Materials wastage on construction sites in Lagos Nigeria

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ABSTRACT

The construction sector has been one of the most active sectors of the Nigerian economy lately. Construction materials costs are going through a period of price increase for almost all variety of construction materials. This study aimed at identifying the main sources and causes of materials waste on construction sites arising from storage and handling of high waste generating building materials; and magnitude of wastage of construction materials on construction projects sites in Lagos state, Nigeria, with a view to maximizing profit in the construction sector. One hundred and fifty (150) questionnaires were distributed to participants (clients, contractors, and consultants) in the construction industry. The study revealed that materials storage and handling, operational factors, design and documentation factors and procurement factors are the main sources of waste on building construction sites. The findings also revealed that the most important causes of wastage of materials on construction sites are frequent design and client's changes; rework due to workers mistakes; poor contract documents; wrong and lack of storage of materials; poor strategy for waste minimization; shortage and lack of experience of skilled workers; poor site conditions; damage during transportation; theft and vandalism; and mistakes in quantity surveying and over allowance. The study concluded that the percentage of wastage materials is accounted for by values between 18% and 25% on Lagos construction sites. It was recommended that designers should coordinate dimensions between materials specified during design and those procured for use at sites. Employment of skilled experienced labour and supervisor and implementing training programs for the jobs should be done

Keywords: Construction site, waste, materials, causes, Lagos

INTRODUCTION

Construction waste is regarded as the waste generated by the economic activities involving the construction, maintenance, demolition and deconstruction of buildings and civil works. The heterogeneity of construction activities therefore makes impossible to establish reliable consumption patterns of construction materials or waste generation rates per capita, per work or per m^2 floor area (Gálvez *et al*., 2018; Obiegbu, 2019). Currently, the European construction sector produces 820 million tones (megagram, Mg, or 1000 kg) of construction and demolition waste (CDW) every year, which is around 46% of the total amount of total waste generated (EUROSTAT, 2017).

Material waste is defined as comprising of unwanted materials generated during construction, including rejected structures and materials, materials which have been over ordered or are surplus to requirements, and materials which have been used and discarded (Agyekum *et al*., 2013). Building material wastage on construction sites can be attributed to joint activities emanating from clients, contractors, and consultants respectively. Koshy & Apte (2012) defined material wastage as the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work after deducting the cost saving of substituted materials transferred elsewhere in which unnecessary cost and time may be increased by the material wastage.

Muhwezi *et al*. (2012) classified materials wastage on building construction projects into nine groups. These are design and documentations, site management and practices, procurement, materials handling, storage, transportation, operation, and environmental and other conditions. In the foregoing, Jaillon *et al*. (2009) opined that lack of experience of skilled labor was the main cause of building waste on sites in Hong Kong. This assertion was supported by Alwi *et al*. (2002) that lack of trade's skill was the main cause of construction waste and the contractors are still facing a lack of trade's skills to complete a project satisfactorily in Indonesian construction projects.

Construction waste as defined by Ekanayake and Ofori (2004) and cited in Ghanim (2014) is any material apart from earth material which needs to be transported elsewhere to the construction sites or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing, or composting rather than the intended specific purpose of the project due to material change excess, nonuse, or noncompliance with the specifications or being a bye product of the construction process. Over the years before the interruption of Covid 19 pandemic, there has been an increase in the rate of construction activities in the country. This has inevitably led to the generation of waste at different stages of projects. Currently in Nigeria, little consideration has been paid to the control of generation of construction and demolition waste in the last decade.

According to Wahab and Lawal (2011), this can be attributed to the availability of relatively low means of waste disposal and the generally, low environmental awareness of the construction industry wastes in the country. Despite being a major generation of considerable waste, the construction industry in Nigeria, has been slow to embrace environmental friendly practices. The study aims at identifying the sources of waste, determine the major causes of material waste on construction sites based on the opinion of contractors, consultants, and clients, and assess the quantities of wastage in main building materials used in the Nigerian construction sites with a view to seeking for ways to control waste generation in future construction projects

THE CONSTRUCTION INDUSTRY IN NIGERIA

According to Wahab and Lawal (2014), the construction activities in the context of the Nigeria economy cannot be treated with a wave of hand. They claimed that the construction industry contributes between 3 and 6% of the gross development product (GDP) in developing countries and records from the Federal Office of Statistics specifically ascertain that the contribution of construction industry to Nigeria's gross development product (GDP) has hovered around 2% for the past 15 years and this accounts for about 69% of the Nation's Gross Fixed Capital Formation. Skoyles (2000) emphasized that cost of material alone in the building construction project is 55% to 65%. To reduce cost of construction projects, an optimum material control on site should be therefore adopted. Construction waste is a growing problem in many countries (Wahab and Lawal, 2014).

The construction industry in particular and the built environment in general has been found to be among the main consumers of resources and energy. Moreover, the construction sector is reported to be generating unacceptable levels of material and manpower waste. Generally, construction activities which produce wastage can be grouped into off-site and on-site operational activities (Adams *et al*., 2016). Off-site activities include prefabrication, project design (architectural, structural, mechanical and electrical design), manufacturing and transporting of materials and components. On-site construction activities relate to construction of a physical facility which consists of the substructure and superstructure of the building.

Some degrees of waste materials are inevitable in the construction process. All estimators allow wastage factors in pricing a bill of quantities. Over the years, experience has shown, however, that unless site management control is tight, wastage can frequently exceed, often by a large margin, than the figure allowed in the tender document (Wahab and Lawal, 2014).

SOURCES AND CAUSES OF WASTE

Waste in construction can be classified into three main types; waste of materials, waste of time and waste of machinery. Materials waste account for the largest input into construction activities in the range of 50% - 60% of the total cost of a project (Agyekum *et al*., 2013). The building industry uses a considerable amount of resources most of which are wasted because of poor material control on building sites. Many factors contribute to construction waste generation on site. Waste may occur due to one or a combination of many causes. Table 1 shows a summary of the various causes of waste from four sources in construction identified from literature.

Table 1: Sources and Causes of Materials Waste

Design	Operational	Material storage and handling	Procurement
Lack of attention paid to dimensional coordination of products	Errors by tradesmen or operatives	Damages during transportation	Ordering errors (e.g. ordering significantly more or less)
Changes made to the design while construction is in progress	Accidents due to negligence	Inappropriate storage leading to damage or deterioration	Lack of possibilities to order small quantities
Designers inexperience in method and sequence of construction	Damage to work done caused by subsequent trades	Materials supplied in loose form	Purchased products that do not comply with specification
Lack of attention paid to standard sizes available on the market	Use of incorrect material, thus requiring replacement	Use of whatever material close to working place	
Designers unfamiliarity with alternative products	Required quantity unclear due to improper planning	Unfriendly attitudes of project team and operatives	Equipment malfunctioning

Source: Agyekum *et al*. (2013)

RESEARCH METHOD

The scope of coverage of this work was limited to construction companies in Lagos to determine issues related to waste management and control on construction sites. The restriction to Lagos state was informed by the fact that the vast majority of construction activities in the country take place in the state (Wahab and Lawal, 2014). Construction companies that are based in Lagos state, Nigeria were selected. For the purpose of this study, simple random method was used from the study population of construction firms in Lagos State, Nigeria. In this study, primary data was obtained using structured questionnaires, interviews and site visits. Questionnaires were designed on structural basis to get information about personal data of the respondents to depict their profile that may let them have experience on issues relating to building materials waste on construction sites The questionnaires were also designed in line with the method adopted by Ghanim (2014). One hundred and fifty (150) structured questionnaires were administered to the practitioners in the industry who had knowledge of waste generated during construction process. The reliability and validity of the questionnaire is based on the use of measurement scale to assess the causes of construction waste. Personal interviews were conducted to complement the questionnaires administered to the respondents. Site visits were carried out to physically identify the methods used at the construction sites to manage streams of waste generated. The data collected were analysed with the use of descriptive and inferential statistical methods.

The respondents were requested, depending on their previous experience in implementing construction projects, to score their opinions on construction materials wastage as follows: 0–10, 11–20, 21–30, 31–40, and 41–50. The wastage as scored would cover all stages from design through purchasing, transportation, storage, and putting in place. The kinds of materials selected are concrete, steel reinforcements, concrete blocks, cement, sand, ceramic tiles, aggregates, facing stones, timber for formworks, and PVC water pipes.

The number of causes adopted for the causes was distributed on the six major groups (10 causes for each group). These are as follows.

Group 1: design and contract documents;
Group 2: site management;
Group 3: procurements;
Group 4: storage and handling of materials;
Group 5: workers and supervision;
Group 6: site conditions and external factors.

The data collected from the survey were analyzed using the frequency and severity index method. Details of both frequency and severity index analysis are explained below.

According to Ghaim (2014), a formula as shown in (1) was used to rank wastage based on frequency of occurrence as identified by the participants, which is called the Frequency Index (F.I).

Consider Frequency Index (F.I) (%)

$$\frac{\sum a\left(\frac{\mathrm{n}}{\mathrm{N}}\right)}{5} \times 100, \qquad (1)$$

where (a) is the constant expressing weighting given to each response (*ranges from 1 for never up to 5 for very high occurrence*), n is the frequency of the responses, and N is the total number of responses.

Similarly, a formula as shown in (2) is used to rank wastage based on severity index as indicated by the participants, which is called Severity Index (S.I).

Consider Severity Index (S.I) (%)

$$\frac{\sum a\left(\frac{n}{N}\right)}{5} \times 100, \qquad (2)$$

where (a) is the constant expressing weighting given to each response (*ranges from 1 for no effect to 5 for very severe effect*), n is the frequency of the response, and N is the total number of responses.

In addition, the importance index of each cause is calculated as a function of both frequency and severity indices, as follows:

Importance Index (I.I) (%)

$$\frac{\text{F. I (\%)x S. I (\%)}}{100}.$$

PRESENTATION OF THE RESULTS

A total number of one hundred and sixty questionnaires (160) were administered and one hundred and fifty (150) were retrieved and this ought to be useful to depict issues concerning waste generation during construction process. Table 1 shows the number of questionnaire sets for clients, consultant and contractors in construction industry. Some 89.86% of the respondents were from indigenous firms while 10.14% were from foreign firms. Some 50.60% of the respondents possess 0 to 5 years of experience; the period of the experience of the remainder were; 6 to 10 years 16.21%; 11 to 15years 9.33% and 16 to 20 years 8.00%. Some 75.60% of the respondents were in the employment of the medium sized construction firms and the remainders, 11.40% were in small sized firms and 13.00% in large sized firms. The small, medium and large-sized firms are categorized based on their level of capitalization and annual turnover (BOIS, 2016; Wahab and Lawal, 2014). Also, from the interview conducted it was gathered that about half of the respondents had executed sizeable number of projects in the last four years. This implies that they would have reasonable understanding on issues concerning waste generated on construction sites.

Table1: Number of questionnaire sets

	Clients	Consultants	Contractors	Total
Number distributed	60	60	60	180
Number received	50	52	48	150
Response rate	83%	86%	80%	83%

Table 2: Ranking of causes of wastage.

Cause of wastage	F.I	S.I	I.I	Rank
Frequent design and client's changes	74.22	74.86	55.57	1
Rework due to workers mistakes	73.54	74.35	54.67	2
Poor contract documents	72.63	72.15	52.40	3
Wrong and lack of storage of materials	71.86	70.67	50.76	4
Poor strategy for waste minimization	70.04	70.25	49.18	5
Shortage and lack of experience of skilled workers	69.67	69.69	48.55	6
Poor site conditions	70.02	68.54	47.98	7
Damage during transportation	69.94	67.56	47.24	8
Theft and vandalism	68.50	68.35	46.82	9
Mistakes in quantity surveying and over allowance	68.11	67.25	45.80	10
Poor quality and non availability of equipment	67.78	66.35	44.98	11
Weather conditions	68.06	65.89	44.83	12
Waste resulting from poor packaging	67.59	65.31	44.14	13
Leftover material on site	66.15	66.12	43.67	14
Wrong handling of materials	65.13	65.42	42.61	15
Poor quality of materials	64.28	65.14	41.86	16
Ordering errors	63.70	65.33	41.62	17
Purchasing materials not complying with specifications	63.02	64.28	40.49	18
Supply in loose form	61.98	65.08	40.34	19
Complicated design	61.88	64.39	39.84	20
Damage caused by workers due to lack of experience	60.26	64.24	38.72	21
Long project duration	58.97	63.48	37.44	22
Unnecessary material handling	58.48	62.34	36.46	23
Change in material prices	57.46	62.18	35.73	24
Interaction between various specialists	56.32	55.98	31.54	25

Table 3: Results of the survey, percentages of wastage of materials.

Material	scores of wastage of materials					Mean
	0–10	11–20	21–30	31–40	41–50	
Sand	35	44	36	22	13	20.98
Aggregate	40	45	27	21	17	20.70
PVC water pipes	48	38	29	22	13	19.61
Timber for formworks	44	40	35	20	10	19.49
Cement	48	46	28	19	9	18.34
Concrete block	55	44	30	12	9	17.05
Steel reinforcement	56	42	30	16	6	16.91
Concrete	60	40	27	14	9	16.76
Ceramic tiles	60	49	22	15	4	15.57

Table 4: F.I, S.I, and I.I ranking of the groups of factors.

Group	F.I	S.I	I.I	Rank
G1: factors related to design and contract documents	66.75	66.39	44.28	1
G5 : factors related to workers and supervision	65.33	62.77	40.98	2
G4 : factors related to storage and materials handling	57.08	58.38	33.35	3
G3 : factors related to procurement	55.37	53.35	29.54	4
G6 : factors related to site conditions and external factors	52.68	50.49	26.63	5
G2 : factors related to site management	49.24	48.67	23.97	6

DISCUSSIONS OF FINDINGS

Table 2 shows the frequent design and client's changes; rework due to workers mistakes; poor contract documents; wrong and lack of storage of materials; poor strategy of waste minimization; shortage and lack of experience of skilled workers; poor site conditions; damage during transportation; theft and vandalism; and mistakes in quantity surveying and over allowance were ranked in the first ten positions as the most significant waste causes on sites. This is in agreement with the findings of Wahab and Lawal (2014) and Muhwezi *et al*. (2012).

From Table 3 "Change to the design" is ranked first with Importance Index of 55.57. These changes while construction is in progress can result in waste in different ways. Firstly if the construction materials have already been purchased based on the original design, waste will result if the materials cannot be resold or returned to the supplier (Styles *et al*., 2015). Similarly if a structure has already been constructed, a change in design may result in partial demolition, thus resulting in material wastage. This is line with the study carried out by FERCD (2015) and Ghanim (2014) which revealed that design changes were the most significant source of construction waste which was ranked the highest. Similarly, Skoyles (2000) as cited

in Ghanim (2014) found that design changes were ranked as the most significant factor leading to site waste in the construction industry.

The "Rework due to worker's mistakes" was ranked in the second position with Importance Index of 54.68. Worker's mistakes may be a result of their inefficiency, inexperience, or the contractor's bad supervision. Errors by trades labours were considered one of the main causes of material waste in operational group in Jordan construction industry; those results were found by Ghanim (2014) and supported by Arm et al. (2014) and BOIS (2016).

The "Poor contract documents" was ranked in third place with Importance Index of 52.40. This cause of wastage was strongly supported by contractors. The study revealed that the "Wrong and lack of storage of materials" was ranked in the fourth position with Importance Index of 50.75. This cause can result in many different ways. European Aggregates Association (2017) and Ghanim (2014) also found that inadequate stacking and insufficient storage of materials was one of the material waste factors in Gaza rip. Similar studies by Ghanim (2014) and Poon *et al*. (2009) concluded that inappropriate storage of material was the main cause of wastage on construction projects.

The results shown in Table 2 showed that "Poor strategy for waste minimization" is ranked fifth with Importance Index of 49.17. From the author's experience and discussions with survey's respondents, contracting companies usually have a plan to manage the materials in construction projects. These plans are represented in managing material purchasing, delivery, inventories, stockiest, handling, and transportation. However, these plans are often neglected by site managers. Jaillon *et al*. (2009) and Butera *et al*. (2014) in Hong Kong stated that lack of strategy for waste minimization was the main source of construction waste.

The "Shortage and lack of experience of skilled workers" was ranked in the sixth place with Importance Index of 48.55. Lack of experience may result lack of trade's skills which lead to waste. ANEFA (2017)) revealed that lack of trade's skill was the main cause of construction waste and the contractors are still facing a lack of trade's skills to complete a project satisfactorily in Indonesian construction projects which is also in agreement with Blengini and Garbarino (2010) and Craven (2015)

Table 4 outlines result of the collected data and illustrates the frequency, severity, and importance of each group. The survey revealed that the factors in the design and contract documents (G1) group are the major causes of material waste with average I.I of 44.28 and the highest ranking, while site management group (G2) is the lowest ranking with I.I of 23.97 (EUROSTAT, 2017).

CONCLUSION

The study has identified materials storage and handling, operational factors, design and documentation factors and procurement factors as the main sources of material waste on construction sites in Lagos state. The study also identified last minute client requirement, errors by tradesmen or operatives, purchased products that do not comply with specification and lack of onsite materials control as the main causes of materials waste. The study concluded that construction wastage materials are accounted for by values between 18% and 25% in Lagos construction sites in Nigeria. These figures seem to be high if compared with results obtained from construction sites in studies by Koshy and Apte (2012) and Poon *et al*. (2009)

about wastage of materials in Hong Kong and the values between 15 and 21% obtained by Ghahim (2014) and Adams *et al.* (2016) in Jordanian construction sites.

RECOMMENDATIONS

Based on the results and findings of this study, the following recommendations are made to foster effective materials waste management on construction sites in Nigeria:

1. Improving the standard of the contract documents to avoid wastage resulting from poor documents, design changes, and changes of the client's requirements and avoiding design errors should be done.

2. The contractors should play important role in reducing the waste during the construction process. This would be through implementing good strategies for resource management, waste minimization, procurement policy, control of the progress of the project, and coordination and communications between parties.

3. Contracting firms need to evolve better means and facilities in which building materials could be well-stored with pallets at the base or as may be applicable to prevent undue damage which may lead to wastages.

4. Employing qualified on-site administrative staff by the contractors to avoid mistakes in quantity surveying and over allowances, ordering mistakes, and poor coordination between warehouse and construction should be done.

5. Employing skilled experienced labor and supervisors and implementing training programs for the jobs should be done.

6. The designer should co-ordinate dimensions between materials specified during design and those procured for use at sites so as to guide site personnel on how to prevent avoidable waste in the use of various types of materials during execution of construction projects.

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