduation (inclusive of the "National Youth Service Corps - NYSC year), completed and passed assessment of logbook and diary of experience for two years and registered with the QSRBN. Any candidate with these qualifications are automatically regarded and recognized as qualified quantity surveyor.

Senior quantity surveyor, Principal quantity surveyor, Chief quantity surveyor, and Principal Partner/Consultant cadres

These cadres have to do with post qualification couple with the number of years of experience. The experience garnered over time goes a long way to affecting the proficiency level of an employee. The experience often comes in the form of continuing professional development. A proactive framework, to ensuring that the experience garner over time is adequately rewarded by way of moving up the ladder with corresponding benefits, is therefore considered highly imperative. This will not only encourage an employee to put in more effort, but it will also help in the stability of the organization.

5. Conclusions and Recommendations

In response to bridging the gap and resolving the dichotomy that exists in quantity surveyors' recruitment, placement and promotion in private practice in comparison with that of public service in Nigeria working environment; this study was aimed at providing a framework that could serve as a regulated scheme of service and career pathway metrics for quantity surveyor employees in private practice. From the consensus obtained from a panel of expert, a conceptual framework for career path and development of quantity surveyors employees in private practice is proposed. The framework which detailed the agreed posts/cadres to be adopted in private practice as well as the qualifications and experience to match them, ranges from the trainee quantity surveyor, assistant quantity surveyor, through principal partner/consultant. The implications of the study have a direct effect on the employers of quantity surveyors in private practice, the potential (quantity surveyor) employees and quantity surveying service delivery in general. For employers, who are looking for people to hire, the framework can help in drafting better job descriptions internally as well as help the human resource team shortlist candidates and conduct the initial interviews. This has profound implications when trying to evaluate potential employees for respective positions and more importantly when evaluating job changes or responsibility assignments within the organization. This also has relevance for potential employees who are preparing for careers in quantity surveying to help them develop more effective career path development plans. Defined career path framework can improve performances. Employees become familiar with their career progression, and eventually, the entire organization begins to speak consistently when talking about its employees' professional development goals. This is seen to take account of and encourage the career management of prospective employee which is vital to high-quality service delivery. By this means, organizational effectiveness coupled with employee satisfaction can be enhanced and thereby give a win-win situation.

While this study focused majorly on placement and promotion for quantity surveyors; future study is recommended on establishing a uniform, equitable remuneration for the respective cadres in the proposed framework and job description for each cadre. This will further concretize the framework and make it more applicable to a scheme of service in the private practice as obtainable in the public service. Furthermore, the study can be extended, in context, to other construction professionals in Nigeria.

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JCBM (2018) 2(2). 24-35

University of Cape Town

Journal of Construction Business and Management

http://journals.uct.ac.za/index.php/jcbm

Evaluation of Risk Factors and their Impact on Road Projects

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Received 8 January 2018; received in revised form 9 February 2018, 12 April 2018; accepted 19 June 2018
https://doi.org/10.15641/jcbm.2.2.2018.486

Abstract

Construction projects are generally known to be susceptible to risks. This results in an inability to meet performance targets. This paper assessed the risk factors encountered in the delivery of road projects in Osun State, Nigeria. A questionnaire survey was used to obtain data from all the 146 construction professionals involved in the construction of the 34 road projects executed in the study area. The professionals comprised of 34 Consultant Civil Engineers, 34 Consultants' Civil Engineers, 34 Consultant Quantity Surveyors, 34 Consultants' Quantity Surveyors, one project financier and 9 Project Managers, making a total of 146 respondents. Using two-dimensional scaling, the respondents were asked to provide opinions on risk occurrence and their impacts on road projects. The data collected were analysed using mean ranking analysis and student t-test. A further analysis was carried out using factor analysis to reduce the factors impacting road projects into fewer factor components. The results revealed that the risk factors with high extent of occurrence are in the order of change in scope of work, defective design, error and re-work, change in design, delay in availability of design details and unforeseen adverse conditions. Surprisingly, the top ranking risk factors are not the ones with high impact based on the result of the analysis. Using factor analysis, 9 component factors regarding the extent of risk occurrence were obtained and they accounted for 73.73% of the variance explained while 4- component factors were obtained regarding the impact of risk occurrence and they accounted for 46.16% of the variance explained. The study concluded that professionals involved in the delivery of road projects need to be aware of the significant risk factors impacting road projects and put proactive risk management approach in place to deal with them to avoid surprises.
Keywords: Performance, Projects, Risk factors, Risk impact, Road.

1. Introduction

The National Transport Policy for Nigeria (Federal Government of Nigeria (FGN), 2010) outlined the benefits of efficient infrastructure to include the stimulation of national development, enhancement of quality of life, facilitation of the movement of goods and people, connection of spatially separated facilities, facilitation of community and national integration among others. Awodele, Ogunlana and Motawa (2009) also concluded that road networks are key business drivers. Several attempts have been made by various tiers of government responsible for road construction in Nigeria to successfully deliver road projects, but evidence abounds regarding project abandonment, low quality or delayed delivery, and excessively high construction cost (Udeh and Onwuka, 2015). It has been established that road projects are capital intensive and require proper planning as well as a well-coordinated execution (PMI,2012). The attributes mentioned above make road projects risky and uncertain. The risk and uncertainty result in failure to meet performance targets (Greedy, 2005).

According to Mousavi, Mojtahedi and Makui (2011), road projects have peculiar characteristics; these includes the multiplicity of project participants, substantial financial requirement, complex procurement methods among others. This emphasizes the need to understand the specific risks and deploy appropriate risk management strategies on road projects. As a result of the infrastructure deficit in Nigeria, road projects are being proposed and executed in different locations. Unfortunately, previous studies reported that formal risk management techniques needed to avoid time and cost overruns on projects and enhance profitability were not utilised in the Nigerian

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construction industry (Windapo et al., 2010 and Dada, 2010).

Studies have been carried out on risk identification and management on construction projects, but limitations abound. For instance, Hazim and Salem (2015) investigated the key factors causing a delay in road projects in Jordan, but the study was based on literature review only. Ehsan et al. (2010) identified the common risks factors and uncertainties within the building industry in Pakistan, but the research was not empirical as it was based on literature review only. Odeyinka et al. (2005) conducted a study on the likelihood of occurrence and impact of risk factors, but the study was limited to building projects only. Similarly, Belel and Mahmood (2012) used a questionnaire survey to assess risk management practices on building projects in Nigeria while Alagwe and Adegoke (2013) analysed risk factors affecting project performance in Southwestern Nigeria, both studies also failed to consider roadworks. Therefore, this study aims to address the identified gap in the literature by identifying and analysing the risk factors impacting road projects in Osun State, Nigeria. The study area was selected because of the preponderance of road projects there at the time of this study. The findings of this study are expected to enhance the success of road projects regarding cost and time performances.

2. Risk and Road Project Risks

According to Baloi and Price (2003), risk refers to the possibility of an unfavourable occurrence in the course of executing a project. Devripasadh (2007) submitted that within the construction industry, the risk is perceived as any internally or externally motivated event which negatively affects the objectives of a project. Baloi and Price (2003) submitted that risk concept is influenced by the viewpoint, attitude, and experience of an individual. It is also believed that individuals interpret risk based on areas of practice; for instance, financial managers often perceive risk from the financial standpoint while engineers view it from the technological standpoint (Baloi and Price, 2003). Uncertainties characterise construction projects, this is as a result of issues such as planning needs, design demands, resource sourcing, climatic conditions and economic policies among others (Greedy, 2005).

In the project context, the Association for Project Management (APM) (2012) defines risk as ‘an unknown event that, if it occurs, will affect the achievement of one or more project objectives’. Also, the Project Management Institute (PMI) (2016) defines risk as an uncertain occurrence that, if it occurs will have either a positive or negative effect on one or more of the project’s objectives’. A peculiar inclusion in the PMI definition is the probability of a risk having either favourable or an unfavourable impact on the objectives of a project. Miller and Lessard (2001) conducted a study on large engineering projects; the study categorised risks according to three sources. The sources are market, completion and instructional; market risks are caused by uncertainties in demand, completion risks can be described as strategic risks occurring at pre and post completion of a project while experimental risks are associated with uncertainties regarding specification (Miller and Lessard, 2001). Smith (1999) agreed that risks in road projects arise from various sources which include technical, environmental, health, political, and market sources. Management of risk is key to a successful project, but assessment of risk is complex and sometimes not understood in practice (Smith, 1999).

Zou et al. (2007) highlighted the common risk factors on road projects to comprise work changes, delay in contract payment, client’s financial incapability, and labour issues among others. Similarly, Odeyinka et al. (2007) identified before and after contract risk factors in the construction industry in Nigeria, risk in design, estimating, tendering, and tender evaluation was among the risks identified. In a related study, Cohen and Palmer (2004), identified risk factors in road projects to include project scope change, design errors and omissions, insufficient skilled workers, subcontractors and contractors’ experience. Also, Osama and Salman (2003) identified three classes of road risks, comprising of financial risk, time and design–related risks. In contrast, a similar study conducted by Mousavi et al. (2011) classified risk factors involved in road projects under four significant headings namely: engineering, procurement, construction and management.

From the preceding, it is evident that the term ‘risk' has several definitions but the fact that it is the likely occurrence of an event is common to all definitions. Also, risk factors are classified under different headings by different authors from various perspectives. It is also interesting to note that risk in construction has been viewed from different perspectives such as the construction industry as a whole, large engineering projects, pre and post-contract stages of building projects, road projects among others. However, the concern of this study is a risk as they relate to road projects. Presented in the next section is the research method adopted in this study.

3. Research Methods

This study commenced with a review of related literature to extract the risk factors potentially thought to impact road projects. The survey research design was adopted in carrying out the study as it was considered appropriate in reaching a wider number of respondents. A structured questionnaire survey was administered on construction professionals who participated in road projects in Osun State, Nigeria between 2011 and 2015. Osun state was chosen as the study area because of the preponderance of road projects during the period under consideration. The State comprises of 30 Local Government areas, 1 area office and 3 Senatorial Districts. One road project was selected from each of the 30 local governments, one area office and one from each of the 3 Senatorial Districts giving a total of 34 road projects. All the stakeholders that participated in these road projects were engaged in the questionnaire survey. The stakeholders consist of 34 Consultant Civil Engineers, 34 Consultants’ Civil Engineers, 34 Consultants’ Quantity Surveyors, 34 Contractors’ Quantity Surveyors, one project financier and 9 Project Managers, making a total of 146 respondents who constitute the study population. Due to the manageable size, a total enumeration of the study population was engaged in the questionnaire survey. Thus, there was no need for sampling. The questionnaire design was based on 33 risk factors identified from literature and from discussions with professionals involved in road construction. Respondents' opinions were sought using a two-dimensional scaling based on the theory of two-dimensional nature of risk (Williams, 1996). The theory suggests that risk analysis should be based on the pair of risk occurrence and risk impact. A 0 to 5 (i.e. 6-point) Likert-type scale was used to assess respondents' strength of opinions whereby 0 meant no risk occurrence and no impact and 5 meant very high probability of risk occurrence and very high impact. Presented in Table 1 is the background information of the respondents. From the Table, it is evident that the respondents are well experienced with 10.78 mean years of experience. They are highly educated, professionally qualified and they have been previously involved in handling road projects. Thus, the responses provided by them could be relied upon. The outcome of the survey and associated discussions are presented in the next section.

Table 1: Respondents' background information

Background Information	Parameters	Frequency	Per cent	Cum. Freq.	Mean
Years of Experience in road construction	0-5 years	3	2.6	2.6	
	6-10 years	64	55.7	58.3	
	11-15 years	32	27.8	86.1	10.78
	16-20 years	12	10.4	96.5	
	Over 20 years	4	3.5	100	
Professional Designation	Consultant's CE	30	26.1	26.1	
	Contractor's CE	21	18.3	44.	
	Consultant's QS	28	24.3	68.7	
	Contractor's QS	26	22.6	91.3	
	Project Financier	1	.9	92.2	
	Project Manager	9	7.8	100	
Educational Qualification	HND	17	14.8	14.8	
	B.Sc/B.Tech/B.Engr	56	48.7	63.5	
	M.Sc/M/Tech/MBA	36	31.3	94.8	
	PhD.	6	5.2	100	
Professional Qualification	MNSE/FNSE	35	30.4	30.4	
	MNIQS/FNIQS	58	50.4	80.4	
	MICE/FICE	10	8.7	89.1	
	MRICS/FRICS	6	5.2	94.3	
	MAPM/PMP	6	5.2	100	
Road Projects executed in last five years	0-5	27	23.5	23.5	
	6-10	50	43.5	67.0	
	11-15	29	25.2	92.2	8.80
	16-20	4	3.5	95.7	
	Over 21	5	4.3	100	
Total		**115**	**100.0**		

A total of 146 questionnaires were administered, and 115 were returned, filled and fit for analysis. Data analysis was done using mean ranking analysis, Student t-test and factor analysis. The mean score was used to rank the risk factors, and it was calculated using the formula in Equation 1.

$$MS = \frac{5n5+4n4+3n3+2n2+1n1+0n0}{n5 + n4 + n3 + n2 + n1 + n0} \qquad \text{(Equation 1)}$$

where, MS = Mean Score

n_0= no of respondent who chose "no occurrence" or "no impact"

n_1 = no of respondents who chose "very low occurrence" or "very low impact."

n_2 = no of respondent who chose "low occurrence" or "low impact"

n_3 = no of respondent who chose "moderate occurrence" or "moderate impact"

n_4 = no of respondents who chose "high occurrence" or "high impact."

n_5 = no of respondents who chose " very high occurrence" or " very high impact."

Student t-test was used to test the hypothesis of no difference between the mean scoring of clients' consultants and contractors' organisations while factor analysis was used to categorise the occurrence of risk factors and their impact on road projects. To establish the adequacy of the factor loading arising from factor analysis the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used. The Bartlett's test tests the hypothesis which states that the original correlation matrix is an identity matrix. For the use of factor analysis to be adequate, Kaiser stated that values greater than 0.5 are acceptable, this condition was satisfied in this study.

4. Presentation of Results

Presented in this section is the result of data analysis with relevant discussions.

4.1 Analysis of extent of occurrence of risk factors in the delivery of road projects

Table 2 presents the results of data analysis on the extent of occurrence of risk factors in the delivery of road projects. Table 2 shows that the top 5 risks factors regarding occurrence include 'change in project scope', 'defective design, error and rework', 'change in design', 'delay in availability of design details' and 'unforeseen adverse ground condition'. These risk factors have a mean score ranging from 3.64 to 3.73 on a Likert-type scale of 0-5.

A statistical test using Student t-test was carried out at 5% level of significance to test the hypothesis that there is no statistical difference in the mean responses of clients' consultants and responses from contractors' organisations on the extent of occurrence of the identified 33 risk factors in the delivery of road projects they were involved with. Table 2 shows the t- statistics and the p-values. However, four risk variables namely 'high maintenance cost', 'non-availability of spare parts for construction plant and equipment', 'shortage of experts in road construction' and 'change in government' were found to have statistically significant different mean values(P<0.05). Whereas high maintenance cost ranked 6th in the overall mean score, it ranked 13th and 2nd under the client's consultants and contractors' organisations scoring respectively. This is not surprising because contractors are more involved in post construction road maintenance and tend to be more aware of the high cost of maintenance than the consultants who were only involved at the design and construction stages. Hence, they scored this risk factor higher. Similarly, non-availability of spare parts for construction plant and equipment ranked 23rd and 5th under the client's consultants, and contractors' organisations scoring respectively but ranked 11th overall.

Table 2: Extent of Occurrence of Identified Risk Factors in the Delivery of Road Projects

Risk Factors	Overall Mean Score	Overall Rank	Client's Consultant Mean	Rank	Contractors' Organisations Mean	Rank	T-statistic	*P*-values
Change in scope of work	3.73	1	3.63	2	3.87	1	1.604	0.208
Defective design, error and rework	3.70	2	3.63	2	3.80	5	0.881	0.350
Change in design	3.65	3	3.54	7	3.80	5	1.933	0.167
Delay in availability of design details	3.64	4	3.51	9	3.83	3	2.685	0.104
Unforeseen adverse ground condition	3.64	4	3.71	1	3.54	19	0.714	0.400
High maintenance cost	3.61	6	3.45	13	3.85	2	5.640	0.019*
Contractors cash flow problem	3.60	7	3.62	4	3.59	15	0.032	0.859
Poor relationship with the community	3.59	8	3.42	16	3.83	3	3.918	0.050
Shortage of major road construction materials	3.56	9	3.42	16	3.76	9	3.301	0.072
Lack of commitment between parties	3.56	9	3.55	5	3.57	18	0.005	0.943
Non- availability of spare parts for construction plants and equipment	3.54	11	3.35	23	3.80	5	6.332	0.013*
Lack of attention to market conditions	3.54	11	3.48	10	3.63	14	0.729	0.395
Subcontractors incompetence	3.53	13	3.38	20	3.74	10	3.540	0.063
Lack of attention to contract requirements	3.53	13	3.54	7	3.52	23	0.009	0.924
Inclement weather	3.52	15	3.48	10	3.59	15	0.331	0.566
Shortage of experts in road construction	3.51	16	3.32	25	3.78	8	6.076	0.015*
Public opposition to projects	3.51	16	3.38	20	3.70	12	2.270	0.135
Shortage of equipment	3.50	18	3.35	23	3.72	11	3.587	0.061
Shortage of skilled labourers	3.50	18	3.38	20	3.65	13	2.194	0.141
Delay in receiving projects permits and approval	3.50	18	3.55	5	3.43	27	0.367	0.546
Delay in payment by the client	3.48	21	3.43	14	3.54	19	0.400	0.529
Inadequate specification	3.48	21	3.48	10	3.48	25	0.000	0.994
Failure of major construction equipment	3.47	23	3.42	16	3.54	19	0.404	0.526
Inflation/interest rate fluctuation	3.46	24	3.40	19	3.54	19	0.517	0.474
Lack of legal, regulatory framework	3.42	25	3.31	27	3.59	15	2.313	0.131

Lack of communication between central office and site Office	3.41	26	3.43	14	3.37	29	0.114	0.737
Adverse ground condition	3.38	27	3.32	25	3.46	26	0.536	0.466
Foreign exchange rate fluctuation	3.36	28	3.25	29	3.52	23	1.865	0.175
Flood	3.32	29	3.25	29	3.43	27	0.772	0.382
Strong political interference	3.27	30	3.31	27	3.22	30	0.267	0.606
Government officials demanding bribe/unjust reward	3.20	31	3.18	31	3.22	30	0.024	0.877
Project documents not issued on time	3.11	32	3.15	32	3.04	32	0.343	0.560
Change in government	2.95	33	3.14	33	2.67	33	6.345	0.013*

**p-value is significant at 0.05*

A further analysis was carried out regarding the extent of occurrence of risk factors using factor analysis. The goal was to reduce the 33 risk variables to smaller groups of factors. The principal component analysis 'varimax rotation method' was utilised. Table 3 shows the total variance explained and how the variance is distributed among the 33 risk occurrence variables. It should be noted that nine factors have eigenvalues (i.e. a measure of explained variance) greater than 1.0, a common criterion for determining the usefulness of a factor. Together these nine factors accounted for 73.73% (more than two-thirds) of the variance in the original variables. This suggests that nine component factors were associated with the perception of client's consultants as well as contractor organisations regarding the extent of risk occurrence in the delivery of road projects, but there was room for much-unexplained variation. Tables 3 and 4 show the total variance explained by the factors and the rotated component matrix for the extent of risk occurrence respectively.

Table 3: Total Variance Explained for Extent of Risk Occurrence

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.082	30.552	30.552	10.082	30.552	30.552	3.821	11.577	11.577
2	3.007	9.112	39.663	3.007	9.112	39.663	3.561	10.792	22.369
3	2.273	6.887	46.551	2.273	6.887	46.551	2.810	8.516	30.885
4	1.941	5.883	52.433	1.941	5.883	52.433	2.567	7.780	38.665
5	1.918	5.813	58.247	1.918	5.813	58.247	2.526	7.653	46.318
6	1.508	4.571	62.818	1.508	4.571	62.818	2.516	7.623	53.941
7	1.312	3.975	66.793	1.312	3.975	66.793	2.510	7.605	61.547
8	1.208	3.661	70.454	1.208	3.661	70.454	2.510	7.605	69.151
9	1.081	3.277	73.731	1.081	3.277	73.731	1.511	4.580	73.731
10	.881	2.671	76.401						
11	.811	2.456	78.858						
12	.661	2.004	80.862						
13	.654	1.983	82.845						
14	.537	1.629	84.474						
15	.496	1.504	85.978						
16	.477	1.445	87.422						
17	.453	1.373	88.795						
18	.401	1.214	90.010						
19	.384	1.165	91.174						
20	.340	1.029	92.203						
21	.311	.942	93.145						
22	.286	.867	94.012						
23	.270	.818	94.831						
24	.247	.748	95.579						
25	.242	.733	96.311						
26	.219	.663	96.974						
27	.209	.632	97.607						
28	.177	.535	98.142						
29	.161	.487	98.629						
30	.139	.420	99.049						
31	.115	.348	99.397						
32	.111	.337	99.734						

33	.088	.266	100.000

Extraction Method: Principal Component Analysis

Table 4: Rotated Component Matrix for Extent of Risk Occurrence

	Component								
	1	2	3	4	5	6	7	8	9
Poor relationship with the community	.826								
Public opposition to projects	.800								
Shortage of equipment	.766								
Shortage of major road construction materials	.664								
Inflation/interest rate fluctuation	.639								
Project documents not issued on time		.841							
Change in government		.824							
Strong political interference		.788							
Government officials demanding bribe/unjust reward		.774							
Foreign exchange rate fluctuation		.598							
Inadequate specification			.789						
Delay in receiving projects permits and approval			.729						
Non-availability of spare parts for construction plants and equipment			.727						
Lack of communication between central office and site office			.603						.534
Shortage of experts in road construction				.843					
Shortage of skilled labourers				.790					
Subcontractors incompetence				.657					
Lack of commitment between parties				.535					
Change in scope of work					.843				
Change in design					.772				
High maintenance cost					.727				
Delay in availability of design details									
Lack of attention to contract requirements						.830			
Defective design, error and rework						.690			
Delay in payment by the client							.890		
Contractors cash flow problem							.805		
Failure of major construction equipment							.714		
Adverse ground condition								.811	
Inclement weather								.723	
Flood								.644	
Lack of attention to market conditions									.757
Lack of legal regulatory framework									

Note -Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 9 iterations.

The nine principal factors extracted are interpreted as follows (see Table 4 for factor loadings):
Factor 1: Socio-economic risk
Factor 2: Socio-political risk
Factor 3: Project regulation and administration;
Factor 4: Shortage of skilled and committed manpower risk;
Factor 5: Project complexity risk;
Factor 6: Design risk;
Factor 7: Financial risk;
Factor 8: Environmental risk;
Factor 9: Legal and economic risk.

Factor 1: Socio-economic risks

This factor loading incorporates the following five risk variables: poor relationship with community, public opposition to projects, shortage of equipment, shortage of major road construction materials and inflation/interest rate fluctuation. These risk variables have loadings of 0.826, 0.800, 0.766, 0.664, and 0.639, respectively.

Factor 2: Socio-political risk

This factor loading incorporates the following five risk variables: project documents not issued on time, change in government, strong political interference, government officials demanding bribe/unjust reward and foreign exchange rate fluctuation. These five components have loadings of 0.841, 0.824, 0.788, 0.774, and 0.598, respectively.

Factor 3: project regulation and administration

Loaded on this factor are the following four risk variables: inadequate specification, delay in receiving projects permits and approval, non-availability of spare parts for construction plants and equipment as well as lack of communication between central office and site office. These four components have loadings of 0.789, 0.729, 0.727, 0.774, and 0.603, respectively.

Factor 4: a shortage of skilled and committed manpower risk

The four risk variables that loaded onto Factor 4 comprise of a shortage of experts in road construction, shortage of skilled labourers, subcontractors' incompetence and lack of commitment between parties. These four components have loadings of 0.843, 0.790, 0.657, and 0.535 respectively.

Factor 5: project complexity risk

Risk variables that loaded unto Factor 5 comprise of change in scope of work, change in design and high maintenance cost. These three components have a loading: 0.843, 0.772 and 0.727 respectively.

Factor 6: design risk

It is evident from Table 3 that these two risk variables, namely, lack of attention to contract requirements, and defective design, error and rework loaded unto project design risk. These two components have a loading of 0.830 and 0.690 respectively.

Factor 7: financial risks

Likewise, the three risk variables that loaded onto the seventh factor relates to funding of the project. They comprise of delay in payment by the client, contractors cash flow problem and failure of major construction equipment. This factor was labelled, "financial risks". These three components have factor loadings of 0.890, 0.805 and 0.714 respectively.

Factor 8: environmental risks

The three risk variables that loaded onto Factor eight are an adverse ground condition, inclement weather and flood. This was labelled, "environmental risks. These three components have factor loadings of 0.811, 0.723 and 0.644 respectively.

Factor 9: Poor legal and economic risks

Lack of communication between central office and site office" had its highest loading from the third factor with a cross-loading over the ninth factor. Lack of attention to market conditions also loaded on this factor. This factor was categorised as "legal and economic risks".

4.2 Impacts of risk factors in the delivery of road projects

This section examines the perceptions of client's consultants and contractors' organisations on the impacts of the identified risk factors on the delivery of road projects. The 33 risk factors derived from literature as potentially affecting the delivery of road projects were analysed and presented in Table 5. The result showed that the nine (9) top ranking risk factors with high impacts on the delivery of road projects are 'change in government', 'lack of attention to contract requirements', 'poor relationship with community', 'strong political interference', 'contractors' cash flow problem', 'delay in payment by the clients', 'inflation/interest rate fluctuations', 'unforeseen adverse ground condition' and 'projects documents not issued on time'.

Further analysis with t-test was carried out to test the hypothesis that there was no statistically significant difference in the perceptions of client's consultants and contractors' organisations on the impact of the 33 identified risk factors in the delivery of road projects. The results shown in Table 5 indicates that client's consultants and contractors were mostly unanimous in their scoring of the risk factors impacting the delivery of road projects($P<0.05$). The exceptions are three risk factors with evidence of a statistically significant difference of opinion ($P<0.05$). These three risk factors are 'poor relationship with the community', 'defective designs, error and rework' as well as 'adverse ground conditions and they ranked 3rd, 13th and 32nd respectively in the overall mean score.

Table 5: Impact of identified Risk Factors on Road Projects

Risk Factors	Overall Mean Score	Overall Rank	Client's Consultant Mean	Rank	Contractors' Organisations Mean	Rank	T-statistic	*P*-values
Change in government	3.61	1	3.53	2	3.53	2	1.423	.235
Lack of attention to contract requirements	3.60	2	3.53	2	3.53	2	1.280	.260
Poor relationship with the community	3.58	3	3.42	12	3.42	12	4.364	.039*
Strong political interference	3.55	4	3.50	4	3.50	4	.456	.501
Contractors cash flow problem	3.53	5	3.55	1	3.55	1	.042	.838
Delay in payment by the clients	3.52	6	3.44	9	3.44	9	1.416	.237
Inflation/interest rate fluctuations	3.50	7	3.44	9	3.44	9	.813	.369
Unforeseen adverse ground condition	3.50	7	3.48	5	3.48	5	.078	.780
Projects documents not issued on time	3.50	7	3.44	9	3.44	9	.697	.406
Public oppositions to projects	3.49	10	3.38	17	3.38	17	2.129	.147
Failure of major construction equipment	3.48	11	3.48	5	3.48	5	.008	.929
Lack of attention to the market condition	3.44	12	3.42	12	3.42	12	.061	.805
Defective design, error and rework	3.43	13	3.20	31	3.20	31	13.177	.000*

Inadequate specifications	3.43	13	3.39	14	3.39	14	.317	.575
Lack of legal, regulatory framework	3.43	13	3.45	7	3.45	7	.073	.788
Government officials demanding bribe/unjust reward	3.42	16	3.36	19	3.36	19	.679	.412
Shortage of equipment	3.41	17	3.26	25	3.26	25	3.795	.054
Non-availability of spare parts for construction plants and equipment	3.39	18	3.39	14	3.39	14	.005	.946
Lack of communication between central office and site office	3.37	19	3.30	22	3.30	22	.786	.377
Subcontractors incompetence	3.36	20	3.32	21	3.32	21	.409	.524
Foreign exchange rate fluctuation	3.35	21	3.23	28	3.23	28	2.541	.114
Shortage of skilled labourers	3.35	21	3.29	24	3.29	24	.948	.332
Change in scope of work	3.35	21	3.39	14	3.39	14	.282	.596
Lack of commitment between parties	3.35	21	3.24	27	3.24	27	1.755	.188
Delay in receiving projects permit and approval	3.33	25	3.33	25	3.21	29	2.235	.138
Inclement weather	3.33	25	3.33	25	3.45	7	2.955	.088
Delay in availability of design details	3.30	27	3.30	27	3.18	33	2.853	.094
Change in design	3.30	27	3.30	27	3.33	20	.217	.643
Shortage of major road construction materials	3.29	29	3.29	29	3.21	29	1.058	.306
Shortage of experts in road construction	3.29	29	3.29	29	3.26	25	.229	.633
High maintenance cost	3.29	29	3.29	29	3.30	22	.024	.878
Adverse ground condition	3.22	32	3.22	32	3.38	17	4.995	.027*
Flood	3.21	33	3.21	33	3.20	31	.038	.845

p-value is significant at 0.05

Using factor analysis, a further analysis was done to reduce the 33 risk variables to smaller groups of factors impacting the delivery of road projects. The varimax rotation method in the Principal Component analysis was employed. The KMO obtained from the analysis was 0.734, and it falls into the range of 'good'. This confirms the appropriateness of the use of factor analysis for the data set. Similarly, Bartlett's test is highly significant (p = 0.000) and further confirms that factor analysis is appropriate. The four impact factors generated accounted for 46.16% of the variance explained (see Table 6). Tables 6 and Table 7 show the total variance explained by the factors and the rotated component matrix for the impacts of risk respectively

Table 6: Total Variance Explained for Impact of Risk Factors

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.926	20.988	20.988	6.926	20.988	20.988	4.628	14.023	14.023
2	3.670	11.122	32.110	3.670	11.122	32.110	3.952	11.975	25.998
3	2.384	7.225	39.335	2.384	7.225	39.335	3.795	11.499	37.498
4	2.253	6.828	46.163	2.253	6.828	46.163	2.860	8.666	46.163
5	1.907	5.780	51.943						
6	1.649	4.998	56.941						
7	1.560	4.728	61.670						
8	1.388	4.207	65.877						
9	1.308	3.963	69.839						
10	1.079	3.270	73.109						
11	.958	2.904	76.013						
12	.778	2.357	78.371						
13	.685	2.077	80.448						
14	.664	2.011	82.458						
15	.560	1.696	84.154						
16	.516	1.563	85.717						
17	.482	1.462	87.179						

18	.458	1.387	88.566
19	.424	1.284	89.851
20	.396	1.201	91.051
21	.344	1.041	92.093
22	.325	.985	93.078
23	.322	.975	94.052
24	.287	.870	94.922
25	.251	.762	95.684
26	.237	.718	96.402
27	.230	.696	97.098
28	.211	.638	97.736
29	.178	.540	98.275
30	.161	.488	98.763
31	.149	.450	99.214
32	.135	.408	99.621
33	.125	.379	100.000

Extraction Method: Principal Component Analysis

Table 7: Rotated Component Matrix for Impact of Risk Factors

	Component			
	1	**2**	**3**	**4**
Subcontractors incompetence	.713			
Shortage of experts in road construction	.689			
Delay in availability of design details	.673			
Shortage of skilled labourers	.661			
High maintenance cost	.619			
Lack of commitment between parties	.585			
Defective design, error and rework	.564			
Lack of attention to contract requirements	.544			
Change in scope of work	.542			
Change in design	.524			
Non-availability of spare parts for construction plants and equipment				
Shortage of equipment		.701		
Poor relationship with community		.670		
Public oppositions to projects		.643		
Shortage of major road construction materials		.643		
Adverse ground condition		.638		
Inclement weather		.622		
Flood		.548		
Change in government				
Failure of major construction equipment			.726	
Delay in payment by the clients			.690	
Contractors cash flow problem			.674	
Lack of legal regulatory framework			.574	
Delay in receiving projects permit and approval			.559	
Unforeseen adverse ground condition			.545	
Inadequate specifications				
Lack of communication between central office and site office				
Lack of attention to market condition				
Government officials demanding bribe/unjust reward				.788
Foreign exchange rate fluctuation				.727
Strong political interference				.679
Projects documents not issued on time				.528
Inflation/interest rate fluctuations				.510

Note - Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 4 iterations.

The four principal factors extracted are interpreted as follows (see Table 7 for factor loadings):
Factor 1: Project complexity risk;
Factor 2: Logistic, social and environmental risk;
Factor 3: Political and financial risks;
Factor 4: Socio-economic risks.

Factor 1: Project Complexity Risk

In all, nine risk variables loaded into factor 1: Project complexity risk. The risk variables are subcontractors' incompetence, shortage of experts in road construction, delay in availability of design details, shortage of skilled labourers, high maintenance cost, lack of commitment between parties, defective design, error and rework, lack of attention to contract requirements, change in scope of work and change in design. These nine components have a loading: 0.713, 0.689, 0.673, 0.661, 0.619. 0.585, 0.564, 0.544, 0.542 and 0.524 respectively.

Factor 2: Logistic, social and environmental risk

In all, seven risk variables loaded into factor 2: logistic, social and environmental risk. These risk variables are a shortage of equipment, poor relationship with the community, public oppositions to projects, shortage of major road construction materials, adverse ground condition, inclement weather and flood. These seven components have factor loadings of 0.701, 0.670, 0.643, 0.619, 0.638, 0.622, and 0.548 respectively.

Factor 3: Political and financial risks

A total of 6 risk variables loaded into factor 3: political and financial risk. These comprise of failure of major construction equipment, delay in payment by the clients, contractor's cash flow problem, lack of legal, regulatory framework, delay in receiving projects permit and approval and unforeseen adverse ground condition. These six components have factor loadings of 0.726, 0.690, 0.674, 0.574, 0.559, and 0.545 respectively.

Factor 4: Risks relating to socio-economic issues

A total of 5 risk variables loaded into factor 4: risks relating to socio-economic issues. The risk variables are government officials demanding bribe/unjust reward, foreign exchange rate fluctuation, strong political interference, projects documents not issued on time and, inflation/interest rate fluctuations. These five components have factor loadings of 0.788, 0.727, 0.679, 0.528 and 0.510 respectively.

5. Discussion of findings

The top-ranking risk factors, regarding the extent of occurrence of risk factors (Table 2) relate to project scope, design issues and ground condition. These are usually areas of considerable uncertainty and pose great concerns to construction professionals in the delivery of road projects. Contractors' organisation scored these risk factors higher than the client's consultants because being more directly involved in project execution; they are constantly confronted with the issues. Generally, the result (Table 2) showed that client's consultants and contractors' organisations agreed on their scoring of the degree of risk occurrence in the delivery of road projects. There is a statistically significant difference in the ratings of the two groups of respondents on only four out of thirty-three factors.

On the impact of the risk factors, this study revealed that political as well as economic issues impact much more on the delivery of road projects in Nigeria while issues relating to scope changes and design issues tend to occur more. Surprisingly, the order of impact differs from the order of extent of risk occurrence. For instance, the impact of 'contractors cash flow problem', 'delay in payment by the clients', and 'inflation/interest rate fluctuations' are high (Table 5) but their probability of occurrence was negligible. These risk factors could be the result of bureaucracy involved in the processing of certificates, invoices and valuations. Buertey et al. (2012a) and Oyewobi et al. (2011) conducted studies in Ghana and Nigeria respectively on risks impacts on construction projects and confirms that this category of risk factors has the greatest impact on construction. The differing order of impact and occurrence underscores the theory of two-dimensional nature of the risk (Williams, 1996). This circumstance was also described in a study on risk factors impacting construction cash flow forecast by Odeyinka et al. (2008). Contractors' organisations and client's consultants ranked high the impact of 'contractors cashflow problem' - a financial risk (Table 5), this indicates that irrespective of the value of contracts, the impact of financial risks on road project is high. Buertey et al. (2013) submitted that the effect of financial risks on projects cannot be overemphasized, as they have the high propensity to affect the cash flow of projects which can result in a delay.

Generally, it can be argued that client's consultant and contractors' organisations were largely unanimous on their ratings of risk impacts and their rating of the extent of occurrence of risks on road projects. However, few factors were also rated far apart by the two groups of respondents. For instance, non-availability of spare parts for construction plant and equipment ranked 23rd and 5th under the client's consultants, and contractors' organisations scoring respectively but ranked 11th overall (Table 2). It can be said that contractors' organisation scored these risk factors higher than the consultants because they are more aware of the non-availability of spare parts for construction plant and equipment. The consolidation of the 33 risk factors using factor analysis revealed the occurrence of social, economic, legal, political and environmental risks among others, while project complexity, logistic, political and socio-economic risks best describes the substantial risks impacting road projects. It is essential that proactive arrangements be made to manage the risks when they are occurring.

6. Conclusions

Several attempts have been made by various tiers of government responsible for road construction in Nigeria, but evidence abounds regarding project abandonment, low quality or delayed delivery, and excessively high construction cost. Based on the findings from this study, three main conclusions are offered. First, 33 risk variables were identified as occurring in the delivery of road projects in Osun State, Nigeria and they variously impact the delivery of road projects. The risk factors could be reduced to nine component factors, namely; socio-economic risk, socio-political risk, project regulation and administration risk, shortage of skilled and committed manpower risk, project complexity risk, design risk, financial risk, environmental risk, and legal and economic risk. Out of all these factors, the risk factors with the highest level of occurrence related to project scope changes, design issues and the problem with site conditions. This implies that the construction contractors and designers need to be aware of these risk factors as a whole and the most important ones to focus on so they can be proactive in managing them.

Second, the 33 identified risk factors impacting the delivery of roadworks in Osun State, Nigeria could be reduced to four principal factors, namely: project complexity risk, logistic, social and environmental risk, political and financial risks, and socio-economic risks. Out of all these factors, the risk variables with the highest level of impact relate to political and economic issues. This implies that the construction contractors and Consultants need to have an awareness of the risk factors impacting road projects and pay particular attention to those with high impacts for effective management.

Third, the fact that the set of risk factors with a high level of occurrence is different from the set of risk factors with a high level of impact underscores the purpose of exploring the two-dimensional nature of risk in risk analysis and management.

6.1 Recommendation

Based on the above conclusions, the following recommendation is proposed; The construction Contractors and Clients Consultants should pay close attention to the identified top-ranking risk factors with high extent of occurrence and impact. A devise pro-active approach is needed to manage them.

6.2 Suggestions for Further Research

The study was limited to Road projects. The study area was also restricted to Osun State of South Western Nigeria. The study can be further extended to other parts of the country as well as to building projects. Also, there is a need for the use of many more road projects in developing risk impact models and exploring the use of other modeling techniques like artificial intelligence to achieve more reliable results.

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JCBM (2018) 2(2). 36-41

University of Cape Town

Journal of Construction Business and Management

http://journals.uct.ac.za/index.php/jcbm

Assessment of the Use of Locally Available Materials for Building Construction in Ado-Ekiti Nigeria

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Received 13 November 2017; received in revised form 1 February 2018, 14 June 2018; accepted 23 June 2018
https://doi.org/10.15641/jcbm.2.2.2018.449

Abstract

The potentials and benefits of local building materials (LBM) remain untapped and seem to progress at a slow rate in the Nigerian building industry. This research examined the availability and level of usage of LBM in Ado-Ekiti, South-Western Nigeria. Further, it considered hindering and helpful factors for the use of LBM in the study area. Based on the extensive review of literatures, ten (10) LBM were identified and examined in the study area. One hundred and fifty (150) professionals closely involved with building construction in Construction companies that are fully operational in Ado-Ekiti were investigated for this study. The Relative index analysis of the frequency in the use of LBM available for building construction in Ado Ekiti revealed that the following LBM are available and in the following order, in the study area: Stone(1) with RII 0.95 , timber(2) RII 0.93, laterite(3) RII 0.92, clay and mud(4) RII 0.91, bamboo(5) RII 0.90, leaves and barks of trees(6) RII 0.88, Palm kernel shells (7) RII 0.85, wild coconut trees(8) RII 0.79, animal wastes (9) RII 0.76 and dung(10) RII 0.74. However, the level of usage of these materials is still very low. Considering the economic, socio-cultural and environmental benefits of LBM, this study recommended more awareness campaign and sensitization of the public on LBM in order to promote its social acceptability. In addition, it recommended that Federal and State governments should facilitate more research in the use of the available local materials for building construction. Availing funds specifically for research and development of LBM will also promote its use.

Keywords: Affordable Housing, Building Materials, Construction, Local knowledge, Nigeria.

1. Introduction

Building materials often constitute the single largest input to housing construction in most developing country cities particularly in Africa (Ugochukwu and Chioma, 2015).

It accounts for about 35% to 37% of the construction cost component and in a standard low income housing unit, the cost of building materials alone can take up to 70% (Windapo and Iyagba, 2007; Ugochukwu and Chioma, 2015). It therefore remains a major reason for the high cost of building construction (Taiwo and Adeboye, 2013). Local Building Materials (LBMs) are materials sourced locally, either occurring naturally or manufactured with locally sourced raw materials (Omole and Bako, 2013). Such materials are within reach and when compared to imported materials, they are cheaper and more affordable in cost (Oloruntoba and Ayodele, 2013).

Africa in general, and Nigeria in particular is endowed with abundant natural resources that can meet their building materials production. However, they still depend largely on imported building materials in order to meet the construction needs (Ugochukwu and Chioma, 2015). For example, the study of Iwuagwu, Onyegiri and Iwuagwu (2016) revealed that fibrous tree (used to produce good structural members for roof, wall, lintel, ceiling and bridges construction) is found mainly in the Savannah region (Middle Belt) of Nigeria. Furthermore, grasses found in abundant measures in the Middle Belt and Northern region of Nigeria are used for the purpose of construction in the Nigerian traditional Architecture (Oruwari and Opuene, 2002).

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Taiwo and Adeboye (2013) affirmed a gradual decline in the use of locally manufactured building materials, as well as massive importation of building materials in Nigeria thus, greatly widening the gap between imports and exports. There are several factors militating against the use of LBMs for building construction in Nigeria. Omole and Bako (2013) noted legal acceptability, social acceptability, doubtful durability, technology to handle setting, uncertainty of cost, double standard on the part of the government, lack of standards and specification, problem of mass production, uncertainty about the demand and uncertainty about the strength of material when compared with their imported counterparts.

Vying the abundant availability of LBMs and its under-utilization in Nigeria several studies have been carried out but there is yet to be a focused one in towns or cities in Nigeria to consider in specific terms, the availability, level of usage and problems associated with the adoption in specific towns or cities in South-Western Nigeria, in order to promote the usage. This study bridged this gap. It focused on Ado-Ekiti, an indigenous city in South-Western Nigeria which also doubles as the State Capital of Ekiti State. The City has several building construction companies and building projects (on-going and completed) and is endowed with abundant natural resources.

2. Literature Review

2.1 Research Work on Local Building Materials (LBMs) in Nigeria

There are two Research Institutes that are presently sourcing for all functional materials in Nigeria i.e. Raw Materials Research Institute (RMRI) and Nigeria Building Road Research Institute (NIBRRI) (Madedor, 2002). The major role of these Institutes has to do with the selling-out of information on local materials through seminars, conferences and workshops. NIBRRI is specifically required to research into all forms of construction materials. Oloruntoba and Ayodele (2013) gave insight to the potentials of LBM as an alternative to imported building materials at different stages of building construction. According to them, stones and rocks with laterite can be utilized jointly to form a very strong strip foundation that will stand the test of time. Similarly, laterite when reinforced with bamboo or coconut palm, can be used as bamboo reinforced terracrete which is as good as concrete slab.

Timber, when well treated and impregnated with liquid preservation can be used to achieve good timber board flooring. In the same vein, Bamboo floor and foist provide good building flooring when polished and treated to form Bamboo floor and foist. Cow dung when properly mixed with clay screening produced strong and good looking floor. This can be improved with the addition of fermented leaves and bitumen to further improve the flooring having a reasonable damp resistance.

Furthermore, Brick with laterite joining forms a good building wall with good conductivity advantage over the hollow concrete block. Also, Stone jointed with laterite mortar or lime stabilized mortar produces a desirable building wall with high compressive strength while Coconut palm, bamboo and Timber treated as stakes inside earth form a desirable building wall.

Earth when required to mix cement, conserves the volume of cement used because of its cohesive properties. Earth wall can also be reinforced with some additives (Vegetable, stems, reeds and straws) to achieve desirable strength and check cracking in walls. Laterite reinforced with bitumen for wall will have in addition to the strength the ability to act as a repellant to ants and rodents.

Clay and bricks stand out among other materials for building walls. Bolaji (2000) submits that clay products are significant areas that need be explored urgently considering such advantages that go along with its usage. e.g. (Durability, aesthetic, cost effectiveness and fire resistance).

Oloruntoba and Ayodele (2013) asserted that Bamboo in particular has a meaningful tensile strength depending on the specie. The ultimate tensile strength of some species of bamboo has been found to be about the same as that of steel at its yield point-Average1,400kg/cm to 2 2,800kg/cm (Fadamiro and Ogunsemi, 1996). Such remain a very good local material option for building roof. Similarly, Sun-dried earth block bricks have also been used in the construction of vault and domes; the procedure involves laying and bonding the masonry units over a wooden framework which is to be removed when the vaults or domes becomes dried (Popoola, Ayegbokiki and Gambo, 2015). Clay and bricks stand out among other materials for building walls according to (Oloruntoba and Ayodele, 2013). For finishes and fittings, Earth stabilized with cement forms a good plastering material. Stones can be used as stone facing on the walls while timbers are good cladding.

2.2 Utilization of Local Building Materials and Technologies

Many African countries, despite the abundant natural resources that can meet their need for building materials production, still depend largely on imported building materials and technologies (Ugochukwu and Chioma, 2015). It is pertinent to note that a key benefit of the use of LBMs in housing delivery is cost reduction and enhancing of foreign exchange (Omole and Bako, 2013). Other benefits of LBMs include affordability, availability, biodegradability, energy efficiency, re-usability and ozone friendliness (Oloruntoba and Ayodele 2013).

2.3 Challenges in the use of Local Building Materials in Nigeria

Taiwo and Adeboye (2013) noted that some existing locally produced building materials are capital intensive to manufacture locally, as their production is based on sophisticated technologies.

In the same vein is the findings of Omole and Bako (2013) that technology to handle the setting and uncertainty of the cost is a major challenge facing the production of locally produced building materials. In addition to this is the problem of legal and social acceptability and doubtful durability. Other criticisms of local building materials in the Nigerian context are lack of standards and specification, lack of organizational and institutional framework, problem of mass production, uncertainty about the demand and uncertainty about the strength of material when compared with their imported counterparts. Ikechukwu and Iwuagwu (2016) also identified the problem of acceptability with the public, durability and low strength, deforestation, civilization, frequent maintenance and challenges with the use for tall buildings as other factors affecting the use of LBMs in Nigeria.

3. Research Methodology

The area investigated for this study is Ado-Ekiti, the capital of Ekiti in South-Western Nigeria. The city and the rural settlements at its fringe now exist and function as a Local Government Area (LGA)- a single regional entity with a population of 308,621 (Gazatte, 2007).

Using a survey approach, this study considered the availability and level of usage of LBM for building construction in Ado-Ekiti. Further, it investigated the hindering and helpful factors to the usage of LBM as well as strategies to promote the use of LBMs for building construction in the study area.

Respondents for the study include Professionals involved directly and indirectly with Construction activities- Builders, Engineers, Surveyors, Architects, Project and Facility Managers in Construction companies that either has a branch or its headquarter in Ado-Ekiti.

A total of one hundred and fifty (150) questionnaires were administered. One hundred and nine (109) of these were returned, valid and useable, representing 72.7% of the sample population. The data presented and interpreted are based on responses from the set of questionnaires administered.

A semi- structured questionnaire designed on the basis of extensive literature review on LBM was used to capture the various types of LBM that can be available in the study area. Information on level of usage, was also included in the questionnaire while a section was dedicated to the hindering factors and suggestion strategies to promote usage of LBM. The Relative Importance Index (RII) method was used to analyze data obtained based on the set of questionnaires administered. One hundred and fifty (150) questionnaires were distributed out of which one hundred and nine (109) were usable and valid, which represents (72.7%) of the sample population, were returned.

4. Data Presentation, Analysis and Interpretation of Results

Prior to the survey, the review of literatures helped in identifying the common local building materials used in the Building construction industry in Nigeria. After this analysis, a total of ten (10) LBM were shortlisted for this study. These identified LBM were presented to respondents in the questionnaire so as to determine their level of availability and usage in Ado-Ekiti, Nigeria.

As shown on Table 1, Stone was found to be the most available indigenous building material in Ado-Ekiti, Nigeria. 76% of the respondents stated that stone is always available for use as a LBM in Ado-Ekiti and its environs. Thus, it ranked first, having a Relative Importance Index (RII) of 0.95. This availability of stone could be as a result of the numerous hills and mountains found in Ekiti State, Nigeria. Respondents ranked Timber as the second most available LBM for building construction in Ado-Ekiti. This is shown by its Relative Importance index (RII) of 0.93, with 68% of the total respondents agreeing that timber is always available for use for building construction.

Laterite, with a RII of 0.92 as shown on Table 1 was rated third by 60.6% of the respondents. Clay and Mud was also found to be very available in Ado-Ekiti, this availability is largely due to the nature of the soil found in some parts of Ekiti state, especially areas where artisanal mining activities is frequent. This is further supported by about 60% of the respondents who stated that clay and mud is always available for building construction. In some villages and settlements in Ekiti State, there are still today, several houses built with clay and mud, as a result of the poverty level in these villages.

As shown Table 1 the respondents rated Bamboo as fifth in terms local building materials availability in Ado-Ekiti. About 57% of the respondents stated that Bamboo is always available while about 2% agreed that Bamboo is not available at all in Ado-Ekiti; with RII of 0.74. From this study, Dung was found as the least used LBM in Ado-Ekiti. Most respondents stated that dung is usually used as manure or decomposed to serve as other source of energy. Besides, Ekiti state is not known for cattle rearing and has very few ranches, which is further aggravated by a recently passed anti-grazing bill in the state.

Table 1 also shows that leaves and bark of trees, palm kernel shell, wild coconut trees, animal waste and dung are other identified LBM available in Ado-Ekiti. These were ranked as 6th, 7th, 8th, 9th and 10th with RII scores of 0.88, 0.85, 0.79 0.76 and 0.74 respectively. As available as these LBM are, they are not yet fully utilized. Some key factors have however been identified as constraints to the realization of the full potential of local materials in Nigeria, these include according to Oladapo and Oni (2012) include poor quality of product and inappropriate use of LBMs in construction (Sanusi,1993).

Table 1: The Relative Importance Index (RII) of available LBM in Ado Ekiti

Local Building Materials	**Percentage of respondent scoring**					**RII**	**Rank**
	1	**2**	**3**	**4**	**5**		
Stone	0.0	0.0	0.9	22.9	76.1	0.95	1
Timber	0.0	1.8	0.0	30.3	67.9	0.93	2
Laterite	0.0	0.9	0.0	38.5	60.6	0.92	3
Clay and Mud	0.0	0.0	3.7	36.7	59.6	0.91	4
Bamboo	1.8	0.0	3.7	37.6	56.9	0.90	5
Leaves and bark of trees	1.8	1.8	3.7	38.5	54.1	0.88	6

Palm Kernel Shell	0.0	0.9	11.1	48.6	39.4	0.85	7
Wild coconut trees	1.8	1.8	22.9	45	28.4	0.79	8
Animal waste	1.8	1.8	26.6	54.1	15.6	0.76	9
Dung	1.8	0.9	33.9	49.5	13.8	0.74	10

Source: Researchers' Field Survey (2017)

This study also assessed the level of usage of LBMs in the study area. This study found timber as the most widely used LBM in Ado-Ekiti. About 73% of the respondents stated that timber is mostly used for building construction in the study area, with the RII of 0.93. Timber in Ado-Ekiti is mostly utilized for flooring and roofing truss members thus, making it to readily replace ceramic tiles and steel trusses that are alternative imported materials according to the studies of (Oloruntoba and Ayodele, 2013).

Although it was the most available in the study area, Stone was found to be the second mostly utilized LBM in the study area. This is shown by its RII of 0.92 ranked as very high. About 72% of the respondents stated that stone is very frequently used in building construction, 22% asserted that it is frequently used while 6.4% stated that it is moderately used. Stones and rocks in the study area are alternative building materials to Sandcrete blocks and Fibre glass which are imported and used at sub-structure (foundation) and for structural frame and walls respectively. This study confirmed the findings of Oloruntoba and Ayodele (2013), on the use of stones and rocks as alternative building materials.

As shown on Table 2, laterite is adjudged to be the third most utilized LBM in the study area with a RII of 0.90, ranking very high. About 64.2% of the respondents stated that laterite is very frequently used, 21.1% affirmed that it is frequently used while 14.7% of the respondents stated that laterite is moderately used in the study area. As pointed out by Arayela (2000), laterite bricks contributed increasingly to housing stock in Nigeria. Despite the fact that it has been used in numerous places throughout the world since pre-historic times it seems that today, this material is in need of some re-evaluation in processing.

As further shown on Table 2, laterite stabilized block was ranked as the fourth most used local materials in the Nigerian built environment. 49.5% of the respondents stated that laterite stabilized blocks are very frequently used as an indigenous building material, 27.5% stated that it is frequently used, 16.5% stated that it is moderately used while 1.8% of the respondents stated that it is not used at all. This is ranked to be high in terms of the level of usage. In addition, the respondents reiterated that the use of laterite stabilized blocks can be improved upon if there is adequate technology.

Bamboo and interlocking bricks were ranked as fifth and sixth in terms of the level of their usage. This is shown on Table 2 with RII scores of 0.782 and 0.692 respectively. 38.5% of the respondents stated that Bamboo is very frequently used as an indigenous building material while 13.8% stated that interlocking bricks are very frequently used as local building material in Nigerian construction industry. Bamboo in the study area readily replaces steel reinforcement and structural steel for flooring in the study area. Fired/unfired clay bricks in the study area readily replaces the hardboard imported materials for Structural frames and walls.

Clay and mud, Fire Clay bricks and Grasses, with RII 0.634, 0.616 and 0.616 respectively are moderately utilized in the study area. Wild Coconut Tress, Leaves and bark of trees and Animal wastes, with RII 0.450, 0.384 and 0.380 respectively are poorly used in the study area. This is because they are not available in large quantities in the study area.

Table 2: Relative Importance Index (RII) of usage of LBM in Ado-Ekiti, Nigeria

Local Building Materials	**Percentage of respondent scoring**					**RII**	**Remark**
	1	**2**	**3**	**4**	**5**		
Timber	0	2.8	6.4	18.3	72.5	0.930	Very High
Stone	0	0	6.4	22	71.6	0.922	Very High
Laterite	0	0	14.7	21.1	64.2	0.900	Very High
Laterite stabilized blocks	1.8	4.6	16.5	27.5	49.5	0.836	High
Bamboo	0.9	9.2	24.8	26.6	38.5	0.786	High
Interlocking bricks	0.9	7.3	50.5	27.5	13.8	0.692	High
Clay and Mud	0.9	23.9	44	19.3	11.9	0.634	Moderately High
Fired clay bricks	1.8	16.5	59.6	15.6	6.4	0.616	Moderately High
Grasses	30.3	39.4	21.1	4.6	4.6	0.616	Moderately High
Wild Coconut Tress	26.6	37.6	22.9	10.1	2.8	0.450	Low
Leaves and bark of trees	37.6	38.5	18.3	5.5	0	0.384	Low
Animal waste	37.6	41.3	14.7	6.4	0	0.380	Low

Source: Researchers' Field Survey (2017)

Table 3 below reveals the strategies to promote the use of LBM in the study area. There is need for vigorous advertisement of LBMs in the study area. This strategy was ranked first as shown (Table 3) with a RII score of 0.804. Most construction stakeholders are not familiar with the inherent cost-benefits in the use of local building materials, hence its avoidance. This may be largely due to lack of awareness of the LBM potentials to stakeholders in the Building industry. In addition, promulgating an enforceable National Housing Policy which promotes the production was ranked 2nd with RII of 0.782. Although the policy exists already in the Nigerian local context, it is not always in motion.

Increasing research in this area is also found to be one of the critical factors in promoting the use of LBMs as this was ranked by 3rd (RII = 0.778). Government should support research and encourage the use of LBM in construction of buildings particularly to overcome the challenges in technology and its use.

Respondents added that LBMs are not always used due to its poor quality, which can be improved on through intensive research conducted in this direction. This is in agreement with the assertion of Hammond (1984) that the overall effect of the technical deficiencies of locally produced building materials creates acceptability barriers.

Furthermore, some of the respondents stated that LBM are not being well patronized due to the ignorance of the construction workers. Respondents believed that the outcome of researches conducted by research institutes should be published as construction manuals for local building materials. This proposed strategy will help in promoting the use of local building materials. This strategy is ranked 4th with RII of 0.776 (Table 3). Training of manpower and increase in the use of local building materials by professionals in the industry were also identified as strategies for promoting the use of local building materials in Ado-Ekiti with RII of 0.760 and 0.754 respectively. Respondents opined that if intensive training of manpower, on the use of local building materials, is carried out effectively, indigenous building materials will be well appreciated. In addition, the adoption of local building materials by construction professionals and government agencies will also motivate and promote local building materials use.

Promoting the use of LBM in the construction of public buildings was ranked the least by respondents, with RII 0.754. Public buildings are usually characterized by astounding solidity and some respondents thought that the use of LBM may compromise this. However, with improved processing, the Government can also play a critical part in encouraging the use of LBM.

Table 3: Relative Importance Index (RII) of strategies needed to promote use of LBM for building construction in Ado-Ekiti, South-Western Nigeria

Local Building Materials	**Percentage of respondent scoring**					**RII**	**Rank**
	1	**2**	**3**	**4**	**5**		
A vigorous advertisement of the materials	2.3	4.7	18.6	37.2	37.2	0.804	1
Promulgate an enforceable National Housing Policy to promote the production and utilization of local building materials at the national level	4.7	4.7	20.9	34.9	34.9	0.782	2
Increase research on the properties of local building materials	2.3	14.0	14.0	30.2	39.5	0.778	3
Production of construction manuals on local building materials	4.7	7.0	16.3	39.5	32.6	0.776	4
Training of manpower	11.6	0.0	16.3	39.5	32.6	0.760	5
Increase use of local building materials by the professionals of the Industry	0.0	7.0	25.6	51.2	16.3	0.754	6
Government should promote the use of local materials in the construction of public buildings.	2.3	16.3	16.3	34.9	30.4	0.754	7

Source: Researchers' Field Survey (2017)

4.1 Hypothesis Testing

The study's hypothesis is to test whether local materials are frequently used for building constructions in Ado Ekiti or not. The statistics shown below is the chi square test result, to test the frequency in the use of local materials for building constructions in Ado Ekiti. The statistical results show that the estimated Chi-square statistic is significant at the 99% level (because Significant value ($p = 0.000 < .01$), so the null hypothesis, H0: Local materials are not frequently used for building constructions in Ado Ekiti, can be rejected and the alternate hypothesis H1: Local materials are frequently used for building constructions in Ado Ekiti, accepted.

Table 4: Chi square test result, for the use of local materials for building constructions in Ado Ekiti.

Chi-Square	26.978
Df	1
Asymp. Sig.	.000

5. Conclusions and Further Research

This study considered the availability, level of usage and strategies to promote the use of LBM in the Nigerian building construction industry, using Ado-Ekiti, Ekiti State as study area. The study confirmed that LBM is available as an alternative source of building materials to imported materials. The three most available LBM in the study area are: Stone (1), Timber (2) and Laterite (3) However, imported or foreign materials are still competing favorably with locally manufactured materials for building construction. Although LBM are available in large quantities in the study area, they are not yet utilized to their full potentials. This is in line with some other studies and key findings of Taiwo and Adeboye (2013); Oloruntoba and Ayodele (2013) and Omole and Bako (2013); Ikechukwu and Iwuagwu (2016).

This study contributed to local knowledge in the area of Building construction and Construction business noting among other things that the key constraints to the

realization of the full potentials of local materials in the study area include, technological constraints and poor quality of
product which is as a result of non-compliance with standards. This is in line with the study of Oladapo and Oni (2012) and Ikechukwu and Iwuagwu, (2016).
Because of its economic, social-cultural and environmental benefits, it is essential to invest in the promotion of LBM using various means. The key strategies for the promotion of LBM are: a vigorous advertisement of the materials; promulgating an enforceable National Housing Policy to promote the production and utilization of local building materials at the national levels and increased research on the properties of LBM.

Further studies on LBM can consider focusing specifically on Professional builders or building contractors who have the sole responsibility for building projects. In addition, local manufacturing companies of LBM can also be thoroughly examined to understand their limitations in the production of LBM so that it can favorably compete as alternatives to foreign building products.

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JCBM (2018) 2(2). 42-50

University of Cape Town

Journal of Construction Business and Management

http://journals.uct.ac.za/index.php/jcbm

Exploring the Components of Cost on Construction Projects

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Received 3 April 2018; received in revised form 26 June 2018, 12 July 2018; accepted 21 July 2018
https://doi.org/10.15641/jcbm.2.2.2018.573

Abstract

This study examines the components of construction projects and whether there are construction resources that are key project constituents. The rationale for the study stems from the unexplained assumptions regarding the primary components responsible for increases in construction costs in South Africa, due to the lack of a national building cost database. The study adopts a qualitative research approach that employs case studies of six new and six refurbished projects, to obtain the necessary data to answer the research questions. The study found that the primary cost constituents of construction projects were materials and sub-contracted work, accounting for 63.69% and 74.6% of the value of renovation and new construction work respectively. On the average, the major materials by value used in construction projects were identified as reinforcement, cement and filling, while electrical installation was the primary sub-contracted item by value. Based on these findings, the study concluded that future levels of construction costs could be predicted, when levels of specialist subcontractor costs and building material costs are known. To improve cost performance of project, the study recommends that the subcontractor and material inputs into construction projects should be carefully managed, both on projects and in the construction industry. The study contributes to the literature on resource planning and control in construction.
Keywords: Cement, Construction cost, Electrical installation, Reinforcement, Specialist subcontractor.

1. Introduction

Most construction contracts are awarded on competitive basis and this obliges tenderers to prepare bids based on accurate prediction (Ng, Cheung, Skitmore, Lam & Wong, 2004). Construction clients often demand early and accurate cost advice, because this assists in determining budget, predicting tender price and managing design (Lowe, Emsley, & Harding, 2006). However, increases in construction costs also affect the following: building contract price (Ashuri & Lu, 2010), contractors' profit margins (in the absence of any provision in the contract) (Chappel, Cowlin, & Dunn, 2010), and they create major financial stress and difficulties within the project lifespan. There are also effects such as the inability of developers to deliver affordable housing, high tender valuation, a decrease in tender competition and poor construction industry performance. This becomes more difficult on infrastructure projects, such as the Medupi power station in South Africa, which may experience project challenges persisting for many years.

The South African construction industry, like the other sectors of the economy, has been facing several challenges over the past few years (since 2012). With 1.431 million people employed in the construction industry (Stats SA, 2018) it plays a crucial role as a major driver of economic growth and development; thus, the need arises for a proper understanding of the main project components by value, to provide more accurate knowledge of cost indicators and inflators in the construction industry. Furthermore, due to the effect that cost increases in construction have on project performance and on construction industry stakeholders, a study is essential to identify the components responsible for the increases in the cost of construction work in South Africa. This is because so far, only unexplained assumptions have described how cost components are related to key project constituents. This paper therefore presents a review of literature on the cost of delivering infrastructure projects, and descriptions of construction cost components, in medium to large construction

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projects. The research methodology used in the study is articulated, and the results of the study and the conclusions derived from the study are also presented.

1.1 Overview of the delivery cost of construction projects

A comparison of the construction cost per square metre between South Africa, Brazil, Russia, India and China (BRICS), the G8 and some African Union (AU) countries, shows that South Africa has relatively lower construction costs than most other countries, at only $741/sq.m (Compass International Consultants Inc, 2016). Labour productivity is also lower in South Africa: it takes an average South African worker 1 450 hour to complete a task, compared with 1 000 hours by a labourer in the USA. The USA has the highest productivity constant globally. On the basis of the comparatively low labour cost ($25.50/hour) and lower labour productivity in South Africa, this country continues to have lower construction costs when compared to other BRICS and AU countries (Angola, Egypt, Ghana, Kenya, Morocco and Nigeria) (Compass International Consultants Inc., 2016). Despite this advantage, construction cost in South Africa increased by 26% between 2010 and 2015 (Bureau of Economic Research, 2016). Exploring the construction components driving the increase would enable stakeholders to plan and put measures in place to address future cost increases.

1.2 Construction cost components

The components of construction costs consist of the resource factors (labour, materials, plant and subcontractors); project factors (profit margin, overhead costs, supervision/management, finance, transportation and exchange rates); and the cost of legislative requirements (professional fees, transaction costs and permits). Resource factors are the inputs used in the production process to produce an output – this is the final product-building or infrastructure in construction. According to Odediran and Windapo (2014), Skitmore, Runeson and Chang (2006), Lowe, Emsley, and Harding (2006), Sawhney, Walsh and Brown IV (2004), Eastham (1986) and Snyman (2007), resource factors contributing to the cost of construction work comprise of labour, materials, equipment and subcontractors. Regarding project factors, earlier studies by Skitmore, Runeson and Chang (2006) identified overhead costs as a significant contributor to final construction cost. Olatunji (2010), Ng, Cheung, Skitmore, Lam and Wong (2000), Eastham (1986) and Snyman (2007) identified transportation costs, interest rates, fuel price and energy costs as significant contributors to construction costs. Meanwhile, previous studies by Sawhney, Walsh and Brown IV (2004), Akintoye (2000) and Eastham (1986) found that stakeholder requirements such as professional fees (for design and supervision), contract documentation/transaction costs, and legal and financial requirements were significant contributors to construction costs.

2. Research Methodology

A multi-case study approach was used to achieve the purpose of this study. Because the study employed a longitudinal approach, only construction cost components that were seasonal/ time based and changed consistently over time, such as labour, materials, equipment, subcontractors and project preliminaries were considered. Other cost strategies such as mark-ups/profits were not included. Only direct construction costs were considered. In this study, construction cost refers to the total value of works executed by medium to large sized general building and civil engineering contracting firm.

The details of projects and their cost estimates are presented in Table 1. The selection criteria for projects are: they were designed and planned for construction within the last five years that is 2012 to 2017; they were representative of public sector projects; they were of a size and tender price typical of works undertaken by medium- to -large sized general building and civil engineering contractors.

Table 1: Description of Case Studies

No	Renovation project	Tender Price (million ZAR)	GFA (m^2)	Tender submission date
R1	Admin Building	7,380	1 900m^2	2012
R2	School Building	45,134	5 336 m^2	2016
R3	Hospital	130,304	2 400 m^2	2015
R4	Road (concrete)	98,825 (+Upgrade)	7.98Km long & 9.8m wide	2013
R5	Court	Unknown	13 060m^2	2015
R6	Community Clinic	45	1 950 m^2	2016
No	**New project**	**Tender Price (million ZAR)**	**GFA (m^2)**	**Tender submission date**
N1	School Building	10,373	2 771 m^2	2015
N2	Hospital	171,786	3 691 m^2	2015
N3	Road (concrete)	98,825 (+Upgrade)	2.17km long & 9,8m wide	2013
N4	Administration Building	56,386	1 194 m^2	2015
N5	Municipal waste water treatment plant	180,923	11 300 m^2	2015
N6	Community Clinic	45,506	1 549 m^2	2015

The relevant priced Bills of Quantities of the 12 representative public-sector projects were obtained. Thereafter a model of the cost components for each case study was developed. This model was used to identify direct/indirect cost components: labour, materials, equipment, subcontractors and project preliminaries, and their share of the project cost envelope. The research team made use of standard estimating protocol, which included developing constants from first principles. The COMPASS Estimating Handbook (2016) was used as a reference and CCS CANDY Estimating Software (used by construction companies in South Africa) was used to develop cost models for the project.

2.1 Specification of cost variables

The project costs were obtained consistently for all the projects in the study, based on the following assumptions:

- Unit rates for resources were priced at industry accepted charge-out rates.
- A daily shift was specified at 8.5 working hours.
- Concrete was generally priced as mixed on-site.
- Concrete for roads would be mixed at a batch plant and pumped into position on site.
- Scaffolding requirements were priced in preliminaries.
- Carting away of discarded or surplus material was priced in preliminaries.
- Where no specification was provided, wall height was assumed to be 3m.
- Trades priced directly were considered to be the least specialized, namely earthworks, concrete, formwork, reinforcement, masonry, carpentry and joinery, ironmongery, plastering, tiling, plumbing, glazing, roadworks and painting.
- Inefficiencies such as delays in production were not allowed for.
- Only the cost of materials and on-site costs were considered in terms of the installation of materials; all costs required to deliver materials to the site were ignored, as these would skew the cost of the material.
- Production rates were specified as constant through the day.
- Labour costs did not include standing time.
- Building method was a constant and changes were based on the specification of the bill item.

2.2 Main resources priced

The main resources priced were:

- Material: cement, sand, bricks, sawn timber, fill material for earthworks and roads, diesel, reinforcement, structural steel; glazing, bitumen, tar and copper piping.
- Labour skill level: general labourer, artisan, and operator for plant.
- Plant: excavator, digger loader, road paver, and earth-filling compactor.
- Preliminaries: all indirect costs associated with construction, provided for by a lump-sum value. The factors that would cause resources to be priced in the preliminaries were that the resource would be used across all trades managed by the main contractor, and that it would be required for a long period of time on the project. Therefore, the following items were priced as preliminaries: health and safety requirements, management costs on and off-site, general scaffolding, general miscellaneous resources, commissioning requirements, head office and site overheads, costs to deliver resources to site, contractual requirements attracting a cost, and provisional sum.
- Subcontracted work: specialist installation including subcontractor overheads and management fees, delivery costs to bring resources to site and all commissioning requirements of specialist installations. These specialist installations were: – ceilings and partitions, drainage, electrical installation and reticulation, humidification, air-conditioning and ventilation, landscaping, fire detection and protection, data and IT installation, telecoms, core drilling, access control, heat pumps, gas and gas conduits, roller shutter doors, piling and signage.

3. Results

Tables 2 and 3 show a summary of the portion of the construction cost components obtained from the cases examined.

Table 2: Construction Cost Distributed According to Constituent Resources for Renovation projects (Q1: 2016 Prices)

Projects	Resource Component Share (%)					
	Labour	**Material**	**Plant**	**Preliminary**	**Subcontractor**	**Total**
R1. Admin building	5.19	9.23	0.37	15.61	69.60	100
R2. Renovation of school building	19.70	52.18	10.53	7.46	10.13	100
R3. Renovation of hospital	28.82	12.95	2.76	14.01	41.47	100
R4. Rehabilitation of municipal road (concrete)	7.08	54.26	16.90	21.75	0.00	100
R5. Refurbishment of family and regional Court	34.30	42.87	5.19	3.87	13.76	100
R6. Renovation of community clinic	13.89	31.00	3.01	7.44	44.66	100
Average share	**18.16**	**33.75**	**6.46**	**11.69**	**29.94**	**100**

Table 3: Construction Cost Distributed According to Constituent Resources for New projects (Q1: 2016 Prices)

Projects	Resource component share (%)					
	Labour	Material	Plant	Preliminary	Subcontractor	Total

N1. New primary school	23.83	49.81	3.77	6.24	16.35	100
N2. New hospital	8.89	24.98	1.14	10.16	54.86	100
N3. New road (concrete)	5.70	56.76	14.22	15.23	8.09	100
N4. New admin building	11.17	25.22	2.39	11.18	50.05	100
N5. Waste management facility	7.77	30.62	3.75	4.21	53.65	100
N6. Community clinic (new)	17.81	35.68	1.16	3.83	41.52	100
Average Share	**12.53**	**37.18**	**4.41**	**8.48**	**37.42**	**100**

Table 2 and 3 show that while the cost of materials had the highest proportion on the average (33.75%) in large renovation projects, in newly built project, the value of specialist subcontractor work was the highest (37.42%). The two resource components of building materials and specialist subcontractors account for a total of 63.69% and 74.6% of the total cost of renovation and new construction work respectively. It can be inferred from these findings that building material and sub-contracting are the most heavily weighted construction components in the cost of both new and renovation projects. The study therefore further explored the two components, building materials and sub-contracting, to determine the constituent elements of these resource factors.

The study sought to know the value of the key building materials used on the renovation and new building projects. Data related to this enquiry is presented in Figures 1 and 2, and Tables 4 and 5.

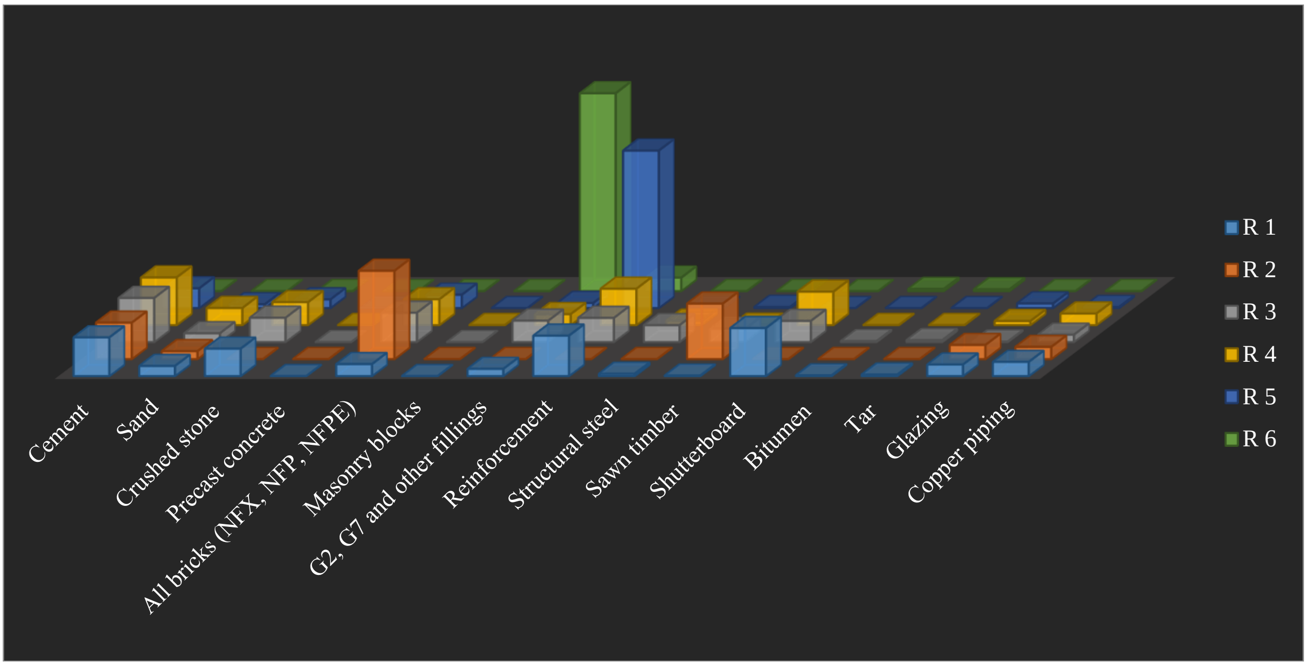

Figure 1: Value of Building Materials Used in Renovation Projects, Sorted by Type

Table 4: Distribution of the Value of Building Materials Used in Renovation Projects Sorted by Type

Materials	R 1	R 2	R 3	R 4	R 5	R 6	Average utilization
Reinforcement	18.84%	0.00%	11.29%	16.94%	73.26%	6.28%	21.10%
G2, G7 and other fillings	3.36%	0.00%	9.99%	5.09%	2.37%	91.89%	18.78%
Cement	18.05%	17.00%	20.58%	22.21%	9.21%	0.00%	14.51%
All bricks (NFX, NFP, NFPE)	5.59%	41.18%	13.70%	12.03%	6.21%	0.00%	13.12%
Shutterboard	22.40%	0.00%	9.87%	15.58%	0.00%	0.00%	7.98%
Crushed stone	12.78%	0.00%	11.35%	10.68%	4.04%	0.00%	6.47%
Sawn timber	0.20%	25.88%	6.21%	0.15%	0.52%	0.00%	5.49%
Sand	4.72%	3.69%	4.12%	7.97%	1.76%	0.00%	3.71%
Copper piping	6.62%	5.68%	3.42%	5.38%	0.50%	0.00%	3.60%
Glazing	5.37%	6.58%	0.25%	1.90%	2.14%	0.00%	2.71%
Structural steel	1.06%	0.00%	7.89%	2.06%	0.00%	0.00%	1.83%
Tar	0.68%	0.00%	0.91%	0.00%	0.00%	0.84%	0.41%

Bitumen	0.32%	0.00%	0.43%	0.00%	0.00%	0.99%	0.29%
Precast concrete	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Masonry blocks	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 4 and Figure 1 show that on the average and across the six renovation projects examined, reinforcement, filling, cement and bricks are used more, by value, while masonry blocks and precast concrete items are not used at all.

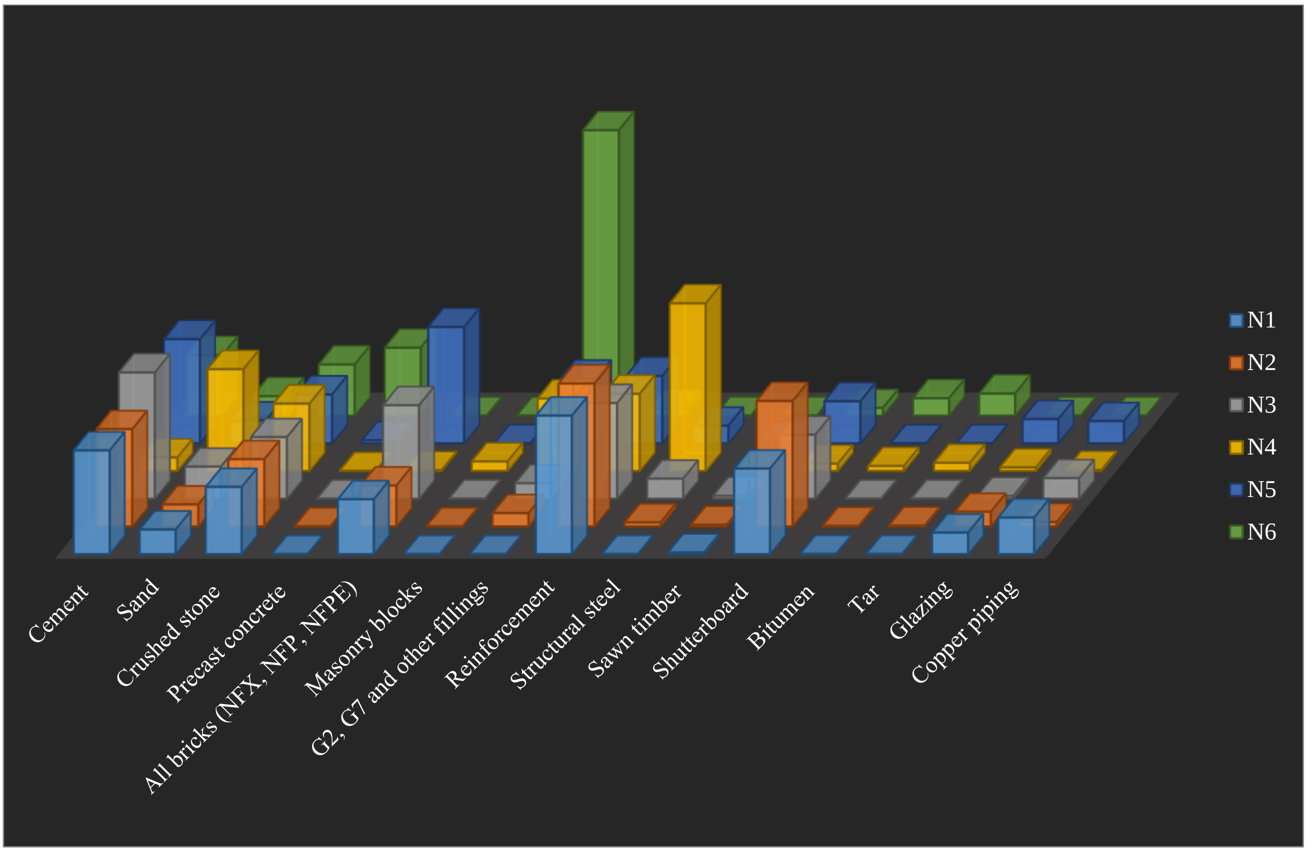

Figure 2: Value of Building Materials Used in New Projects, Sorted by Type

Table 5: Distribution of the Value of Building Materials Used in New Projects Sorted by Type

Materials	N1	N2	N3	N4	N5	N6	Average utilization
Reinforcement	25.96%	26.74%	17.93%	14.45%	12.57%	1.22%	16.48%
Cement	19.42%	18.22%	23.60%	2.53%	19.41%	11.26%	15.74%
G2, G7 and other fillings	0.00%	2.48%	2.88%	13.57%	12.06%	53.01%	14.00%
Crushed stone	12.58%	12.60%	11.53%	12.61%	9.13%	9.51%	11.33%
Shutterboard	16.01%	23.49%	11.97%	1.35%	7.87%	1.43%	10.35%
All bricks (NFX, NFP, NFPE)	10.26%	7.66%	17.51%	0.14%	21.65%	0.00%	9.54%
Sand	4.59%	4.10%	5.99%	19.03%	4.28%	3.61%	6.94%
Structural steel	0.00%	0.73%	3.74%	31.24%	3.29%	0.00%	6.50%
Copper piping	6.84%	0.79%	3.84%	0.18%	4.14%	0.00%	2.63%
Precast concrete	0.00%	0.00%	0.00%	0.00%	0.55%	12.62%	2.20%
Glazing	4.02%	2.71%	0.50%	0.66%	4.52%	0.00%	2.07%
Tar	0.02%	0.12%	0.00%	1.52%	0.00%	4.10%	0.96%
Bitumen	0.01%	0.08%	0.00%	0.93%	0.00%	3.24%	0.71%
Masonry blocks	0.00%	0.00%	0.00%	1.78%	0.00%	0.00%	0.30%
Sawn timber	0.28%	0.28%	0.51%	0.00%	0.52%	0.00%	0.27%

Table 5 and Figure 2 show that on the average and across the six new projects examined, reinforcement, cement, filling, crushed stone and shutterboards account for 67.9% of the building material component, while masonry blocks and sawn timber are used much less.

The study also sought to know the key specialist subcontractors by value that were engaged on the renovation and new building projects. Data related to this enquiry is presented in Figures 3 and 4, and Tables 6 and 7.

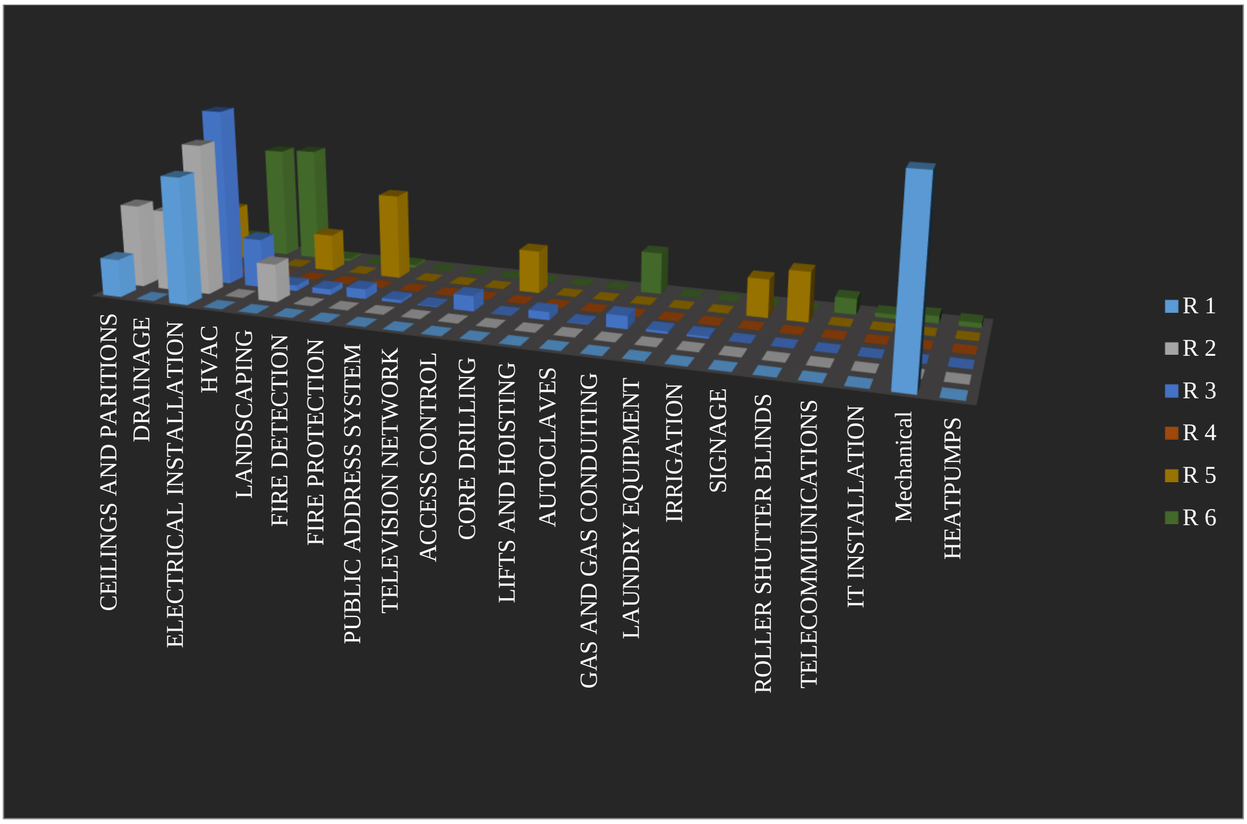

Figure 3: Value of Specialist Work in Renovation Projects, Sorted by Type

Table 6: Distribution of the value of Specialist Work Used in Renovation Projects Sorted by Type

Specialist Subcontractor	R 1	R 2	R 3	R 4	R 5	R 6	Average utilization
Electrical installation	36.07%	42.70%	50.27%	0	0.00%	32.45%	40.37%
Ceilings and partitions	10.76%	23.60%	15.23%	0	11.85%	7.48%	17.23%
Mechanical	53.17%	0.00%	0.00%	0	0.00%	2.07%	13.81%
HVAC	0.00%	0.00%	14.01%	0	0.00%	33.12%	11.78%
Drainage	0.00%	22.92%	1.72%	0	15.91%	4.34%	11.22%
Fire protection	0.00%	0.00%	2.81%	0	24.50%	0.88%	7.05%
Landscaping	0.00%	10.79%	1.63%	0	10.77%	0.68%	5.97%
Gas and gas conducting	0.00%	0.00%	3.63%	0	0.00%	11.89%	3.88%
Roller shutter blinds	0.00%	0.00%	0.00%	0	14.01%	0.00%	3.50%
Core drilling	0.00%	0.00%	0.05%	0	12.19%	0.00%	3.06%
Signage	0.00%	0.00%	0.00%	0	10.77%	0.00%	2.69%
Telecommunications	0.00%	0.00%	0.00%	0	0.00%	4.48%	1.12%
Access control	0.00%	0.00%	4.35%	0	0.00%	0.00%	1.09%
Lifts and hoisting	0.00%	0.00%	2.28%	0	0.00%	0.00%	0.57%
Fire detection	0.00%	0.00%	1.63%	0	0.00%	0.00%	0.41%
Heat pumps	0.00%	0.00%	0.00%	0	0.00%	1.38%	0.35%
It Installation	0.00%	0.00%	0.00%	0	0.00%	1.22%	0.31%

Public address system	0.00%	0.00%	0.84%	0	0.00%	0.00%	0.21%
Laundry equipment	0.00%	0.00%	0.66%	0	0.00%	0.00%	0.16%
Irrigation	0.00%	0.00%	0.54%	0	0.00%	0.00%	0.14%
Television network	0.00%	0.00%	0.19%	0	0.00%	0.00%	0.05%
Autoclaves	0.00%	0.00%	0.15%	0	0.00%	0.00%	0.04%

Table 6 and Figure 3 reveal that on the average and across the six renovation projects examined, the value of electrical installation, ceilings / partitions and mechanical / HVAC systems is higher, while the value of CCTV installation is much lower.

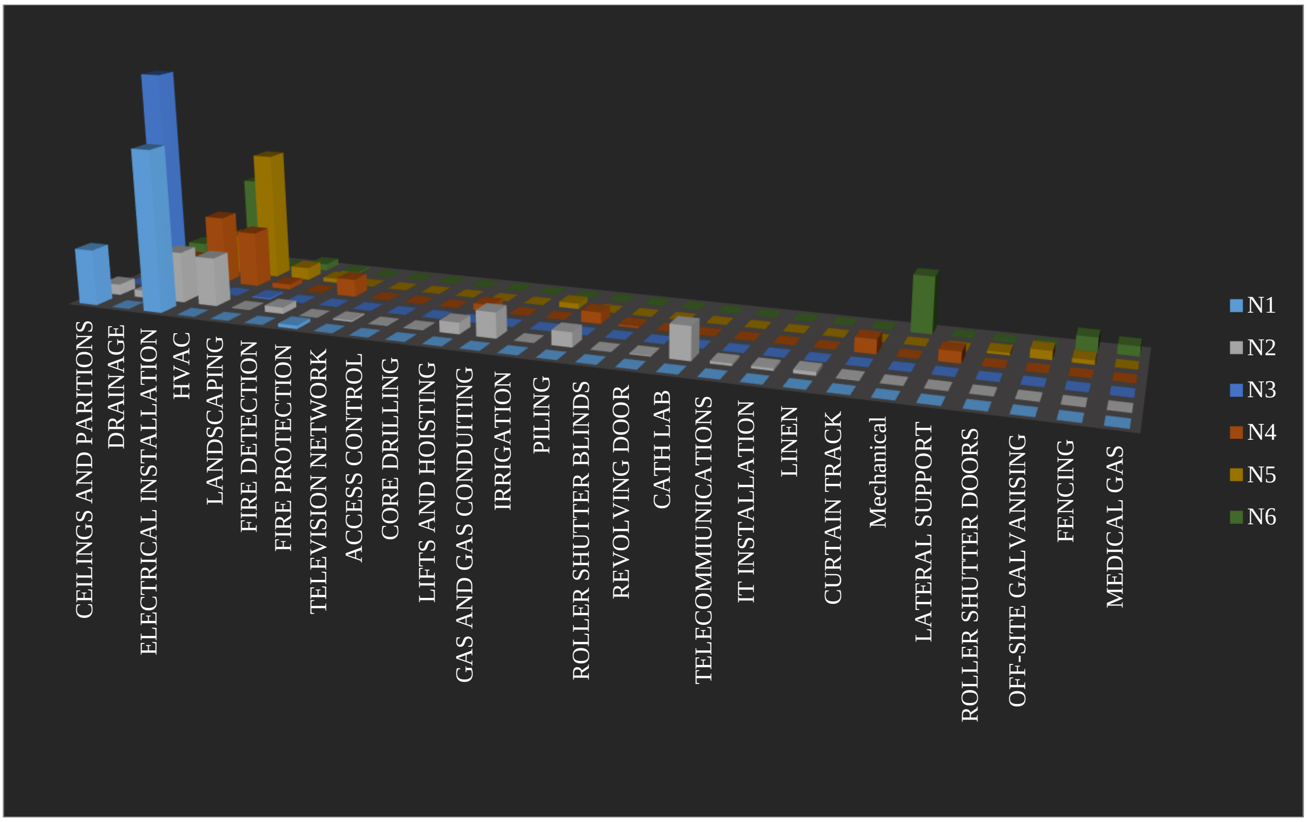

Figure 4: Value of Specialist Work in New Projects, Sorted by Type

Table 1: Distribution of the Value of Specialist Work Used in New Projects Sorted by Type

Specialist subcontractor	N1	N2	N3	N4	N5	N6	Average utilization
Electrical installation	73.14%	22.97%	0.00%	30.92%	17.88%	40.96%	38.74%
Drainage	0.00%	3.35%	99.47%	9.95%	6.40%	12.12%	30.34%
HVAC	0.00%	22.02%	0.00%	25.11%	57.86%	0.00%	19.97%
Ceilings and partitions	25.29%	4.84%	0.00%	3.23%	0.96%	7.02%	9.53%
Mechanical	0.00%	0.00%	0.00%	0.00%	0.00%	25.48%	6.37%
Cath lab	0.00%	15.00%	0.00%	0.00%	0.00%	0.00%	3.75%
Gas and gas conducting	0.00%	11.59%	0.00%	0.00%	0.00%	0.00%	2.90%
Landscaping	0.00%	0.17%	0.53%	2.34%	5.65%	3.05%	2.35%
Fencing	0.00%	0.00%	0.00%	0.00%	1.88%	6.31%	2.05%
Piling	0.00%	6.66%	0.00%	5.17%	0.00%	0.00%	1.66%
Fire detection	0.00%	2.90%	0.00%	0.00%	1.94%	0.68%	1.38%
Lifts and hoisting	0.00%	5.25%	0.00%	3.07%	0.00%	0.00%	1.31%
Medical gas	0.00%	0.00%	0.00%	0.00%	0.00%	4.39%	1.10%
Off-site galvanizing	0.00%	0.00%	0.00%	0.00%	3.89%	0.00%	0.97%

Irrigation	0.00%	0.00%	0.00%	0.00%	2.47%	0.00%	0.62%
Linen	0.00%	1.59%	0.00%	0.00%	0.00%	0.00%	0.40%
Fire protection	1.57%	0.00%	0.00%	7.93%	0.00%	0.00%	0.39%
Telecommunications	0.00%	1.06%	0.00%	0.00%	0.00%	0.00%	0.27%
It installation	0.00%	1.06%	0.00%	0.00%	0.00%	0.00%	0.27%
Roller shutter doors	0.00%	0.00%	0.00%	0.00%	1.06%	0.00%	0.26%
Television network	0.00%	0.64%	0.00%	0.00%	0.00%	0.00%	0.16%
Revolving door	0.00%	0.36%	0.00%	0.00%	0.00%	0.00%	0.09%
Core drilling	0.00%	0.21%	0.00%	0.00%	0.00%	0.00%	0.05%
Curtain track	0.00%	0.21%	0.00%	6.46%	0.00%	0.00%	0.05%
Access control	0.00%	0.07%	0.00%	0.00%	0.00%	0.00%	0.02%
Roller shutter blinds	0.00%	0.03%	0.00%	0.72%	0.00%	0.00%	0.01%
Lateral support	0.00%	0.00%	0.00%	5.10%	0.00%	0.00%	0.00%

Table 7 and Figure 4 reveal that on the average and across the six new projects examined, electrical installation, drainage and HVAC systems account for a total of 89.05% of the total new building specialist subcontractor component, while the value of CCTV installation is much lower.

4. Discussion of Findings

The study examined the components of construction projects and whether there were construction resources that were the key project cost constituents. The study found that the building material and sub-contracting element were the key construction components contributing to the cost of both new and renovation projects. This finding is aligned with those of previous studies by Odediran and Windapo (2014), Skitmore, Runeson and Chang (2006), Lowe, Emsley, and Harding (2006).

The study also established that reinforcement is used most by value in both new and renovation projects, followed by cement, filling materials and crushed stones. The latter are used more by value in new projects, while filling materials of cement and bricks are used more by value in renovation projects. Furthermore, the electrical installation is installed most by value of total installation in both new and renovation projects and followed by celling and partition installations. The value of mechanical and HVAC installations is higher in renovation projects, while the drainage, HVAC and celling and partition installations is higher in new projects. This finding is of significance to policy makers and clients in the construction industry because it makes available the average cost of components and enables a consistent comparison of construction projects based on cost.

5. Conclusions

The study was able to identify the common components which contribute significantly to construction cost, in medium to large construction projects. The primary objective of any pricing regime should be to ensure that resources are allocated efficiently, and an understanding of the indicators and drivers of cost will aid decision making. This can enhance cost management related to the sector. Based on the analysis of the data collected, it can be inferred that the resource factors with a significant share of construction cost in South Africa, are specialist subcontractors, and materials, while labour cost is observed to be close to the BRICs average cost in absolute terms.

The results imply that challenges such as the weak Rand relative to the US dollar will continue to exert pressure on construction cost, through the material cost component. This is because the import of vital equipment and materials will raise cost above specified budget, thereby increasing the overall cost of the project. However, this may be due to the fact that many of the construction components, including materials, labour and equipment are obtained in South Africa. Therefore, the effects of import costs in the construction industry are not felt to the same extent in other industries.

The data shows that materials and sub-contracted work are the significant cost drivers responsible for trends in the cost of construction projects in South Africa, and that the future levels of the cost of construction work can be predicted using known levels of material and specialist subcontractors' costs. Another significant finding is about the use of specialist subcontractors as a resource on both new and renovation projects. It can be inferred from the results obtained that there are benefits to the use of specialist subcontractors in construction project delivery. This is because the subcontractor has knowledge which can be highly utilized across various project types. As a result of this, the specialist subcontractors can examine cost projections in different and favourable ways, not normally used by the main contractor. The subcontractors' knowledge may make for better coordination and planning and may lower overall costs on projects.

Furthermore, it is expected that in the long term, changes in the price of materials will also be a big factor in increasing future costs of construction. For example, it is expected that building materials affected by international trade, such as cement, reinforcement and bitumen, which have abnormal price growth, will affect future levels of construction costs.

6. Recommendations

To ensure an effective cost driving mechanism, in addition to designing an appropriate pricing policy to minimize production cost, it is important that sound investment decisions and improved management oversight are implemented to ensure that the cost of labour, plant, fuel and material inputs to production are minimised, thereby streamlining operations. Also, a database for the construction sector in South Africa should be properly developed, to facilitate proper estimation of construction cost, as well as improvement in risk management. However, there are at least two constructing firms that provide contractors with cost data, not in the form of indices, but in Rands and cents. These consulting firms have seen the gap in the market because neither the government, nor the professions, are willing to finance a national cost database such as the Building Cost Information Service (BCIS) in London.

The South African government, using the management oriented procurement method, should develop a system that can be used to increase the participation of specialist subcontractors in the construction project delivery process. Materials are also a big cost that needs to be managed effectively by all stakeholders, to ensure that materials are used efficiently on site, so as to reduce waste. It is also important that a Building Industry Price Book be instituted by the cidb/DPW to track the trends in building components and material prices. The results of the study provide significant information for planners, estimators, project and construction managers. These data are useful for resource planning and management of construction projects.

Further studies should seek to determine conclusively whether the cost of cement, reinforcement, timber, bitumen and bricks is related to future levels of construction costs in South Africa.

Acknowledgement

This work is based on research supported by the cidb and DPW of South Africa. The opinions, findings, conclusions and recommendations expressed in the research are those of the authors and should not be attributed to the cidb or DPW.

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