Constructability Tools and Techniques in Use in the Nigerian Construction Industry

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ABSTRACT

This study sought to identify constructability tools and techniques deployed by professionals within the industry with a view to improving the performance of construction projects in Nigeria. Fifty (50) questionnaires were administered purposively in public, private construction and contracting organizations in Port-Harcourt, Rivers State, Nigeria. Forty two (42) out of the fifty (50) questionnaires that had complete responses were used for the analyses. The responses were analyzed using both descriptive and inferential statistical tools via SPSS. The findings from the study indicate that a majority of the respondents are not too conversant with the term constructability, while a handful had. This practically implies that on the average there is generally a low level of awareness and understanding of the concept and the application of constructability tools and techniques among the various professionals. The findings further revealed that corporate lesson learned log/file with a (MS=4.00) was the most used and ranked first. Others are; Brainstorming with a (MS=3.90), Peer Review with a (MS=3.89), Graphical computer based tools and CAD with a (MS=3.83), discussions with clients, contractors, suppliers with a (MS=3.43).

Keywords: Constructability, Constructability tools, construction, construction industry, mean score, ranking.

INTRODUCTION

The concept of “constructability” in the US or “buildability” in the UK emerged in the 1970’s in an effort to stop the declining cost-effectiveness and quality of the construction industry (Wong et al. 2006). It was born out of the realization that designers and contractors see the same project from different perspectives, and that optimizing the project requires that the knowledge and experience of both parties be applied to project planning and design processes.

Kamari and Pimplikar (2012) defined constructability as a project management technique for reviewing construction processes from the conception to finished stage during the pre-construction phrase. It is usually a means for identifying obstacles before a project is actually constructed to help reduce or prevent incidences of error, delays and cost overruns (Kamari and Pimplikar, 2012)

According to Hijazi, et al. (2009), construction industry institute (CII), defined constructability “as the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives”. Furthermore, Hijazi, et al. (2009) opined that construction managers display the benefit of adopting constructability in terms of cost reduction within the range of one to fourteen percent of the total cost. Regardless of the stage of its implementation, constructability centers on the design.

Prior to the improvement of constructability during the planning and design stages, the key to achieving this during the construction phase of the project is normally through an effective feedback construction knowledge system (Kartam, et al. 1999). Furthermore, Kartam, et al. (1999) opined that when a project advances into the construction phase, the feedback system needs to take care of the task at hand is the construction knowledge in terms of methods, materials, equipment and coordination.

According to Ayangade, et al. (2009), the Nigerian infrastructure sector has experienced a massive growth over the past few years with a steady rise in construction expenditure in the country, primarily due to the growing increase in oil revenue. The impact of the construction industry on the economy is a known reality. It is a key indicator and driver of economic activity and wealth creation. The construction industry the world over according to Ayangade, et al. (2009) straddles all human endeavours. Its activities include the procurement of goods and services as well as the execution of a variety of physical structures and infrastructures. It has helped in contributing to Gross Domestic Product (GDP), Gross fixed capital formation and creation of high level of employment to the entire populace.

In the industrialized and advanced countries of the world, the building and construction industry is responsible for up to 22% of the GDP and employs up to 12% of the total labour force, but in Nigeria, it is responsible for 16% of the GDP and employs up to 20% of the labour force. The contribution of the construction industry to the growth of the Gross Domestic Product (GDP) of Nigeria according to Olatunji (2008) is steady and improving; from about 5% in 2001 to over 13% in 2007 and this has been forecast to grow at an average of 5.4% per annum over the same period significantly above the global average (Betts, et al 2013). This growth is motivated by the continued interest of government to reposition the nation's economy as one of the top 20 largest in the world. Interestingly, the government is also responsible for about 75% of infrastructural development in Nigeria.

Evidently, there is very strong relationship between the Nigerian construction industry and larger economies, both in Nigeria and Africa at large as opined by the Global Construction Forecast 2025's 2013 report, that Nigeria is expected to be the second fastest growing construction market amongst the forty six (46) countries of the world behind Qatar whose average growth in construction is 8% pa from 2012-2025 where almost 20 million new homes are expected to be built in Nigeria by 2025, making Nigeria the fifth largest housing market in the world after the U.S. Thus, the government is not only keen to the development of the Real Sector of the economy but there is also a concerted effort by the government to improve the image of the country through the construction sector (Olatunji, 2008)

In as much as the performance of the industry with regards to cost, quality and schedule objectives has not been impressive among the local companies especially the reported cases of project delays, abandonment, cost overrun and failures has been attributed to a large extent, to lack of adequate knowledge and non-implementation of constructability principles in the project delivery processes. (Amade, 2014; Akpan, et al. 2014; Aibinu and Jagboro, 2002; Ubani and Ononuju, 2013)

According to Akpan, et al. (2014), the performance of engineering projects within the Nigerian Construction industry is below internationally accepted standards. Examples abound of failed and abandoned projects which are scattered all over the nooks and crannies of the country with buildings collapsing on a regular basis in different parts of the country and most of the roads and other public infrastructure built with public funds fail to provide value for money spent as a result of the quality of the projects delivered.

PROBLEM STATEMENT

According to Samaneh, et al. (2012), there are many industry-wide problems confronting the construction industry and one of such problem is the lack of integration between design and construction phases as well as the fragmented nature of the industry. In the last decade, the required schedule and cost of completing construction projects has increased due to lack of application of constructability principles. This implies that the implementation of constructability principles which involves the size and complexity of projects while also considering the knowledge and experience of experts is a vital component in achieving success in the construction industry (Samaneh, et al. 2012).

Kamari and Pimplikar (2012) opined that as most projects get complex by the day, the issue of constructability becomes important. Constructability infiltrates and straddles all parts of a project, especially those related to the engineering and architectural profession. With projects becoming more complex and time frame getting shorter by the day, implied warranty and severe professional liability issues may ensue creating a tendency for design professionals to be aware of the potential issues and claims implied by a design constructability or buildability profile. Whenever a project is adjudged to possess some inherent constructability issues, thereby resulting in litigation which must has been precipitated by incidences of delay claims, change order issues and disputes, and owner's dissatisfaction with the delivery process.

In extreme cases, direct claims may be made against the design principal for poor plans, specifications or estimates, or schedules that have subjected the project to difficulty in terms of buildability, or more expensive or time consuming than anticipated (Kamari and Pimplikar 2012).

According to Love, et al. (2004), schedule, deviation from quality and poor safety procedures amongst others has plagued the construction industry. In addition to that, numerous governments sponsored reports that have rendered the construction industry a failure due to the fragmented nature of the industry, poor coordination and communication between participants, adversarial relationships, dearth of a customer-supplier focus, priced-based selection process as well as an ineffective use of technology amongst others. The attendant envisaged problems do often contribute to time wastage, unnecessary costs, frequent errors and disagreements which culminate into reworks thereby contributing to schedule and cost overruns in projects.

According to Akpan et al. (2014), the engineering/construction professionals need adequate knowledge and the deployment of the right tools to deal with these issues. Constructability or buildability is a project quality improvement technique that if implemented throughout the project delivery process, would help in mitigating these challenges.
Constructability implementation enables the design professionals to consider how a constructor will implement the design, which otherwise could lead to scheduling problems, delays, disputes and cost related problems during the construction process.

The state of the Nigerian construction industry to some extent does not suggest the deployment of constructability practices by the professionals in the industry. Hence there is a need to investigate and analyze the extent of application of constructability tools and techniques by industry professionals in a bid to improve the performance of construction projects.

According to Samaneh, et al. (2012), there are various methods of improving constructability on project designs using mechanisms like guidelines, computerized systems, and manual systems, but they are most often not able to optimize the design based on the several aspects or principles of constructability. The aim of this study is to investigate the tools and techniques used in constructability in Nigerian construction industry. The objectives are as follows:

- To identify constructability tools and programs deployed by professionals and determine the extent of their use in the construction industry.
- To make deductions and recommendations that would improve performance of construction projects in Nigeria

In this study, answers will be sought for the following questions:

1. What constructability tools/programs are developed and applied by practitioners in the Nigerian construction industry and to what extent.
2. What can be done to close the gaps identified and so improve the general performance of construction projects in the industry?

THEORETICAL FRAMEWORK

Some theories and models exist in analyzing the creation and application of constructability tools and techniques in construction projects. Most of these theories and models plays significant roles in the deployment of constructability tools and techniques in realization of construction project goals and objectives.

The product realization model has been adjudged as the starting point of the dissatisfaction associated with functional organizations and the development of a product. According to Koskela (2000), the aim of the product realization model is to develop a common formalism or theory for the entire design and manufacturing processes. The theory aims at achieving a structured methodology for product realization in the sense that all actions can be based upon some impact on bottom line metrics of product demand, market share, profit and total quality.

To objectively achieve the realization objective, methods such as quality theory of Taguchi, quality function deployment, design of experiments, conjoint analysis and macroeconomic theory must be unified into a whole. Another on which constructability hinges on is the lean production theory. The lean production theory as opined by Howell and Ballard, (1997) has its gains in the manufacturing industry. Its emergence in the manufacturing sector appears to have created some changes to those in the construction industry. In construction, the changing project environment is the driving force behind the need for an understanding. As opined by Simonsson, (2011) constructability theory integrates design and construction. Whenever there is a blend between design and construction, there is a fuse within the system whereby the construction site can be shielded from the disordered flow of material and work as a result of a loosely coupled supply chain by striving to create a natural flow of work tasks.

Lean production theory in construction must be in line with the entire design and construction processes as a result of the complex nature of projects and the consequence of increasing state of uncertainties thereof. As stated by Howell and Ballard (1997), a construction project is analogous to the preparation of a prototype and in completing the construction phase of a project, it is better seen as one of the preliminary steps leading to production which occurs as soon as the project is consummated instead of it being seen as a manufacturing/production outfit.

The technology acceptance model (TAM) is a widely applied and proven initiative developed by Fred Davies. The model according to Cornelius, et al.(2011) is an extension of the theory of reasoned action. The TAM measures attitude of users in terms of their perceived usefulness towards a product. It is the intension to achieve the likelihood of an innovative solution by combining the basic principles of user-driven innovation in a bid to achieving a sustainable solution that is dependent on the level of user acceptance. Cornelius, et al.(2011) further defined behavioural intention as a yard stick of measuring one's intention to carry out a specific act which may involve the zeal to willingly adopt an innovative means.

Building information modeling (BIM) is a term used in referring to a family of technologies and related practices that are used in representing and managing information used in creating the processes of designing and carrying out construction related activities using a computer aided design (CAD), 3D representation (Davies and Harty, 2011). Davies and Harty (2011) further opined that attempts have been made to tap from the technologies associated with BIM into the production, sharing and representation of information in design and construction processes by repeatedly using the information down the supply chain while also digitally mediating construction activities. One of the families of BIM is the virtual prototyping (VP) technology.

The virtual prototyping (VP) technology according to Li (2007) is a computer-aided design process that is used in the construction of a digital product model ('virtual prototypes') and realistic graphical simulations that resolves issues of broad physical layout, operational concept, functional specifications and the dynamics of analysis under various operating environments. The VP technology also enables a construction project designer to predict and eliminate errors and risks inherent in any design and construction process. The technology further provides an avenue for effective learning, knowledge recycling while also improving the construction process effectively.

According to Trigunarsyah, et al. (2007), the increase in competitiveness within the construction industry requires the industry players to improve on their ability to combine quality materials and construction works with economic and schedule to achieve their objectives.

They further opined that different studies and procedures in quality improvement focuses on project quality improvement techniques and efficiency like total quality management (TQM), value engineering, designability, constructability, operability, maintainability and other quality improvement techniques.

Various definitions of constructability exists, but the one defined by the CII stands outstanding and all-encompassing as it takes into cognizance the importance of construction input in all the phases of a project, (Chua, 2003). The construction industry institute as opined by Chua (2003), defined constructability as "the optimum integration of construction knowledge and experience in planning, engineering, procurement and field operations to achieve overall project objectives". As stated by Chua (2003), constructability is not merely a review of completed construction drawings to make sure that no ambiguities are found or any misunderstanding arising from poor specifications and details that may lead to conflicts during implementation, nor is it making construction methods efficient after execution. But rather constructability is seen as a mechanism that can aid in improving significant savings and better project performance. Construction input at the design stage will help to resolve different design related issues such as those directly linked to access restrictions and incompatible design and construction schedules.

Constructability and Buildability are two concepts that share similar goals but have slightly different approaches in terms of application. They both strive to improve productivity and safety of on-site production while reducing costs. The term "buildability" was coined by CIRIA (Construction Industry Research Information Association) in the UK, whereas the term "constructability" originated from the CII (Construction Industry Institute), based in the USA. Both concepts were originally presented in the late 1970s and early 1980s by the two different institutes. The idea behind constructability includes management's function, whilst that of buildability does not. If managed properly, creating constructability within in-situ cast concrete structures such as bridges and other civil engineering products can improve productivity, resulting in reduced construction time and an increased profit margin. Reduced construction time also helps in reducing the environmental impact of the construction via reduced traffic and energy consumption (Simonsson, 2011).

Designers play a critical role in the adoption of buildability/constructability concepts in construction projects. However, most designers are skeptic over adopting the idea as a result of the lack of the knowledge of the effect and uncertainty of how constructability can be integrated into the design. The benefits of adopting constructability in a construction project according to Simonsson (2011) leads to about 10 to 20 times the cost of integration. Simonsson (2011), further pointed out that designers do not generally take into account the construction methods proposed by the contractor in the design. It is often the inexperienced junior designers who carry out the finishing details of the design. (Simonsson, 2011)

According to Saghatforoush, et al. **(**2010**),** constructability and buildability are two terms whose concept have been used and applied in most construction projects for a long period of time. There are a lot of literatures on constructability and buildability issues (O'Connor & Davis, 1988).

There have been lots of researches done in different locations mainly in developed countries like United States, United Kingdom, Australia and recently in Hong Kong, trying to find various constructability activities to resolve project barriers to achieving overall aims of projects. In United Kingdom, Construction Industry Research Information Association (1983) determines seven concepts for constructability issue. These concepts were increased to sixteen by CIRIA itself later. This procedure was followed by some more recent studies in the United States which resulted into fourteen concepts. (See O Connor and Miller, 1994, Akpan, et al, 2014). Further researches carried out by the Construction Industry Institute in the United States gave rise to seventeen concepts. Meanwhile, the Australian CII published twelve constructability concepts. While Trigunarsyah (2004) further broadened the concepts as the latest versions of constructability concepts to twenty six detailed activities.

A. PRINCIPLES AND CONCEPTS OF CONSTRUCTABILITY

The development of integration planning and control of design according to Samaneh **(**2012**),** is the most important issue in the construction industry. In order to increase the quality of production and achieve a project's objective, the constructability concept was presented in the 1970s. The concept integrates knowledge and experience of construction managers and design engineers thereby eliminating the redesign and rework issues common with construction sites.

Evidence abounds that the application of constructability in UK, USA and Australia reduced the cost and schedule of most projects. Chua (2003) opined the concept of constructability arose from the recognition that construction is not merely a production function that is separated from engineering design, but their integration could result into significant savings and better project performance. Construction input in design can resolve many design-related difficulties during construction, such as those arising from access restrictions and incompatible design and construction schedules. Construction input includes knowledge of local factors and site conditions that can influence the choice of construction method and, in turn, the design. Chua (2003)

One of the major problems in construction sites is the lack of integration between design and construction. Therefore, the implementation of constructability which involves the size and complexity of projects and also considers the knowledge and experiences of experts is a vital point in the construction industry (Samaneh, 2012).

Although there are various methods for improving constructability on project designs like guidelines, computerized systems, and manual systems but they are not able to optimize design based on several aspects or principles of constructability. (Samaneh, 2012)

According to IPENZ **(**2008**),** constructability is a project management technique used in reviewing construction processes from the start to finish stage during the pre-construction phrase. It normally identifies obstacles before a project is actually built to reduce or prevent error, delays and cost overruns.

Chua (2003) opined that the integration of construction knowledge and experience should be introduced early in the project when the cost influence on decisions in the early phase is high. The ability to influence the cost of the project occurs at the conceptual phase, where the decisions at that time could greatly affect the project plan, site layout and accessibility, as well as the choice of construction method. Detailed integration will require that the contractor or construction representative be introduced into the project team at the same time as the designer. Thus, the choice of the contractual approach can be critical in determining early construction involvement in a project **(**Chua, 2003).

Chua (2003) further opined that another important consideration for meaningful construction input to design is the commitment to preconstruction planning. Preconstruction planning determines three important elements affecting design and plan sequence. They include:

- Choosing the right construction method and sequence so that designers can make provisions for them in their design
- Making sure that the design is constructible with at least one feasible way to execute the work
- Giving a firm assurance that all necessary resources will be made available when required, including accessibility, construction space, and information.

B. CONSTRUCTABILITY TOOLS AND PROGRAMS

Constructability according to Chua (2003), is a complex and unstructured process in itself. In these days of high-speed computing, technology has provided the means with which to carry out certain processes and its development should be closely followed so that it can be incorporated with a view to enhancing effectiveness. In 2007, the American Society of Civil Engineering (ASCE) body on constructability research came up with the idea of inculcating new technologies such as 4D CAD, BIM as key to the realization of constructability goals which were obviously not being used (Hijazi, et al. 2009). While Hui-Hsuan, et al. 2013), adduced BIM to be the latest concept and technology in construction engineering used in enhancing constructability analysis during construction using 3D embedded facilities. According to Chua (2003), a four-dimensional as well as three-dimensional CAD models incorporated with animation features are providing visual capabilities for enhancing communication between designers and constructors.

Several other models have also been developed for various aspects of constructability. For instance, constructability reviews of merged schedules used for checking construction space, information, and resource availability, and a logical scheduler from the workspace perspective.
According to Kamari and Pimplikar (2012), different solution models for constructability improvement have been developed to assist project teams in integrating construction knowledge/experience during the pre-construction stage. For instance, a Construction Knowledge Expert (COKE) guides designers in designing structures that are more constructible. There are other computer tool that uses a multimedia enablers to give the designer the capability of accessing constructability information at the point of design. While the Automated Design Aid (ADA) provides the designer with useful decision support regarding design corrections and adaptations during construction.

Furthermore, Kamari and Pimplikar (2012), stated that there is a methodology that uses a computer aided drafting (CAD) 3D model of a project to review design layouts as well as to identify design conflicts as part of a pre-construction activity for constructability review. Within this methodology two reviews can be performed.

According to Arditi, et al. (2002), two types of peer reviews exist: they are project management and project design peer reviews. The first focuses on the planning or management aspects of a project; whereas, the latter is an evaluation procedure that focuses on the technical aspects of a project. The peer review process may involve both types of reviews in order to improve on the quality of a project prior to the commencement of the construction phase. The main advantage of peer review method is that it uncovers and corrects design inconsistencies, while also specifying the alternative construction method the designer is not familiar with.

Arditi, et al. (2002), further opined that the peer review and feedback systems are the most popular tools used in conducting constructability reviews in design firms with 88% and 87%, respectively of the firms using these approaches. The popularity in the use of the peer review method could be explained by the fact that most public agencies mandate the application of project peer reviews as a pre-condition for specific contracts **(**Arditi, et al. 2002).

According to Othman (2011), there are a number of techniques/tools used in constructability reviews. Othman, (2011) further stated that the ‘‘peer review’’ and ‘‘feedback systems’’ are the most popular tools used in conducting constructability reviews. Othman (2011) also corroborated Arditi, et al (2002) view on the adoption of peer reviews and feedback systems. This is because government authorities the City of Boston mandate peer reviews for specific contracts and before issuing building permits for complex projects.

The feedback process according to Arditi, et al. (2002) involves the capture and transfer of past lesson learned experience using either hard copy records or multimedia tools.

In the latter, the computer tool captures, records, and stores constructability concepts and lessons learned, while also providing design professionals with an easy access to graphical retrieval of concepts and lessons to deepen their understanding of constructability issues.

While Othman (2011) and Arditi, et al. (2002) opined that small-scale physical models are considered the least common tool used in constructability analysis. Othman (2011) in his findings opined that this once popular tool used in visualizing projects is on its way to becoming obsolete. Most design firms appear to rely more on computer generated models in conducting their constructability related activities than building physical models, probably because of cost and time considerations. It is imperative to state that design firms utilize various tools in their pursuit of constructability, depending on the characteristics of the project being under-taken. Other techniques include discussions with contractors, clients, and suppliers quality assurance/quality control after each design stage as well as the construction manager getting involved in design reviews and design checklist reviews **(**Othman, 2011). While Ekweozor (2013) in a study on analysis of constructability practice in the Nigerian construction industry identified graphical computer based tools/CAD, brainstorming and peer review as constructability tools adopted by most firms amongst others.

RESEARCH METHOD

The design used for this study was that of a survey which relied on questionnaire and interview to generate data for the analysis. The study focused on constructability tools and techniques in use in the Nigerian construction industry.

The population for the study consists of professionals from the public and private engineering and construction firms made up of design engineers, architects and quantity surveyors, project managers, construction supervisors etc. These professionals are usually engaged in the planning, design, management and execution of construction projects and therefore they formed the nucleus on which the respondents for the study were collected. The total population for the study was fifty (50). Since the population was small, as opined by Ogolo (2007), that if the population of a study is unknown, 30 % of the samples should be selected from the population to constitute the sample.

The questionnaire items were made up of the demographic characteristics of the respondents, constructability tools and techniques in use in the study area as well as other related factors in the Nigerian construction industry. The questionnaires were personally administered by the researchers and that gave them the opportunity to interact with the professionals. The researchers explained in detail the rationale for the study and gave explanations where necessary. Ample time was given to the professionals to respond to the questions. The questionnaires were delivered to the respondents by hand in their respective organizations head/branch offices, site offices.etc. Some were sent by e-mail. A total of 50 questionnaires were distributed out of which 46 were returned, representing 92% response rate.

However, 42 out of 46 questionnaires had complete responses which were further used for the analyses. A five point Likert scale was used to solicit respondent's response to their level of use of constructability tools and techniques, where "5" represented always used; "4" often used; "3" sometimes used; "2" seldom used; and "1" never used. The researchers faced some difficulties during the period of administration of questionnaires as most of the respondents were not too conversant with the themes of the research, while some were too busy due to their tight schedule and this contributed to their inability to respond to the questionnaires on schedule. However, with constant persistence and perseverance, a good number of them responded positively.

The data obtained were later analyzed using Statistical Package for Social Sciences (S.P.S.S) version 17.0. Descriptive statistical tools in the form of tables and charts were employed. While mean item score was used for the analysis of the data collected from the respondents. The analysis was done in accordance with the Mean Item Score approach of Odeyinka, et al (2010), Amade (2012).

DATA ANALYSIS AND PRESENTATION

A. SUMMARY OF DATA COLLECTED FROM CONSTRUCTION INDUSTRY PROFESSIONALS

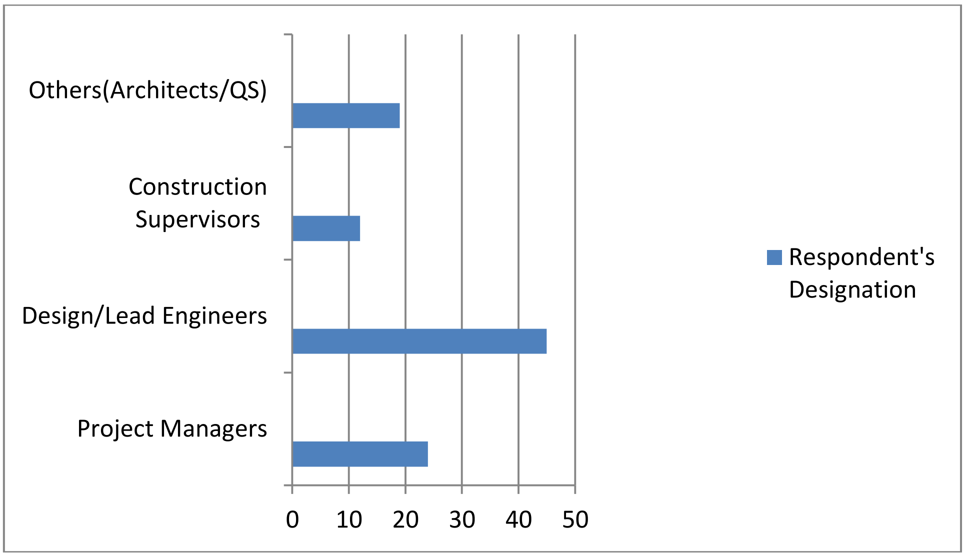

FIGURE I: POSITION HELD BY RESPONDENTS IN CONSTRUCTION INDUSTRY

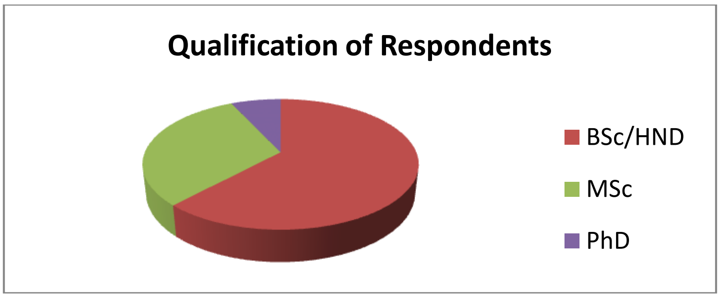

FIGURE II: QUALIFICATION OF RESPONDENTS IN CONSTRUCTION INDUSTRY

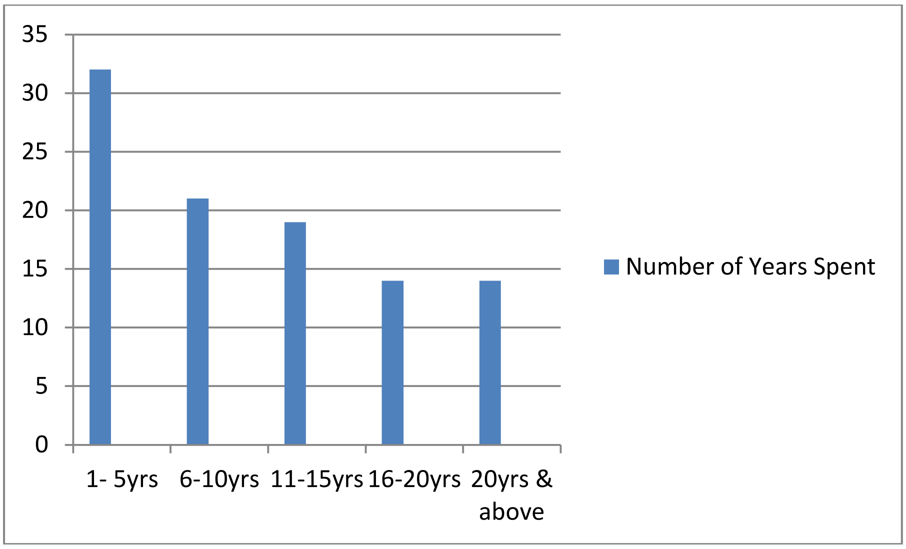

FIGURE.III: EXPERIENCE OF CONSTRUCTION INDUSTRY PROFESSIONALS

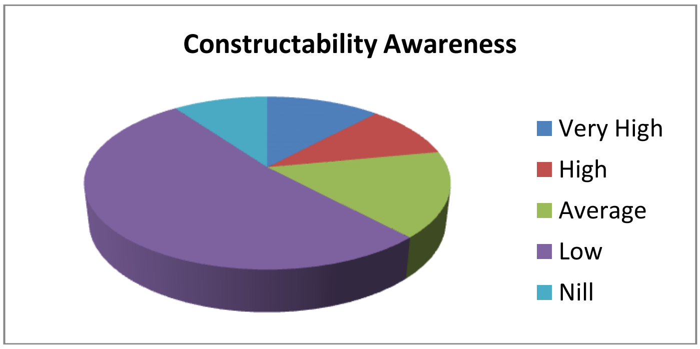

FIGURE IV: CONSTRUCTABILITY AWARENESS OF PROFESSIONALS

Constructability Techniques/Tools	**Responses (Rankings)**					**Total**	**Mean Score**	Rank
	5	**4**	**3**	**2**	**1**			
Corporate implementation manual	3	4	7	12	16	42	2.1429	13
Contract Incentive Clause	6	7	6	13	10	42	2.6667	6
Formal Implementation Process	6	6	7	12	11	42	2.6190	7
Corporate lessons learned log/file	22	10	3	2	5	42	4.0000	1
Constructability resources	7	6	5	10	14	42	2.5714	8
Graphical computer based tools CAD	16	14	5	3	4	42	3.8333	4
PDMS models	3	6	7	9	17	42	2.2619	12
Non graphical computer models	2	2	4	14	20	42	1.8571	15
Small scale physical models	2	3	2	12	23	42	1.7857	16
Brainstorming	16	14	6	4	2	42	3.9048	2
Peer Review	17	13	5	4	3	42	3.8810	3
Automated Design Aids	3	2	5	14	18	42	2.0000	14
Feedback Systems	5	6	9	10	12	42	2.5714	8
Design Checklist Reviews	3	6	6	12	15	42	2.2857	11
Quality Assurance and Control	5	6	8	10	13	42	2.5238	10
Discussions with clients,contractors,suppliers	10	12	9	8	3	42	3.4286	5
Small scale physical models	2	2	7	14	17	42	2.0000	14

TABLE I. CONSTRUCTABILITY TECHNIQUES/TOOLS USED BY RESPONDENTS

B. RELIABILITY TESTS

The results of the analysis was conducted to determine the reliability of the seventeen (17) items (statements) in the questionnaire. The overall Cronbach"s coefficient α was calculated to determine the internal reliability of the factors by determining their Cronbach's coefficient α value. Table II below presents the results.

Reliability Statistics	
Cronbach's Alpha	N of Items
.696	17

TABLE II: CRONBACH'S COEFFICIENT VALUE FOR ALL FACTOR CATEGORIES

Cronbach's α value for all factor categories were ≥ .50, which according to Pallant, (2005) is regarded as an adequate proof of internal consistency. It should also be noted that Cronbach's α values of 0.50 to 0.70 are of acceptable standard. (Pallant, 2005)

C. DISCUSSION OF RESULTS

The highest percentage of respondents from the findings are Design/Lead Engineers (45%), Project Managers (24%) and Construction Supervisors (12%), others (19%).

Of the total respondents, (62%) had B.Sc./HND as qualification, while (31%) had M.Sc. and (7%) had PhD.

In terms of the level of experience exhibited, (32%) had 1-5 yrs experience, (21%) 6-10yrs, (19%) 11-15yrs, (14%) 16-20yrs and (14%) over 20 years. This shows that the respondents are mostly professionals with high level of training and experience. On the level of awareness in respective organizations among the respondents, majority of them have not heard of constructability, while a handful of them had. This implies that on the average there is generally a low level of awareness of constructability concepts, tools and techniques among the various professionals surveyed. Whether this amounts to an equally high level of constructability input and performance is another issue to be debated upon someday.

On the use of constructability tools/ techniques and their implementation by organizations sampled, shows the following summary as obtained in table 1.

The most used constructability tools are: *Corporate lessons learned log/file* with a (MS=4.00) was ranked first. This is followed by *Brainstorming* with a (MS=3.90) and ranked second. While *Peer review* with a (MS=3.89) was ranked third. *Graphical computer based tools and CAD* with a (MS=3.83) was ranked fourth, *Discussions with clients, contractors, suppliers* with a (MS=3.43) ranked fifth. For the last two, most organizations, carry this out in the form of project review meetings, inter-discipline reviews etc. It is noteworthy to state that most respondents indicated the absence of corporate implementation manual and formalized approach to constructability implementation as non-existing in their organization. It is only a few engineer, procure and construct (EPC) as well as some multinational organisations especially in the oil and gas industry that occasionally adopt this approach. Even at that, this is usually client-driven.

Formal constructability implementation requires finance; but the benefits outweigh the costs. This assertion is supported by the research works of (Othman, 2011, Arditi, et al. 2002). Sometimes there is need to deploy special software like PDMS or 3D CAD and BIM enabled suites in order to manage the interface with different disciplines (Li, et al.2007; Kamari and Pamplika, 2012).

CONCLUSION

On the basis of the findings discussed above, the study concludes as follows:

The level of awareness of constructability concepts and principles among industry professionals is somehow appreciable. The general principles of constructability are accepted by professionals and the fact that its application in project delivery is beneficial and can lead to improvement in project performance.

However, the level of knowledge and application of formal constructability programs/tools by sampled population is very low as discovered from the findings. For instance, *Formal Implementation Process ranked (7th).* This includes scheduled constructability reviews for pre-determined milestones. Other formal techniques also scored low such as *use of constructability resources and feedback systems which were ranked (8th) respectively.* The most commonly used constructability techniques/tools as indicated by the respondents in the order of their mean score values are: *corporate lesson/learned log/file, Brainstorming, Peer reviewing, Graphical computer based tools CAD, and Discussions with clients, contractors, suppliers*.

The application of such informal tools alone cannot make the desired impact for improved project performance. Constructability implementation is therefore neither systematic nor comprehensive in majority of the firms surveyed as their input is mostly informal and mainly at the design phase. This may account to a large extent for the low performance of construction projects in Nigeria, without prejudice to other political or technical reasons.

Only few of the sampled firms understood the formal implementation procedures/tools as applicable to constructability implementation.

In view of the findings from this study, it is recommended that more awareness and knowledge of formal constructability implementation processes be created by professional bodies through workshops, trainings and researches. Improvement on project performance is better achieved by diligent application of formal as well as informal constructability techniques and tools. Better use of the formal constructability tools should to be encouraged among industry practitioners. As opined by Li, (2007) project teams can use 3D/4D models and BIM enabled tools to efficiently support the knowledge communication and generation needed during the constructability review to deliver construction projects to fruition.

Also formal constructability methodology could be included as part of a contract clause to ensure compliance in the project delivery process. Project owners/client need to be informed and educated on the benefits of constructability input in the project delivery processes and to play active roles by requesting and enforcing the implementation of formal constructability processes as a pre-condition for the execution of construction projects.

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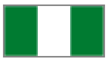

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