

Factors Affecting Adoption of Prefabrication Method for Sustainable Construction in Kaduna Metropolis

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ABSTRACT

Concrete in-situ construction generates numerous construction wastes during building and transportation of waste tends to incur high building resource consumption, low building efficiency and frequent accidents, which results in relatively serious environmental pollution pressure. The objective of this study is to identify factors affecting the adoption of prefabricated construction in Kaduna Metropolis. Questionnaire survey was used for the collection of data needed for the study. A total of 86 questionnaires were obtained from the respondents who are actively involved public projects in the city and analyzed using Mean Item Score. The study identified those factors affecting the adoption of prefabrication method as: fewer demand by clients, the venue restriction and transportation cost, lack of skilled labour and Lack of availability of prefabricated industries amongst others. The study concludes that prefabricated construction system should be encouraged to develop workers health and safety due to cleaner and good working environments.

Keywords: Prefabrication, Sustainable Construction, Kaduna Metropolis

I. INTRODUCTION

The construction industry is facing numerous difficulties in managing construction waste, quality, environment, permanence, safety and greater construction cost. Dynamic change is needed today to overcome new challenges in the construction industry. Adoption of prefabrication is one of the possible solutions to such problems (Kharo, 2019). The World Green Building Council (WGBC) stated in their yearly report of 2015–2016 that buildings account for 30% of CO₂ emissions with a 7.4 billion world population (The World Bank 2017; WGBC 2016, UNEP, 2020).

Construction projects represent more than 40% of universal power generation and account for 30% of gross Green House Gas (GHG) emissions in developing nations and developed countries (International Energy Agency, 2013; SBCI, 2009; Climatic Chance, 2019; Ampratwumetal., 2019). Prefabricated construction is viewed as the sustainable construction method which can salvage the problem.

Prefabrication may be defined as the production of entire building, or substantial building constituents' offsite, in a factory location prior to fitting or assembly onsite (Bellis, 2011; Li 2014). It is an emerging new technology in the architecture, engineering and construction industry (WEF 2016). Prefabricated construction is a state-of-the-art construction technology of both socio-economic and environmental benefits, but sometimes, it is not welcome due to its high cost (Baoquan et al., 2020). To meet up with time and budget requirements of construction projects, contractors are utilizing prefabricated construction methods to accelerate the construction process. Prefabricated construction methods require an adequate schedule and understanding by the contractors and constructors to be successful. The designers and constructors must have a strong understanding of the assembly process to experience the full benefits of the method (Gilmarie et al., 2020). Prefabricated construction has been widely accepted as an alternative to conventional cast-in-situ construction, given its improved performance (Yingbo et al., 2019). Several problems are associated with traditional cast-in-place buildings, such as heavy energy consumption, severe environmental pollution, and low labour productivity, have delayed the development of the construction industry (Zhao et al., 2020).

Traditional cement building generates abundant construction wastes during construction and waste transportation. Thus, it incurs high building resource consumption, low building efficiency, and frequent occurrence of safety accidents, which result in relatively low utilization ratio of building resources and relatively serious environmental pollution pressure (Nan and Jie 2020). Prefabricated buildings have a direct bearing on national economic development and transformation of people's lifestyle because of their high economic, environmental, social, and safety benefits. A prefabricated building can save building materials and energies and decrease construction waste emission; it is also an essential choice when the construction industry develops to a high level in a country (Nan and Jie, 2020). Prefabricated mechanically fixed components, in comparison with conventional concrete and brick in situ construction, can be more easily separated during demolition, allowing its reuse, and even if this is not possible, at least allowing the recycling or the energetic recovery. It is very important that construction practitioners understand the benefits of the prefabrication (Couto et al., 2020)

Clients and the construction team do not often patronize prefabrication methods of construction but continue to heavily rely on in-situ construction which does not encourage diversity in the method of construction (Feld and Carper, 2016). There are a lot of uncompleted projects dotted across the length and breadth of the country (Oladiran, 2017). Also, most projects are far behind their completion schedule time, because a lot of time is spent on erecting formwork, mixing and casting concrete, waiting for the concrete to cure, striking of the formwork, and other activities which could have been avoided on site as it is in the case of prefabrication which just require assembling the components in to position. This could take just one third (1/3) of the time required (Seeley, 2017). The construction industry is bedeviled by the challenges of balancing environmental concerns with the erection of new structures. Even though government has recognized the promotion of prefabricated construction as a significant approach for tackling this challenge, little attention has been paid by the government to the practical schemes to be used (Luo et al., 2020). Therefore, the objective

of this study is to identify factors affecting the adoption of prefabricated construction in Kaduna Metropolis. The results obtained will assist the contractors in fast tracking and minimizing construction wastes in order to protect the environment for a sustainable future of the industry. This study is significant to the Nigerian government and its regulatory agencies.

II. LITERATURE REVIEW

Prefabrication is 'a manufacturing process, generally taking place at a specialized facility, in which various materials are joined to form a component part of the final installation' (Wang et al., 2019). Durdyev and Ismail (2018) viewed prefabrication as the mode of construction that is being carried out in the factory with higher quality and efficiency and precision while ensuring safety, then is later transported to the construction site. Prefabrication may be defined as the production of entire building, or substantial building constituents' offsite, in a factory location prior to fitting or assembly onsite (Bellis, 2011; Li 2014). It is an emerging new technology in the architecture, engineering and construction industry (WEF 2016). Bon-Gang et al. (2018) stated that prefabrication can improve the workflow continuity, increase the efficiencies in the use of resources, lessen construction wastes, and trim down the number of on-site contractors as well as construction periods. Prefabrication has been considered an effective alternative to conventional building. It has gained an increasing amount of attention over the last few decades as a way to advance sustainable construction (Jiang et al., 2019). Off-site construction involves the process of planning, designing, fabricating, transporting and assembling building elements for rapid site assembly to a greater degree of finish than in traditional piecemeal on-site construction (Smith, 2016). The reward of prefabrication is shown through a major increase in productivity and performance in the construction sector making contractors the major beneficiary of the process (Samarasinghe and Sajeevan, 2020). Table 1 shows the negative factors that affect the adoption of prefabrication method of construction. Nineteen negative factors were identified from the past studies on the prefabrication method in the implementation of construction projects.

Table 1: Negative Factors Affecting Prefabrication Method

S/N	Negative Factors for Prefabrication	Authors
1	Sluggish real estate market	Luo et al. (2021)
2	Market acceptance of prefabricated buildings is low	Luoetal. (2021);Okodi-iyah(2012); Wang etal.(2019)
3	The enterprise is not enthusiastic enough to participate	Luoetal. (2021); Wang etal.(2019)
4	Venue restriction and transportation cost	Luoetal. (2021); Khahro (2019);Murali and Sambath (2020); Taware and Taware (2017);Wangetal.(2019); Shenetal. (2019)
5	Insufficient diversification of prefabricated Buildings	Luoetal. (2021); Wang etal.(2019)
6	The problem on how to control the cost	Luoet al.(2021); Khahro (2019); Moradibistouni and Gjerde (2017)
7	Imperfect industrial chain	Luo et al.(2021); Wang etal.(2019)
8	Strict & difficult design changes	Khahro (2019);Okodi-iyah(2012); Murali&Sambath 2020,
9	Lack of availability of prefabricated industries	Khahro (2019);Okodi-iyah(2012); Wang etal.(2019)
10	Lack of skilled labour	Khahro(2019);Okodi-iyah(2012); Moradibistouni and Gjerde (2017)
11	Limited site space	Khahro (2019);Okodi-iyah(2012)
12	Lack of materials used in prefabrication	Khahro (2019)
13	Increased production volume is required to ensure affordability through prefabrication	Khahro (2019)
14	New process and unfamiliarity of process	Khahro (2019)
15	Lack of experiences	Khahro (2019);Okodi-iyah(2012); Wang etal.(2019)
16	Limited trained labour	Khahro (2019);Okodi-iyah(2012); Murali&Sambath (2020); Wang etal.(2019); Shenetal. (2019)
17	Fewer demand by clients	Khahro (2019)Okodi-iyah(2012); Murali&Sambath (2020)
18	Government legislations and Guidelines	Khahro (2019); Moradibistouni and Gjerde (2017)
19	Leakage problem while joining prefabricated components	Khahro (2019);Okodi-iyah(2012)

Research Method

The study was carried out in Kaduna metropolis, the capital city of present Kaduna State of Nigeria which occupies important political, economic and cultural position among other cities in Northern Nigeria. According to National Population Commission (2006), it has an estimated population of 6,066,562 and the metropolis is regarded as the “power house” and “nerve centre” of the Northern political class in Nigeria (Obioha, 2009). The metropolis is located between Longitude 70 21’ and 70 30’ East of the Greenwich Meridian and Latitude 100 23’ and 100 36’ North of the Equator (Abdulrasheed et al., 2019). The Metropolis is selected for this study due to high

volume of construction activities going on in the city.

Data were collected through a well-structured questionnaire from some selected public projects in Kaduna city. A total of 150 questionnaires were administered to the study population while only 86 successfully completed and used for the analysis. The selection was carried out using stratified random sampling technique to form the study sample. This gives overall response rate of 57.3% rate which is considered to be above the acceptable 20-30% required for quantitative survey in construction management studies (Akintoye and Fitzgerald, 2000). The data was analyzed using Microsoft excel to determine the mean item score of the responses

III. RESULTS

The result of the analysis is shown in Table 2 and 3. The analysis shows that 77.90% of the respondents worked in medium sized construction firms while 22.10 % of the respondents worked with a small sized organization. This shows that the correspondents work with organizations that have large

construction work ongoing in the city and they have large turnover in the construction business.

The result also shows that the respondents are middle- level managers that are fully involved in construction activities. They are site managers (53.8%), Foremen (20.93%), Project Managers (13.95%) and supervisors (9.31%). They also have considerable years of experience in the industry with majority of them having between 10- 15 years.

Table 2 General Information

S/N	Description	Option	Frequency	Percentage
1	Size of Firm	a) Small	19	22.10
		b) Medium	67	77.90
		Total	86	100.0
2	Designation of respondents	a) Site manager	48	55.81
		b) Project manager	12	13.95
		c) Foreman	18	20.93
		d) Supervisor	8	9.31
		Total	86	100.0
3	Years of Experience	a) 0-5 years	10	11.63
		b) 5-10	18	20.93
		c) 10-15	33	38.37
		d) 15-20	16	18.60
		e) Above 20 years	9	10.47
		Total	86	100.0
4	Highest Qualification obtained	a) Ordinary diploma	5	5.81
		b) HND	15	17.45
		c) BSc	31	36.04
		d) MSc	35	40.69
		e) Others	-	-
		Total	86	100.0
5	Types of project handled	a) Building projects	47	54.65
		b) Civil Engineering projects	39	45.35
		Total	86	100.0

Furthermore, it can be observed that a greater percentage of the respondents are experienced with 10-15 years of experience having 38.37%, followed closely by 10-15 years and 15-20 years having 20.93% and 18.60% respectively indicating that most of the respondents are well experienced. Only 10.47% of the respondents are less experienced in their respective firms. Their

qualifications showed that majority of the respondents have at least a Higher National Diploma or its equivalent in construction related discipline. This implies that the Nigerian Construction industry have the involvement of workers with adequate academic qualifications to achieve project objectives. The result also shows the type of projects handled in the organization

visited, building projects have the larger percentage of 54.65% and civil engineering project having a percentage of 45.35%. Showing that majority of the firms were building firms. The result shows that all the organizations visited are exposed to construction activities. This implies that they should be involved in prefabrication to ensure those projects are safely delivered without excesses.

The result of the analysis identified the factors that are responsible for non-adoption of prefabrication method of building development in Kaduna City. It shows that fewer demand by clients; venue restriction and transportation cost; cost control challenges; and non-availability of prefabricated industries are the major factors that prevents the adoption of this method. However, the

sluggish real estate market; new process and unfamiliarity of process; and lack of skilled labour have less impact on the adoption of prefabrication method for building construction in Kaduna city.

Since fewer clients are demanding the prefabrication option in the development of projects, the method will surely have less patronage. Then, this will reduce the capacity and the number of firms that specialize in this construction method. The construction companies operating in the city would be interested in investing in acquiring knowledge and equipment's for such construction method. This will affect the number of persons that will specialize in the sector. These findings are in tandem with Khahro (2019), Okodi-iyia (2012) and Wang et al., (2019).

Table 3: Factors Affecting Adoption of Prefabrication Method

S/No	Negative Factor for Prefabrication	1	2	3	4	5	$\sum f$	$\sum fx$	Mean	Position
1	Fewer demand by clients	1	1	12	11	61	86	388	4.51	1 st
2	Venue restriction and transportation cost	5	2	5	18	56	86	376	4.37	2 nd
3	Insufficient diversification of prefabricated buildings	1	3	10	30	42	86	367	4.26	3 rd
4	Cost control challenges	-	6	8	35	37	86	361	4.19	4 th
5	Lack of availability of prefabricated industries	-	6	10	34	36	86	358	4.16	5 th
6	Leakage problem while joining prefabricated components	-	12	21	8	45	86	344	4.00	6 th
7	Increased production volume is required to ensure affordability through prefabrication	-	6	22	30	28	86	338	3.93	7 th
8	Strict & difficult design changes	3	7	13	41	22	86	330	3.84	8 th
9	The enterprise is not enthusiastic enough to participate	-	9	28	28	21	86	319	3.70	9 th
10	Market acceptance of prefabricated buildings is low	-	-	37	43	6	86	313	3.64	10 th
11	Lack of materials used in prefabrication	-	21	44	20	10	86	284	3.30	11 th
12	Government legislations and Guidelines	12	-	34	26	14	86	273	3.17	12 th
13	Limited trained labour	3	23	33	12	15	86	271	3.15	13 th
14	Imperfect industrial chain	-	30	25	20	11	86	270	3.14	14 th
15	Limited site space	-	30	25	20	11	86	270	3.14	14 th
16	Lack of experiences	5	11	26	21	15	86	264	3.06	16 th

17	Sluggish real estate market	13	12	45	10	6	86	242	2.81	17 th
18	New process and unfamiliarity of process	12	27	30	10	7	86	233	2.70	18 th
19	Lack of skilled labour	41	21	10	7	6	86	171	1.98	19 th

IV. CONCLUSION

The current study investigated the challenges of prefabricated building systems from literatures. This review shows that prefabricated construction have a high potential to improve the efficiency and performance of the Nigerian construction industry in a more sustainable manner. However the findings from the study observed that; fewer demand by clients; the venue restriction and transportation cost of prefabrication; and insufficient diversification of prefabricated buildings were the major challenges affecting the adoption of prefabricated construction. The study therefore recommends that prefabricated construction system should be encouraged to develop workers health and safety due to cleaner and good working environments. The identified challenges could lead to overcoming the shortcomings of future development of prefabrication practice in Nigeria. Future studies should be conducted in other countries for enhancing the generalization of these research findings.

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