ASSESSMENT OF LEAN TECHNIQUES FOR BUILDING MATERIALS WASTE MINIMISATION IN ABUJA, NIGERIA

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***Abstract**:*
Lean construction techniques have been known globally as production system with a high capacity of waste minimisation. However, previous studies revealed a sub-optimal understanding of the construction professionals on the relevant lean techniques for building material waste minimisation in Nigeria. Thus, this paper assessed lean techniques for material waste minimisation in building projects in Abuja, Nigeria. The study adopted a survey design approach using quantitative data. Data was purposively collected using well-structured questionnaire administered to 320 construction practitioners (project managers, contractors, heads of waste management departments, and consultants) of 80-active building construction sites that are practicing lean within Abuja. A total of 189 questionnaires were retrieved from the 320 distributed. The collected data was analysed using frequencies, percentages and Relative Importance Index (RII). The study revealed that the lean techniques relevant to the pre-construction stage of building projects are: visual management; waste disposal management; and space utilisation management, with average RII values of 0.78. The research also found that the most important lean techniques relevant to the construction stage of building materials waste minimisation are: optimise value/value identification, good supply chain management, and visual management. Based on these findings it can be concluded that the lean techniques advanced in this paper are relevant in building material waste minimisation. Adoption and implementation of the lean techniques would translate into a drastic reduction in the quantity of material waste generation in building construction projects in Nigeria.

Keywords: *Building projects, Team techniques, Material waste, and Minimisation Introduction*

INTRODUCTION

The construction industry plays an indispensable role in any nation's economic growth by contributing to the national Gross Domestic Product (GDP) (Saidu and Shakantu, 2017)). But the industry is considered as a polluter of the environment, since construction activities contribute to environmental degradation through resource depletion, air pollution, and generation of material waste (Umar, 2019).

Construction material waste is a global problem as highlighted by Saidu and Shakantu (2017) that 10-15% of materials delivered to construction sites in the United Kingdom (UK) end up as waste; the United States (US) generates 164m tonnes of construction waste annually; and China alone generates 30% of the world's municipal solid waste, with its Construction and Demolition (C&D) waste representing 40% of the country's municipal solid waste

In Nigeria, the problem of material waste remains unresolved and requiring urgent attention in the construction industry. This problem as concluded by Saidu and Shakantu (2017) and confirmed by Umar (2019) revealed that the amount of materials used significantly predicts the quantity of material waste in building projects in Nigeria. Thus, for every 100 houses built in Nigeria, there is sufficient waste material to build another 10 houses (Ameh and Itodo, 2013). Showing that 10% of materials delivered to building construction sites end up as waste (Osmani, 2011; Saidu, 2016). Hence, Babatunde (2012) emphasised that the problem of construction material waste is well known in Nigeria, but seems not to be given the recognised attention it deserves and thus, building construction sector is often classified at the bottom of the ranking of reports regarding the efficiency of the production management techniques (Bajjou *e t al.*, 2019).

The lean construction concept has been viewed to have more impact in materials waste management than other alternatives which focus on individual process and productivity improvements (Anvari *et al.*, 2011; Ogunbiyi, 2013). Lean production philosophy which was developed by the Toyota production system has been successful in achieving maximum profits and value for money to customers (More *et al.*, 2016). Adoption of the lean technique in the

construction industry became necessary because of the needs to meeting project objectives (cost, quality and timely completion); the need to reduce uncertainty and waste in the production process, by adding value to construction activities; and the need of meeting clients' needs (Sorooshian, 2014; Arditi, 2016; Ansah, 2016; Kokate and Darade, 2018).

Studies have revealed that the lean approach has made a tremendous achievement in construction project performance of developed nations (USA, the UK, Demark, Australia, and so forth) and some developing nations (Brazil, China, among others) (Ballard and Howell, 2003). Lean construction philosophy considers construction materials waste as potential threat that hinders flow of value to the client which must be eliminated (Maru, 2015). Ansah (2016) therefore, concludes that material waste generation on construction sites can be eliminated/minimised by applying lean construction techniques in material waste management process of building projects.

The problem materials waste could be linked to the slowness of the construction sector in adapting modern techniques, like the lean thinking for waste minimisation in construction projects (Maru, 2015; Saidu and Shakantu, 2017); and little understanding of the lean techniques and its benefits in material waste minimisation (Adamu and Abdulhamid, 2017).

Previous studies on lean applications in construction are mostly foreign based and did not provide clear indication or worked specifically on lean techniques as they affect material waste minimisation in building projects precisely in Abuja, Nigeria. The research is significant to building construction professionals, and policy makers, and the Nigerian construction sector, particularly building construction firms on the application of the lean principles for waste minimisation practices.

It is against these backdrops that this study assesses the lean techniques application at stages of material waste minimisation in building construction projects in Abuja, with a view to kerbing the endemic problems of material waste in building construction projects in Nigeria.

LEAN TECHNIQUES RELEVANT TO BUILDING CONSTRUCTION PROJECTS

Bashir (2013) asserts that lean construction techniques are the different features or practices adopted in applying a Lean construction tool. In other words, Lean

techniques are subsets of lean construction tools. A Lean construction tool comprise of one, two or more Lean techniques.

Last planner system

Last Planner System (LPS) aims to change the focus of control from the workers to the flow of work better assignments to direct works through continuous learning and corrective action, and to cause the work to flow across production units in the best achievable sequence of rate (Aziz and Hafez, 2013). The Percent Plan Completed (PPC) is a measurement metric of the LPS showing the effectiveness of the production planning and the workflow reliability across the activities (Forbes and Ahmed, 2011). The PPC is also calculated as the number of planned activities that are accomplished divided by the total number of planned activities (Bashir, 2013). The production planning is said to be reliable when there is a positive (upward) slope between two PPC values. One of the main advantages of the Last Planner System is that it replaces optimistic planning with realistic planning by assessing the last planners' performance based on their ability to achieve their commitments (Song *et al.*, 2008).

5S Work organisation

The five Ss according to O'Connor and Swain (2013) is classified as follows:

i. **Seiri (Sort):** Sorting of things should be done on the basis of its frequency of use; consequently, allow easy access to regularly used things.
ii. **Seiton (Set/Straighten):** Motion required for finding or obtaining an object should be minimised to reduce the waste, by providing easy access to required items.
iii. **Seiso (Shine):** A clean and tidy environment and machines will increase the satisfaction level of the workers, while decreasing waste due to a messy environment.
iv. **Seiketsu (Standardise):** Standardised procedures should be easily understandable to implement the first 3 Ss all over the workplace.
v. **Shitsuke (Sustain):** This process should be sustained through promotions, training, and control, and applied consistently in day-to-day activities.

The 5Ss are ideally suited for a construction site to create easy access to things throughout the site and to create a safer working environment, and consequently, higher morale and worker satisfaction will be achieved through a good working environment.

Visual management (VM)

All over an organisation, VM can be used to immediately communicate unambiguous happenings, so it can be quickly understood. Construction sites are utilising VM in various forms, for instance, on board signs for hazardous or dangerous situations, and color-coding of fire extinguishers and electrical wiring etc. A lean construction environment could also utilise the following (O'Connor and Swain, 2013).

Just- In-Time (JIT)

As an example, JIT could be used to manage the transfer of materials to the construction site, according to which materials are required on site for immediate use in the construction process, without than wasting time putting the materials in temporary storage in a laydown or staging area until they are later required on site. At each step during the process, the main aim of JIT is to deliver timely, accurate quantities of the correct material (Sarhan, 2013). The three elements of JIT are summarised people, plant and systems (Almeida, 2002).

Daily huddle meeting

This planning change is implemented during the execution phase of the project by holding daily meetings to coordinate work activities. The huddle-up meeting is a great communication tool and can be used to address other project issues such as weather, environment, security, quality, or schedule. The huddle-up meeting provides a format to communicate coordination, quality, security, and schedule issues that must be addressed and, like safety, critical issues may require a work pause or stop work order until they are remedied; a warning may be issued for lesser events (Kumar and Rumasamy, 2013).

RESEARCH METHODOLOGY

The study adopted a survey design approach using quantitative data. Survey design was deemed suitable for this study because the lean techniques considered are those identified from the literature to which their applicability in construction project is to be verified in this study. Data was collected through structured questionnaire administered to respondents within Abuja, the Federal Capital Territory (FCT) of Nigeria. Abuja was selected because is one of the epicentre of construction activities in Nigeria. The population consisted of 80 active construction sites gotten from the Federation of Construction Industry (FOCI directory, 2018) that are practicing lean within Abuja. The population of 80 active construction sites were broken into sample frame constituting one each of the following respondents: Project managers; contractors; heads of waste management departments; and consultants, making a total of 320 respondents within the study area. These respondents were selected because they are the key players in applying the lean techniques on construction sites. The value of 320 gotten from sample frame was subjected to Krejcie and Morgan table for determining sample size at 5% limit of error and at 95% confidence level. The 320 was reduced to 175, which is the minimum sample size for this research. Therefore, a total of 189 questionnaires were retrieved out of the 320 distributed. 183 were found valid for the analysis, as five (5) were deemed invalid, because of poor responses. The 183 represents an effective response rate of 96.83% and this was considered suitable for analysis (Alreck and Settle, 1985).

This study adopted purposive/judgemental sampling technique, in order to select only the construction project sites that have acquire experience in applying lean techniques in material waste minimisation on construction site. Thus, not all construction sites were visited. Hence, Blaikie (2010) noted that judgmental sampling is used for selecting some cases of a particular type in the population.

A multi-choice type questionnaire was designed for this research. The questionnaire contains tables and check-boxes for easy selection of options by respondents. The questionnaires were structured in a manner that allows respondents to select from the answer choices provided. The questionnaire reflects the major areas of the study interest, thereby, providing information relevant to the study objectives and answering the research questions. The

questionnaire asked questions some on a 5-point Likert scale while some with 4-points scales.

The questionnaire was divided into two (2) main parts. Part A - is related to demographic information of the respondents and their companies. Part B- asked questions about lean techniques relevant to stages of materials waste minimisation in building project.

Some of the questionnaires were collected same day of their administering, while others were collected from the respondents after some days. This is due to the level of engagement of most of the respondents who were too busy with site works to attend to the questionnaires immediately. In addition, the distances separating one construction sites to the other, contributed to the inability of the researcher to get all the questionnaires on same day. However, with a repeated visit and follow-up calls on the need for the questionnaires to be attended to, a good number of the respondents did give their responses and the questionnaires collected. In order to achieve the aim of this research, the descriptive method of analysing data was employed and this included the use of percentile, Mean Item Score (MIS), and Relative Importance Index (RII). Data processing was done with the aid of Statistical Package for the Social Sciences (SPSS 23) software version.

RESULTS AND DISCUSSION

This section presents and discusses the results of this study by linking the results to existing findings in the literature.

Demographic information of the respondents

Result in Table 1 shows that the most represented gender are the Males with 76.50% while the Females represent 23.50%. A larger percent of the respondents have from 11 to 15 (48.09%) years of working experience. The average years of working experience is calculated at 12 years. This implies that these respondents have considerable numbers of years within the built environment, hence, should be able to give response to the research questions based on experience

Academically, most of these respondents have Bachelor of Science/Technology degree (43.17%) and Higher National Diploma holders (26.78%) respectively.

These result implies that the respondents for this study are academic and professionally qualified to give answers to the questions of this research.
The highest range of the contract sum handled by most of the respondents is 51-100 Million (37.16%). This shows that most of the respondent have handled construction projects involving significant sums, hence their response to the research questions can be relied upon.
The analysis also shows that 95.63% of the respondents had been involved in lean application in the building projects, while only 1.09% are not aware of it.
It can therefore be deduced that the population for the study are well equipped academically and have the requisite experience to give reasonable insight on the subject of this study.

Table 1: Demographic information of the respondents

Category	Classification	Frequency	Percentage
Gender	Male	140	76.50%
	Female	43	23.50%
	TOTAL	**183**	**100.00%**
Years of experience	1 - 5 years	31	16.93%
	6 - 10 years	43	23.50%
	11 - 15 years	88	48.09%
	15 years and above	21	11.48%
	TOTAL	**183**	**100.00%**
Academic Qualification	OND	13	7.10%
	HND	49	26.78%
	Bachelor Degree	79	43.17%
	Master degree	37	20.22%
	PhD	5	2.73%
	TOTAL	**183**	**100.00%**
Highest range of contract	1 – 10 Million	23	12.56%
	11 – 50 Million	44	24.04%
	51 – 100 Million	68	37.16%

	101 – 500 Million	28	15.300%
	500 – 1 Billion	20	10.93%
	TOTAL	**183**	**100.00%**
Experience with lean construction	Not aware of it at all	2	1.09%
	Just aware of it	3	1.64%
	Have been involved in its application	175	95.63%
	TOTAL	**183**	**100.00%**

Source: Researcher's analysis (2019).

Lean techniques relevant to pre-construction stage of materials waste minimisation in building projects

Table 2 indicates that the major lean techniques relevant to planning phase of material waste minimisation by the respondents are: Total Quality Management; visual management; optimising value/value identification; waste disposal management; reducing process cycle time; and supply chain management, with RII values of 0.81, 0.81, and 0.80s respectively. This confirms the result of Small *et al.* (2011) and Marhani *et al.* (2012) that the most important lean techniques at the planning stage of construction process is the Total Quality Management.

At design phase, from Table 2, the relevant lean techniques commonly applied in building construction projects by the respondents are: optimising work content; optimising product system; and defined work process, with RII values of 0.83, 0.82 and 0.80 respectively.

This confirms the study of Adamu and Abdulhamid (2016), who established that before the implementation of lean, workers often stopped work due to lack of materials. This is due to wrong information on request for materials.

Moreover, at the estimating stage of materials waste minimisation, the relevant lean techniques by the respondents are: value stream mapping and root cause analysis (Pareto, 5 why's) each with RII values of 0.80. However, training and development, error proofing and supplier involvement, were deemed to be the least techniques relevant in the estimating stage of building construction projects because they had RII of 0.60, 0.62 and 0.63 respectively.

On the overall, the lean techniques relevant to the pre-construction stage of building projects are: visual management; waste disposal management; space utilisation management were all ranked first with average RII values of 0.78. They were considered by the respondents as the key lean techniques at the preconstruction stage of building project.

However, among the least ranked techniques at the overall pre-construction stage includes; organisational learning, organisational commitment, and training and development, each with RII of 0.64, 0.66 and 0.68 respectively.

Table 2: Lean techniques relevant to the pre-construction stage of building project

	Lean Principle/Techniques	Planning phase		Design phase		Estimating phase		Overall average	
A	**Customer Focus**	**RII**	**Rnk**	**RII**	**Rnk**	**RII**	**Rnk**	**RII**	**Rnkg**
AC1	Customer Relationship	0.77	8	0.71	14	0.64	27	0.71	20
AC2	Customer Involvement	0.73	29	0.68	21	0.71	15	0.71	20
AC3	Flexible resources	0.71	37	0.62	29	0.78	4	0.71	20
AC4	Optimise value/value identification	0.80	3	0.63	26	0.77	6	0.73	13
B	**Continuous Improvement**								
CI1	Metrics (Productivity, Quality, Safety)	0.76	9	0.53	34	0.75	11	0.68	32
CI2	Organisational learning	0.75	19	0.55	33	0.63	30	0.64	38
CI3	First run studies	0.75	19	0.60	31	0.68	20	0.68	32

CI4	Huddle meting	0.75	19	0.78	7	0.76	6	0.76	7
C	**Supply of material**								
S1	Supply Chain Management (SCM)	0.80	3	0.74	11	0.76	6	0.77	4
S2	Just in Time	0.75	19	0.69	20	0.69	17	0.71	20
S3	Supply involvement	0.73	29	0.72	14	0.62	33	0.69	28
S4	Supplier development	0.72	34	0.72	14	0.76	6	0.73	13
D	**Waste Elimination**								
WE 1	Reduce process cycle time	0.80	3	0.71	16	0.70	16	0.74	11
WE 2	Waste awareness and consciousness	0.76	9	0.73	12	0.75	11	0.75	9
WE 3	Value stream mapping	0.76	9	0.73	12	0.80	1	0.77	4
WE 4	Space utilisation	0.76	9	0.78	7	0.79	3	0.78	1
WE 5	Optimize Product system	0.74	25	0.82	2	0.76	6	0.77	4
WE 6	Waste disposal management	0.80	3	0.79	4	0.76	6	0.78	1
E	**People Involvement**								
PI1	Workforce/Workers involvement	0.76	9	0.78	7	0.68	20	0.74	11
PI2	Top management involvement	0.73	29	0.79	4	0.68	20	0.73	13
PI3	Training development	0.73	29	0.71	16	0.60	35	0.68	32

PI4	Team Work	0.79	6	0.70	19	0.64	27	0.71	20
PI5	Organizational commitment	0.74	25	0.59	32	0.65	26	0.66	36
F	**Planning & Scheduling**								
PS1	Last Planner System	0.76	9	0.63	26	0.68	20	0.69	28
PS2	Percent Plan complete indicator	0.75	19	0.67	25	0.68	20	0.70	26
PS3	Collaborative planning	0.74	25	0.70	19	0.67	25	0.70	26
G	**Quality of material**								
Q1	Total Quality Management (TQM)	0.81	1	0.71	16	0.66	25	0.73	13
Q2	Error proofing Poka-yoke	0.76	9	0.68	21	0.62	33	0.69	28
Q3	Response to defect	0.72	34	0.68	21	0.68	19	0.69	28
Q4	Root cause analysis (Pareto, 5 why's)	0.71	37	0.63	26	0.80	1	0.71	20
Q5	Fail Safe for quality	0.79	6	0.67	25	0.78	4	0.75	9
H	**Standardisation of Processes**								
ST1	Optimise work content	0.76	9	0.83	1	0.69	17	0.76	7
ST2	Defined work process	0.76	9	0.80	3	0.64	27	0.73	13
ST3	Takt time	0.74	25	0.68	21	0.74	13	0.72	18

I	**Transparency in Management**								
T1	Visual Management	0.81	1	0.78	7	0.74	13	0.78	1
T2	Work place organization	0.58	38	0.71	16	0.63	30	0.64	38
T3	Building information Modelling (BIM)	0.73	29	0.79	4	0.63	30	0.72	18

Source: Researcher's Field Survey (2019).

Lean techniques relevant to construction stages of material waste minimisation in building projects

Table 3 indicates that the major lean techniques at material procurement phase are: ensuring Total Quality Management; supply chain management; optimising value/value identification, visual management, with RII values of 0.81, 0.80, and 0.80s respectively.

Table 3 also reveals that, the most important lean techniques relevant to the construction stage of material waste minimisation are: Building Information Modelling; Total Quality Management; waste disposal management and supply chain management with RII values of 0.83, 0.81 and 0.80s respectively.

The most ranked techniques for the site management phase of building construction projects are: Takt time; quick response to defect; waste awareness, and optimising value/value identification with RII of 0.89, 0.87 and 0.85 respectively.

The most important lean techniques relevant to the construction stage of building materials waste minimisation as shown in Table 4.3 are: optimise value/value identification, supply chain management, visual management and building information modelling with the most RII.

These confirms the study of Small *et al.*, 2011 who described how to incorporate the key concepts of lean techniques in the construction process and explains the interaction of key concepts in regards to the construction process. According to the study, pre-construction and construction stages are the best time to synergize the LC concepts. Both of these stages are crucial due to determination of

material, equipment and labour during pre-construction and elimination of construction waste during construction

Table 3: Lean techniques relevant to the construction stage of building project

	Lean Principle/Techniques	Material Procurement		Construction Management		Site Management		Overall average	
A	**Customer Focus**	**RII**	**Rnk**	**RII**	**Rnk**	**RII**	**Rkn**	**RII**	**Rnk**
AC1	Customer Relationship	0.78	7	0.77	10	0.78	17	0.78	10
AC2	Customer Involvement	0.72	33	0.72	32	0.66	33	0.70	33
AC3	Flexible Resources	0.71	37	0.70	36	0.74	27	0.72	32
AC4	Optimise/ identification of value	0.80	2	0.79	6	0.85	3	0.81	1
B	**Continuous Improvement**								
CI1	Metrics (Productivity and Quality)	0.75	17	0.76	12	0.78	17	0.76	17
CI2	Organizational Learning	0.74	23	0.74	23	0.75	26	0.74	25
CI3	First Run Studies	0.74	23	0.73	28	0.68	32	0.72	32
CI4	Huddle Meting	0.75	17	0.75	19	0.78	17	0.76	17
C	**Supply of material**								
S1	Supply Chain Management	0.80	2	0.80	3	0.84	6	0.81	1

S2	Just in Time	0.75	17	0.74	23	0.79	13	0.76	17
S3	Supply Involvement	0.73	29	0.73	28	0.76	24	0.74	25
S4	Supplier Development	0.72	33	0.71	35	0.67	33	0.70	33
D	**Waste Elimination**								
WE 1	Reduce process cycle time	0.79	5	0.79	6	0.76	24	0.78	10
WE 2	Waste consciousness awareness	0.76	11	0.76	12	0.85	3	0.79	5
WE 3	Value stream mapping	0.76	11	0.77	10	0.77	23	0.77	13
WE 4	Space Utilization	0.75	17	0.75	19	0.81	9	0.77	3
WE 5	Optimize Product system	0.74	23	0.74	23	0.69	31	0.73	31
WE 6	Waste disposal management	0.79	5	0.80	3	0.78	17	0.79	5
E	**People Involvement**								
PI1	Workforce/Workers involvement	0.76	11	0.76	12	0.84	6	0.79	5
PI2	Top management involvement	0.74	23	0.73	28	0.78	17	0.75	23
PI3	Training development	0.73	29	0.73	28	0.78	17	0.74	25
PI4	Team Work	0.78	7	0.78	8	0.70	31	0.75	23
PI5	Organizational commitment	0.73	29	0.72	32	0.78	17	0.74	25
F	**Planning & Scheduling**								

PS1	Last Planner System	0.76	11	0.76	12	0.85	3	0.79	5
PS2	Percent Plan complete indicator	0.75	17	0.75	19	0.82	8	0.77	14
PS3	Collaborative planning	0.74	23	0.75	19	0.80	10	0.76	17
G	**Quality of material**								
Q1	Total Quality Management	0.81	1	0.81	2	0.72	29	0.78	10
Q2	Error proofing Poka-yoke	0.76	11	0.76	12	0.79	13	0.77	13
Q3	Response to defect	0.72	33	0.72	32	0.87	2	0.77	13
Q4	Root cause analysis (Pareto, 5 why's)	0.72	33	0.70	36	0.80	10	0.74	25
Q5	Fail Safe for quality	0.78	7	0.78	8	0.81	9	0.79	5
H	**Standardization of Processes**								
ST1	Optimize work content	0.76	11	0.76	12	0.71	30	0.74	25
ST2	Defined work process	0.75	17	0.76	12	0.79	13	0.76	17
ST3	Takt time	0.73	29	0.74	23	0.89	1	0.79	5
ST4	Work sequences	0.74	23	0.74	23	0.80	10	0.76	17
I	**Transparency in Management**								
T1	Visual Management	0.80	2	0.80	3	0.79	13	0.80	3

T2	Work place organization	0.63	38	0.61	37	0.67	32	0.63	35
T3	Building information Modelling	0.77	10	0.83	1	0.79	13	0.80	3

Source: Researcher's Field Survey (2019).

CONCLUSION AND RECOMMENDATIONS

Lean construction techniques have been known globally as production system with a high capacity of waste minimisation. However, previous studies revealed a sub-optimal understanding of the construction professionals on the relevant lean techniques for building material waste minimisation in Nigeria. Thus, this paper assessed lean techniques for material waste minimisation in building projects in Abuja, Nigeria. The study concludes that the major lean techniques relevant to the planning phase of material waste minimisation are: Total Quality Management; visual management; optimising value/value identification; waste disposal management; reducing process cycle time; and adoption of good supply chain management. At design phase, the relevant lean techniques commonly applied in building construction projects are: optimising work content; optimising product system; and defined work process. At the estimating phase of materials waste minimisation, the relevant lean techniques are: value stream mapping and root cause analysis (Pareto, 5 why's). However, training and development, error proofing and supplier involvement, were deemed to be the least techniques relevant in the estimating stage of building construction projects. The study concludes that the major lean techniques at material procurement phase are: ensuring Total Quality Management; supply chain management; optimising value/value identification, visual management. The most important lean techniques relevant to the construction stage of material waste minimisation are: Building Information Modelling; Total Quality Management; waste disposal management and supply chain management. At the site management phase of building construction projects are: Takt time; quick response to defect; waste awareness, and optimising value/value identification. On the overall, the most important lean techniques relevant to the construction stage of building materials waste minimisation are:

optimise value/value identification, supply chain management, visual management and building information modelling.

Based on this conclusion, it can be recommended that effective application of these lean techniques would translate into a drastic reduction in the quantity of material waste generation in building construction projects in Nigeria.

REFERENCES

Adam, S. and Abdulhamid, R. (2016). Lean Construction Techniques for Transforming Nigeria Project Delivery Process - A Case Study Report. *Article in Indian Journal of Science and Technology · December 2016* DOI: 10.17485/ijst/2016/v9i48/109625. 9 (48): 0974-5645 www.indjst.org. ISSN (Print): 0974-6846 ISSN (Online).

Almeida, J.C. (2003). Strategic issues in lean construction and the higher education construction market sector, *Doctoral Dissertation, Worcester Polytechnic Institute* (2003).

Alreck, P. L. and Settle, R. B. (1985). *The Survey Research Handbook*. Richard D. Irwin, Inc., Homewood, Ill.

Ansah, R. H., Sorooshian, S., Mustafa, S., and Duvvuru, G. (2016). Lean Construction tools. *Proceedings of the 2016 International conference on industrial engineering and operations management Detroit, Michigan*, USA, September 23-25, 2016. IEOM Society international

Anvari, A., Zulkifli, N., Yusuf, R.M., Hojjati. S.M.H., and Ismail, Y. A. (2011). Proposed dynamic model for a lean roadmap, *African J. Bus. Manag*. 5 (2011) 6727–6737.

Arditi, J. (2016). Applying Lean Construction to Concrete Construction Projects. *A Master's Project Report Presented To The Faculty of the Department of Engineering Technology College Of Technology University Of Houston.*

Aziz, R.F. and Hafez, S.M. (2013). Applying Lean Thinking in Construction and Performance Improvement', *Alexandria Engineering Journal*, vol. 52 no. 4, pp. 679-695, https://doi.org/10.1016/j. aej.2013.04.008

Babatunde, S.O. (2012). Quantitative Assessment of Construction Material Wastage in Nigerian Construction Sites. *Journal of Emerging Trends in Economics and Managent Sciences* 3 (3), pp. 238-241.

Ballard, G. & Howell, G. 2003, 'Lean Project Management', *Building Research & Information*, vol. 31 no. 2, pp. 119-133, https://doi.org/10.1080/09613210301997

Bajjou, M.S., Anas, Chafi., and Ennadi, A. (2018). Development of a Conceptual Framework of Lean Construction Principles: An Input-Output Model. *Journal of Advanced Manufacturing Systems* Vol. 18, No. 1 (2019) 1–34#.c World Scientific Publishing Company DOI: 10.1142/S021968671950001X

Bashir A. M., Suresh S., Oloke, D. A., Proverbs, D. G. and Gameson R. (2013) "Application of Lean Construction Tools in the UK Contracting Companies- Findings from Qualitative

Studies". *Proceeding for Architectural Technology Institute Conference*, Pennsylvania University, April 2013.

Blaikie, N. (2010.) Designing Social Research. Second edition. 65 Bridge Street Cambridge CB2 1UR: Polity press, Federation of Construction Industry (FOCI) (2019). Members directory. Available on: www.foci.org.ng

Forbes, L. H. and Ahmed S. M. (2011) *Modern Construction: Lean Project Delivery and Integrated Practices.* Boca Raton: CRC Press.

Kokate, P. B., and Darade. (2018) Cost Control Techniques for Construction Project. *International Research Journal of Engineering and Technology (IRJET)*. 5(6), pp. 2433-2436.

Kumar, U. V and Ramasamy, G. (2016). A Critical Study of Various Lean Techniques in Practice and Developing a Framework for Different Construction Building Projects. *Int. J. Chem. Sci.: 14(S1), 2016, 175-187 ISSN 0972-768X www.sadgurupublications.com*

Marhani, M. A., Azmi, A.J., and Bari, A. (2012). Lean Construction: Towards Enhancing Sustainable Construction in Malaysia. *Published by Elsevier Ltd*. Selection and peer-review under responsibility of the Centre for Environment-Behaviour Studies (cE-Bs), Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia. doi: 10.1016/j.sbspro.2012.12.209. 1877-0428 © 2012

Maru, A.A. (2015). Lean construction in civil engineering and project management: Case study Analysis of UT Arlington College Park. *American journal of civil engineering*. 3: 70 – 74. doi:10.11648/j.ajce.20150303.13. Published online April 13, 2015 (http:/www.sciencepublishinggroup.com/j/ajce). ISSN: 2330-8729 (Print): ISSN: 2330-8737 (online).

More, V. D. Charhate, Shrikant. & Sinha, M. (2016). Lean construction techniques in Indian construction industry: Some analysis. *International Journal of civil engineering research*. ISSN 2278-3652 Volume 7, Number 1 (2016), pp. 59-65. Research India Publications http://www.ripublication.com

O'connor, R. & Swain, B. (2013). Implementing Lean in construction: Lean tools and techniques an introduction. Published by CIRIA, Classic House, 174–180 Old Street, London, EC1V 9BP, UK. ISBN: 978-0-86017-732-6

Ogunbiyi, O.E. Oladapo, A.K. & Jack, S. G. (2012). A review of lean concept and its application to sustainable construction in the UK. International Journal of Sustainable Construction Engineering & Technology (ISSN: 2180-3242). Vol 4, No2, 2013. Received 18 June 2013, Revised 26 September 2013; Accepted 6 November 2013. http://penebit.uthm.edu.my/ojs.index.php/IJSCET

Osmani, M. (2011) Construction waste. Chap. 15 in *Waste: A handbook for management*, by Letcher and Vallero, 1-565. San Diego: Academic Press an imprint of Elsevier.

Saidu, I. and Shakantu, W.M.W., (2017). A Study of the Relationship between Material Waste and Cost Overruns in the Construction Industry. *The 9th CIDB Postgraduate Conference Cape Town*, South Africa. Emerging trends in construction organizational practices and project-management knowledge area. Edited Windapo, A.O., 124-134, Feb, 2-4, 2016

Saidu, I. (2016) Management of material waste and cost overruns in the Nigerian construction industry. Unpublished PhD Thesis submitted to Department of Construction Management, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Sarhan, J.G. Xia, B. Fawzia, S. & Karim, A. (2017). Lean construction implementation in the Saudi Arabian construction industry. Construction Economics and Building, 17:1, 46-69. http://dx.doi.org/10.5130/AJCEB. V17i1.5098 ISSN 2204-9029/ Published by UTS ePRESS/ajceb.lib.uts.edu.au

Sarhan, S. & Fox, A. 2013, 'Barriers to Implementing Lean Construction in the UK Construction Industry', *The Built & Human Environment Review*, vol. 6 no. 1

Small, E. P., Al Hamouri, K., & Al Hamouri, H. (2017) Examining of Opportunities of Integration of Lean Principles in Construction in Dubai. *Proceeding of Creative Construction Conference*, 196, 616-621.

Song L., Liang D. and Javkhedkar A. (2008) A Case Study on Applying Lean Construction to Concrete Construction Projects [online]. [cited on 16th January 2010] http://ascpro0.ascweb.org/archives/cd/2008/pa-per/CPGT201002008.pdf

Sorooshian, S. (2014). Delay-based Reliability Analysis on Construction Projects, Life Science Journal, 11(3), 104– 113.

Umar, A. (2019) Development of material waste prediction model for building construction works in Abuja, Nigeria. Unpublished MTech Thesis, submitted to Postgraduate School in partial fulfilment for the requirement of Master of Technology, in Quantity Surveying, Federal University of Technology, Minna.