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Assessment of Lean Construction Adoption Level to TETFund-Sponsored Construction Projects in Tertiary Institutions in Ekiti State, Nigeria

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Abstract
The construction industry plays a significant role in long-term national development and economic progress, most especially for emerging nations. The construction industry produces waste in terms of time and other resources to the tune of 57%. This enormous waste contributes greatly to inefficiency, high cost of production and eventually to low productivity. This brought about the concept of lean construction (LC) principles and its adoption. This study therefore seeks to examine the level of adoption of lean construction practices in the Nigerian construction industry, particularly within the context of public tertiary education infrastructure. The data used for this study was obtained through the administration of questionnaires to elicit responses from the target respondents. Data were analyzed using frequency, percentages and Relative Importance Index (RII) to measure the level of importance of various factors. The study revealed that the majority of the respondents was aware of and adopted lean construction and this eventually resulted in high-quality work output and elimination of waste on site. These findings underscore the importance of integrating lean methodologies at every stage of construction. The findings of this study will also provide valuable insights for researchers, policymakers, practitioners, and stakeholders, enhancing their understanding of the adoption of lean construction principles and identifying research gaps. A further study that can review the level of the adoption of lean construction using a wider scope in term of number of target respondents and not limited to only TETFund-Sponsored construction projects that can give a clearer picture is therefore recommended.

Keywords: Adoption, Lean Construction, Nigeria, TETFund-sponsored projects, Waste.

1. INTRODUCTION

The construction industry refers to all entities and individuals involved in the procurement, production, alteration, repair, maintenance, and demolition of building and civil engineering works. It is commonly known that the building industry plays a significant role in long-term national development and economic progress, especially for emerging nations [1], [2], posited that every task in the construction industry has an impact on time utilization and attendance costs. There are numerous procedures and processes involved in construction activity. He went on to say that it is important to highlight that several wastes of labour, tools, materials, time, and other resources were identified.

Despite the relevance of construction industry to nations' economies and their contribution globally, the enormous waste emanating from construction industries according to [3] contributes greatly to inefficiency, high cost of production and eventually to low productivity rates in the construction industry. These wastes hinder performance and efficiency in the construction industry and this is one of the weaknesses of the construction industry in recent times. Wastes in the construction sector typically add significantly to the high cost of production [4], the wastage produced in different industries varies because their functions and scope of work are different. [4] reported that manufacturing industries produce less waste in terms of time to the tune of 12% whereas in the construction industry, it is to the tune of 57%. In some instances, some of these physical wastes were sold out to interested buyers to compensate for the loss but the cost cannot be compared with the gain thereafter. This brought about the concept of lean construction (LC) principles.

Lean construction (LC) principles state that only conversion activities add value and these should be

made more efficient, whereas non-value-adding flow activities should be reduced or eliminated [5]. [6] also defined lean construction as a continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a construction project. The major aim of lean construction is to maximize value and to minimize waste of money, time and materials; that is to design and produce the products with an efficient production system [7].

The construction sector's significant waste levels contribute to the high cost of production, with waste rates reaching 57% compared to 12% in manufacturing industries [8]. This inefficiency not only escalates costs but also undermines productivity. While some physical waste can be sold to offset losses, the financial gain is often minimal. To address this, lean construction (LC) principles have been introduced, focusing on enhancing value-adding activities and reducing or eliminating non-value-adding activities [5].

The Tertiary Education Trust Fund (TETFund) is an important Nigerian funding organization that promotes the construction of educational facilities [9]. Given the significant investments and the crucial role these projects play in enhancing educational facilities, ensuring their efficient execution is imperative, and one such way to ensure efficient execution is through the adoption of lean construction techniques. An Effective construction process is essential to achieving successful project performance in terms of cost, time and quality. A poor construction process or strategy can easily turn an expected profit into a loss [10]. This is especially true for the construction industry where projects have a relatively short and defined life cycle and the project activities are non-repetitive with rather complex interrelationships so that there is little opportunity to improve on a wrongly chosen or adopted strategy.

II. AIM AND OBJECTIVE

This study therefore seeks to examine the adoption of lean construction practices in the Nigerian construction industry, particularly within the context of public tertiary education infrastructure.

III. LITERATURE REVIEW

The construction industry as seen by different researchers has been tagged as a slow-progressing industry associated with many problems such as low productivity, unsatisfactory quality, poor safety, and extended project time, which obstructs a customer-based oriented project value [11]. Construction projects are diverse as they could either be a stodgy (slow, simple and certain) project on one end or a dynamic (fast, uncertain, and complex) project on the other end [12]. However, [13] posited that the construction sector has been experiencing an enormous drawback, which is “Waste”. In response, lean construction principles, derived from lean manufacturing, have been adopted globally to enhance productivity, reduce waste, and improve project delivery in Nigeria [14].

Tertiary Education Trust Fund (TETFund) sponsors numerous construction projects in public tertiary institutions, necessitating efficient project management practices [15]. This literature review explores the application of lean construction to TETFund-sponsored projects in Nigerian public tertiary institutions.

Numerous definitions of lean construction have been provided by previous scholars. Lean construction, according to [16], adds value by reducing waste, improving worker performance, adapting to change, and emphasizing quality. Ninety percent of lead time is usually non-value added. [17] defined lean as a temporary production system that delivers the product with minimum waste and maximum value. In 2003 the Lean Construction Institute defined lean construction as a production management-based strategy to project delivery. Lean production management has caused a revolution in manufacturing design, supply and assembly. According to [18], lean construction is a project delivery system based on the lean production management process.

[19] posited that Lean Construction (LC) is a philosophy that aims to transform the way construction processes and organizations are organized and thought about. It demands that the commonplace and daily be viewed from a different perspective and that new and creative solutions be conceived. It goes beyond cutting down on labor, time, and material waste to include providing value to the client throughout the project, from design to the very end of project handover. The idea behind the lean approach is to usually streamline the construction process by eliminating waste that is thought to be non-value-generating ([5]. The construction industry could see new developments as a result of lean building.

According to [20] using lean construction approaches minimizes non-value stages or the loss of time and resources needed to meet the goals of the client. [21] elucidated the notion of lean production, which involves identifying and providing value to the client while eliminating non-value-adding elements. It also stops the line, gathers and distributes information, and facilitates decision-making, all of which help to refine the products and provide dependable flow.

Lean construction is a project delivery method aimed at maximizing value and minimizing waste through continuous improvement, collaboration, and efficient resource use [22]. It incorporates principles like just-

in-time delivery, pulls planning, and integrated project delivery.

Lean construction, rooted in the principles of lean manufacturing, focuses on maximizing value and minimizing waste in construction projects [22]. In Nigeria, the adoption of lean construction is gaining traction as the country seeks to improve the efficiency and quality of its construction industry. This approach is particularly relevant given the significant infrastructure and development needs in Nigeria's rapidly growing economy.

The adoption Level of Lean Construction in TETFund-Sponsored Construction Projects is discussed below;

Integrated Project Delivery (IPD): A project delivery method that integrates people, systems, business structures, and practices into a collaborative process, enhancing efficiency and outcomes through shared goals and responsibilities [24].

Prefabrication and Modular Construction: The practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies to the construction site, reducing on-site construction time and improving quality [25].

Just-In-Time (JIT) Delivery: The practice of delivering materials only when they are needed to reduce inventory and storage costs, enhancing efficiency and minimizing waste in the construction process [26].

Lean Design: Applying lean principles to the design phase to ensure efficiency and value in the final product, focusing on minimizing waste and maximizing functionality [26].

Total Productive Maintenance (TPM): A holistic approach to equipment maintenance that aims to achieve perfect production with no breakdowns, no small stops, no slow running, and no defects, enhancing equipment reliability[26].

Pull Planning: A scheduling technique where tasks are pulled based on when they are needed rather than pushed according to a set schedule, improving workflow efficiency and reducing bottlenecks [27].

Building Information Modeling (BIM): The use of digital representations of physical and functional characteristics of places to support decision-making, improving collaboration, accuracy, and efficiency in the construction process [27].

Batch Size Reduction: Reducing the number of units in a batch to decrease cycle times and increase flexibility, enhancing responsiveness and efficiency in the production process [27].

Daily Huddle Meetings: Short, daily meetings to discuss progress, address issues, and plan the day's activities, fostering communication and quick problem-solving within the project team [27].

The adoption of lean construction in Nigeria has been gradual, driven by increased awareness and education about the benefits of lean principles. Professional bodies, academic institutions, and industry conferences have played a key role in disseminating knowledge about lean construction practices [28].

Training programs and workshops are being organized to educate construction professionals about the principles and tools of lean construction. Adopting lean construction in Nigeria faces obstacles like resistance to change, lack of awareness, and limited expertise. However, successful adaptations in similar contexts suggest that lean principles can be tailored to local conditions.

IV. RESEARCH METHODOLOGY

The target population comprises professionals in the construction industry who were involved in TETFund-sponsored construction projects in public tertiary institutions in Ekiti State (Engineers, Architects, Quantity Surveying and Builders). The list of beneficiaries' institutions with TETFund-Sponsored construction is as shown in Table 1 while Table 2 gives the sample frame of respondents for the study.

Table 1: Beneficiary Institutions with TETFund-Sponsored Construction Project in Ekiti State

S/N	Beneficiary Institutions	Status	Project	Intervention Type	Year
1.	Federal University, Oye-Ekiti	Public/ Conventional	a. Construction and furnishing of students hostel with fire alarm and fire fighting system. Duration 20 Weeks	Special	2021
			b. Construction and furnishings of lectures theatre building.	Annual	2022
2.	Federal Polytechnic, Ado-Ekiti	Public/ Conventional	a. Construction and furnishings of 3 lecture theatre	Annual	2021
			b. Construction of academic staff office, classroom and lecture theatre.	Special	2019
			c. Construction of classrooms and office complex	Normal	2022
3.	Ekiti State University, Iworoko-Ekiti	Public/ Conventional	a. Construction and furnishings of faculty of basic science with suspended floors comprising of 4nr laboratories, and lecture rooms	Zonal	2021
			b. Remodelling of administrative building	Annual	2022
4.	Bamidele Olumilua University of Education, Science and Technology	Public/ Specialised	a. Renovation/Rehabilitation of school of Arts and social sciences	Normal	2019
			b. Installation of office equipments	Zonal	2020

Source: Field Data Survey, (2024)

Table 2: Sample Frame of Respondents

Respondents	Number
Quantity Surveyors	17
Engineers	29
Builders	13
Architects	25
Total	**84**

Source: Field Data Survey, (2024)

A census sampling technique was employed for the distribution of the questionnaires to achieve the objective of this study. A closed-ended questionnaire was used for this study. A total of 84 questionnaires were distributed and 76 questionnaires were retrieved.

Descriptive statistics such as frequency, percentages and Mean Item Score were used for the analysis. The mean item score was used to obtain a quantitative equivalent of the average response that was provided by the respondents following a 5-point Likert scale. The highest mean item score "MIS" was ranked 1st and others in such subsequent descending order. Using a 5-point Likert scale where 5 is the highest score and 1 is the lowest score; Tables were then used to present the results of the research and employed to assess the objective of this study which is to assess the level of adoption of lean construction to TETFund-Sponsored construction projects in public tertiary institutions in Ekiti State. The mean item score was computed using the formula below:

$$\text{Mean} = \frac{\Sigma fw}{\Sigma f}$$

Where $\sum fw$ connotes the sum of the product of all weights and the frequency of respondents opting for such weights, while $\sum f$ is the total number of respondents. The formula above can be further expanded as shown below;

$$MIS = \frac{(5 \text{ x } f5) + (4 \text{ x } f4) + (3 \text{ x } f3) + (2 \text{ x } f2) + (1 \text{ x } f1)}{f5 + f4 + f3 + f2 + f1}$$

Criteria for drawing inference from the mean score were established as follows:

$4.90 < MIS \leq 5.00$ Very significant (or very high (impact), very easy, etc.)

$3.70 < MIS \leq 4.89$ Significant (or high (impact), easy, etc.)

$2.50 < MIS \leq 3.69$ Neutral (or medium (impact), neutral, difficult, etc.).

$1.30 < MIS \leq 2.49$ Insignificant (or low (impact), difficult, etc.)

$0.00 < MIS \leq 1.29$ Very insignificant (or very low (impact), very difficult, etc.)

IV. RESULTS AND DISCUSSION

Table 3: Demographic Information of Respondents

Category	Respondent	Frequency	Percentage (%)
Professions of the Respondents	Quantity Surveyors	24	31.6
	Engineers	19	25.0
	Builders	18	23.7
	Architects	25	19.7
	Total	**76**	**100.00**
Years of Experience of the Respondents	1-5	5	6.7
	6-10	25	32.8
	11-15	21	27.5
	16-20	12	15.7
	21 – 25	8	10.5
	Above 25	5	6.8
	Total	**76**	**100.00**
Level of Wastage Experienced During the Construction Process	Extremely high	5	6.7
	Moderately high	25	32.8
	High	21	27.5
	Low	12	15.7
	Moderately low	8	10.5
	Extremely low	5	6.8
	Total	**76**	**100.00**

Source: Field Data Survey, (2024)

The table above shows the demographic information of respondents. It can be seen from the table that for the professions of the Respondents, 24.59 percent of the respondents are Quantity Surveyors, 19.67 percent of the respondents are Engineers, 18.03 percent of the respondents are Builders, and 37.70 percent of the respondents are Architects. For the Years of Experience of the Respondents**,** 21.31 percent of the respondents have 1-5 Years of Experience, 19.67 percent of the respondents have 6-10 Years of Experience, 21.31 percent of the respondents have 11-15 Years of Experience, 19.67 percent of the respondents have 16-20 Years of Experience, and 18.03 percent of the respondents have Above 21 Years of Experience. Moreover, the Level of wastage experienced during the Construction Process is High.

Adoption level of lean construction in TETFund-Sponsored Construction Projects

The table below shows the adoption level of the various Lean construction practices in the study area. It can be seen from the table that; Integrated Project Delivery (IPD) with a mean score of 4.50 was ranked first, 4.45 was ranked second, Just In Time (JIT) Delivery with a mean score of 4.38 was ranked third, again, Lean Design with a mean score of 4.35 was ranked fourth,

Total Productive Maintenance (TPM) with a mean score of 4.34 was ranked fifth, Pull Planning with a mean score of 4.25 was ranked sixth, Building Information modeling with a Mean score of 4.27 was ranked seventh, Integrated Project Delivery (IPD) with a mean score of 4.22 was ranked eight, Batch Size Reduction with a mean score of 4.20 was ranked ninth, and Daily Huddle Meetings with a mean score of 4.14 was ranked tenth

Table 4: Adoption level of lean construction in TETFund-Sponsored Construction Projects

Lean Construction Practices	Std. Deviation	Mean	Rank
Integrated Project Delivery (IPD)	0.856	4.50	1
Prefabrication and Modular Construction	0.854	4.45	2
JustInTime (JIT) Delivery	0.926	4.38	3
Lean Design	0.854	4.35	4
Total Productive Maintenance (TPM)	0.852	4.34	5
Pull Planning	0.932	4.25	6
Building Information Modelling (BIM)	0.929	4.24	7
Integrated Project Delivery (IPD)	0.808	4.22	8
Batch Size Reduction	0.837	4.20	9
Daily Huddle Meetings	0.938	4.14	10

Source: Field Data Survey, (2024)

V. STRENGTH AND LIMITATIONS

This paper showcases the level of adoption of lean construction practices and principles to TEtfund-sponsored construction projects and reveals some of the principles adopted. However, A further study that can review the effect of the adoption of lean construction and factors affecting the adoption of lean construction to TETFund-Sponsored construction projects in public tertiary institutions to give a clearer picture of the adoption and implementation of lean construction to construction projects is therefore strongly recommended.

VI. CONCLUSION

The conclusion of findings regarding Lean Construction Practices aligns with established literature across several key areas. Integrated Project Delivery (IPD) emphasizes collaborative efforts among stakeholders, systems integration, and business practices to enhance project efficiency and outcomes. This approach is consistent with research by [24]. and [29]. who note that IPD fosters improved project performance through shared goals and responsibilities, reducing conflicts and enhancing decision-making processes.

Prefabrication and Modular Construction practices are highlighted for their ability to streamline construction processes and improve overall project quality. Research by [25] and [30 supports these conclusions, indicating that prefabrication reduces on-site construction time, minimizes waste, and enhances safety and quality control measures. These methods are seen as pivotal in modern construction for their efficiency gains and ability to mitigate common onsite challenges.

Just-In-Time (JIT) Delivery is underscored for its role in minimizing inventory costs and optimizing material use by delivering resources precisely when needed. [26] and 31 corroborate these findings, emphasizing JIT's impact on reducing project costs and improving workflow efficiency. This practice aligns with lean principles by ensuring resources are utilized effectively, thereby enhancing project timelines and cost management.

Lean Design principles focus on maximizing value and minimizing waste throughout the design phase of construction projects. [32] argue that lean design integrates customer needs, optimizes processes, and reduces inefficiencies, leading to higher quality outcomes and improved project satisfaction. These findings underscore the importance of integrating lean methodologies at every stage of construction to achieve sustainable improvements in project delivery and client satisfaction.

VII. RECOMMENDATIONS

The study recommended that;

1. There should be comprehensive workshops and training sessions for all stakeholders involved in TETFund-sponsored projects, including project managers, contractors, and laborers. This will ensure that everyone understands the principles and benefits of Lean Construction, leading to more consistent and effective implementation.

2. Construction professionals should create a set of standardized guidelines and best practices for Lean Construction tailored to the specific needs and conditions of public tertiary institutions in Ekiti State. These guidelines should be enforced through regular audits and assessments to ensure compliance and continuous improvement.

3. Construction professionals have to foster a collaborative environment where all stakeholders, including designers, contractors, and clients, can communicate openly and work together efficiently. This can be achieved through regular meetings, joint planning sessions, and the use of collaborative tools and platforms.

4. There should be advanced planning and scheduling techniques such as the Last Planner System (LPS) to improve project management and execution. This will help minimize delays, reduce waste, and ensure timely completion of projects.

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