ASSESSMENT OF MATERIALS WASTAGE ON BUILDING CONSTRUCTION SITES IN ABUJA, NIGERIA

Ashiki, Aliyu Musa,
Department of Quantity Surveying,
Federal University of Technology, Minna,
Niger state, Nigeria.

Alumbugu, Polycarp Olaku
Department of Quantity Surveying,
Federal University of Technology, Minna,
Niger state, Nigeria.

Abstract

There are a lot of wasted building materials on Nigerian construction sites. This demonstrates that researchers and project managers have not given construction materials waste management enough thought. Therefore, there is an issue with Nigerian construction professionals' inadequate comprehension and ignorance of the reasons and origins of material waste development at various project phases. In order to promote improved project performance in Abuja, Nigeria, this study intends to evaluate the opinions of contractors, consultants, and clients on material waste on construction sites. The quantitative method was used in the study. The study's population consists of construction sites located in Abuja, Nigeria. Using purposive non-probability sampling approaches, a sample of forty (40) building projects valued at 250 million Naira or more were chosen from this population. One hundred and twenty (120) structured questionnaires were given to the practitioners, who were clients' representatives. consultants and contractor) in the building sites who had knowledge of waste generated during construction process. Mean item score (MIS) and percentage were used to analyse the data collected. Based on average percentage ranges values between 20.16% and 21.7%, the study determined that the most wasteful materials generated on sites were formwork, concrete, and mortar from rendering/plastering and blockwork/brickwork. The most significant factors influencing the development of material waste during construction were found to be Design (poor design and frequent design modifications), Poor materials storage system, and Theft and Vandalism (MIS 4.52-4.91). It was advised that designers should match the dimensions of materials ordered for on-site use with those specified during the design process. All parties involved in construction are accountable for waste management since waste not only costs contractors' money but also harms the environment and depletes client resources.

.

Keywords: Causes of Wastage, Construction Material, Public Building and Wastage,

Introduction

Background to the study

One of the main expenses associated with every construction project is construction material. Approximately 50% to 70% of the whole building cost, depending on the type of project, is attributed to the cost of materials (Ashwini and Patil,2013; Yohannes, 2018). The cost of building is largely borne by the materials used, and wasting them will have a detrimental effect on the contractor's profit, the cost and duration of the project, and may even lead to conflict between important project participants

(Adewuyi *et al.*, 2014). Furthermore, the performance of numerous projects in Nigeria has been impacted by these wastes (Ameh and Itodo, 2013; Adewuyi and Otali, 2013). Due to the industry's subpar waste management practices, waste is disposed of frequently (Ogunmakinde, 2019; Wahab and Lawal, 2011), which places a heavy financial and social load on communities' environmental resources. In addition, the sector is notorious for producing a lot of waste in the nation (Afolabi et al., 2018). According to Oyebanjo et al. (2023), construction waste is defined as waste produced by commercial operations that include the building, maintenance, demolition, and deconstruction of structures and civil works. It is consequently impossible to establish consistent patterns of construction material consumption or waste generation rates per work, per capita, or per m2 floor space due to the variability of construction activities (Gálvez et al., 2018; Obiegbu, 2019). According to EUROSTAT (2017), the construction industry in Europe currently generates 820 million tonnes (mega grammes, Mg, or 1000 kg) of construction and demolition waste (also known as CDW) annually, or almost 46% of all trash generated.

Material waste is described as surplus or overordered items, materials that have been utilized and abandoned, and undesirable materials produced during construction, such as rejected structures and materials (Agyekum et al., 2013). Moreover, "construction materials that are lost in transit on or off site, discarded without adding value to the project for which it was procured, including overproduction or left over from newly constructed facility" is how Adewuyi & Odesola (2015) described construction waste. Ikau et al. (2016) state that the main causes of material waste in construction projects include inexperience with waste management, non-conformance of materials with specifications, inadequate storage, and rework. Construction sites waste building materials as a result of collaborative efforts between contractors, consultants, and clients (Oyebanjo et al., 2023).

The management of garbage generated during building and demolition has received minimal attention in Nigeria over the past ten years (Oyebanjo et al., 2023). Wahab and Lawal (2011) ascribe this to the nation's usually poor environmental awareness of the wastes produced by the building industry as well as the availability of comparatively few means of disposing of garbage. The Nigerian construction industry has been sluggish to adopt eco-friendly techniques, even though it produces a significant amount of garbage (Oyebanjo et al., 2023). Statistics on Nigeria's construction waste (CW) generation rate are conspicuously lacking. According to OlaAdisa et al. (2015) and Ugochukwu et al. (2017), CW has grown to be a significant problem that needs immediate action. As of right now, there's no government.

Among the main issues are the absence of waste minimization policies (Adeagbo et al., 2016) and the incorporation of sustainability into building development (Dania et al., 2013). Materials waste can account for as much as 21–30% of project cost overruns, according to Oko and Emmanuel (2013). Therefore, it is crucial that stakeholders take into account the possibility that improper management of construction material waste could lead to the project's failure to be completed (Rakesh, 2016).

Problem Statement

Construction materials account for 50% to 70% of the overall cost of construction in the construction sector, making them one of the primary cost components (Garba and Shiferaw, 2021). Nevertheless, the sector produces between 30% and 65% of waste for landfills. Efficient utilization of building materials yields financial benefits for both the industry and the economy of any given nation (Garba and Shiferaw, 2021).

Nigeria's construction sector is the main source of garbage in the country, similar to many other regions of the world (Chukwumaobi, 2023). In the UK, waste from the sector makes up 61% of all waste

generated nationally, whereas India produced between 112 and 431 million tonnes of CW in 2016 (Jain et al., 2018). As per Huang et al. (2018), the construction industry accounts for 30-40% of China's total trash production, with an average recovery rate of 5%. Construction accounts for over 40% of the world's solid waste (Eze et al., 2017; Tam et al., 2007), much of which may be recovered using environmentally friendly methods (Aadal et al., 2013). A worldwide issue that affects both researchers and building professionals is construction waste. It can significantly affect the following: timeliness, expense, sustainability, and quality as well as the success of projects Nagapan *et al.* (2012). To learn more about the problems and their current state, researchers have started gathering data on waste from building projects. In conclusion, each country's percentage of construction material waste that is landfilled, measured in weight, varies from 13% to 60% of all garbage (Chukwumaobi, 2023). Researchers that are interested in the management of CW in Nigeria have focused a lot of attention on the causes of CW. But it's unknown how this subject has changed throughout the course of the last 15 years, from 2005 to 2019 (Chukwumaobi, 2023). Many studies (Oladiran et al., 2019; Saka et al., 2019) have produced conflicting results about the major causes of trash generation. As a result, it is still unclear to practitioners what the waste generation variables that previous studies have often documented are.

Nigeria is not alone in having a rising problem with construction trash (Wahab and Lawal, 2014). Furthermore, according to reports, the building industry wastes too much labor and materials (Oyebanjo et al., 2023).

Wasteful use of building materials is expensive regardless of the stage of the project and should worry all members of the team because it results in resource loss (Aderibigbe, et al. 2017). It is a widely acknowledged fact that not all materials requested and delivered to construction sites are utilized for the intended purpose. Additionally, after charging their clients for standard supplies, contractors frequently employ inferior materials. These resources are either lost or the quality is not up to par because of a lack of management. According to Osobajo et al. (2020), the construction sector generates more garbage than any other industrial sector. Researchers Ameh and Itodo (2013) found that material waste contributes an additional 15% to construction project cost overruns in the UK and approximately 11% to construction cost overruns in Hong Kong, although there is disagreement over the exact percentage of waste generated by construction materials. Similarly, research in the Netherlands found that there was a 20–30% cost overrun due to construction material waste, and it concluded that 15.32% of waste from construction materials was present in Nigerian construction sites. The study also suggested allocating 15-20% of the total waste from construction materials to Nigerian construction sites. According to the findings of Oyebanjo et al.'s study from 2023, between 18% and 25% of the materials used on construction sites in Lagos are wasted. In general, a lot of construction materials are wasted around the site of the project. This indicates that researchers and project managers have not given construction materials waste management enough thought (Garba and Shiferaw, 2021). Nevertheless, the cost of building supplies is rising daily, and trash is also turning into a significant issue due to its high cost and negative environmental repercussions. This is especially true for projects involving the construction of public buildings, where little thought has been given to the topic.

Aim and Objectives

The aim of this study is to assess the perception of construction clients, consultants and contractors on materials waste in construction sites, with a view to encouraging better performance of construction projects in Nigeria.

To achieve this aim, the following are the objectives of the study;

i. To determine the most wasteful material generated on construction sites in Abuja.
ii. To evaluate the most important factors that influence material waste production during construction work
iii. To examine the strategies for minimising construction material waste

Literature Review

Sources and level of Construction Material Waste on site

Nigeria's construction sector is the main source of garbage in the country, as it is in many other countries. In the UK, waste from the sector makes up 61% of all waste generated nationally, whereas India produced between 112 and 431 million tonnes of CW in 2016 (Jain et al., 2018). In 2010, England alone produced over 77.4 million tons. According to Huang et al. (2018), the construction sector accounts for 30–40% of China's overall trash production, with an average recovery rate of only 5%. Construction accounts for over 40% of the world's solid waste (Esa et al., 2017; Kulatunga et al., 2006; Tam et al., 2007), most of which may be recovered using environmentally friendly methods (Aadal et al., 2013).

According to research by Oyebanjo et al. (2023), garbage from building materials accounts for between 18% and 25% of all waste at Nigerian construction sites in Lagos. These numbers appear high when compared to findings from construction sites in research on material waste in Hong Kong by Koshy and Apte (2012) and Poon et al. (2009), and values ranging from 15 to 21 percent found in construction sites in Jordan by Ghahim (2014) and Adams et al. (2016). According to Aderibigbe et al. (2017), the biggest percentage of waste is found in Sand Crete blocks (40%) followed by steel reinforcement (7%), ceiling boards (20%), tiles (13%), timber and cement (10%), and tiles (13%). Ugochukwu et al. (2017) measured material waste in a case study of five projects in a related study. According to the findings, the state of Anambra has the greatest average proportion of trash (5.5%), followed by tiles (3.47%), sandcrete blocks (1.6%), reinforcement bars (1.58%), and concrete (1.55%). Additionally, Adewuyi, Idoro, and Ikpo (2014) found that the two materials that construction sites in the South-South States of Nigeria generate the greatest trash from on average are blocks (12.10%) and lumber (14.54%). Hardwood and softwood materials have large percentages of waste from theft and vandalism, according to Babatunde (2012). Formwork made of wood or timbers that is used outside without adequate storage may eventually crumble. Because foundation level work is inherently damp, timber formworks can account for up to 20% of foundation construction waste (Ameh and Itodo 2013). Furthermore, a large portion of application waste is present in the concrete used in walls, lintels, columns, and beams as well as the mortar used in screeding and rendering. According to Ameh and Itodo (2013), concrete through columns, beams, lintels, and walls contributes 14.13%, mortar through screeding contributes 14.91%, and mortar through rendering had contributes 11.97%.

Factors Influencing Material Waste Generation on Building sites

Several studies looked into the respondents' perceptions of the factors influencing the generation of material waste during building activities. The following are the top 10 factors influencing the development of construction trash, according to a study by Eze et al. (2017): Design (poor design and frequent design modifications), Inadequate materials storage system; theft and vandalism; unfavorable site conditions; inadequate waste minimization strategy; inadequate procurement management (incorrect purchase order: quantity, quality, and timing); unfavorable weather; inadequate and ineffective waste management plan implementation; inadequate equipment quality and non-availability; and inadequate site management. According to Meghani et al. (2011), general reasons contributing to

waste generation include theft and pilferage, poor housekeeping and storage, and the absence of a material management system. Waste has been found to be the result of poor site management and waste minimization strategies (Jaillon et al., 2009). The majority of contracting firms typically have a strategy in place for handling the supplies and other resources used in building projects.However, site managers frequently overlook these plans, which include those to handle material acquisition, distribution, inventories, stockiest, handling, and transportation(Ghanim,2014). The primary cause of construction waste, according to a 2009 study conducted in Hong Kong by Jaillon, Poon, and Chiang, was a lack of a waste minimization strategy. According to Eze, Seghosime, Eyong, and Loya (2017), the factors that have the least impact on the generation of material waste are labor-intensive traditional construction methods (3.83), time pressure (3.81), waste resulting from subpar packaging, delivery, and transport (3.71), lack of incentive for contractors to improve their practices (3.59), and poor segregation (2.54).

Strategies of Minimising Construction Material Waste

Shant and Daphene (2014) define waste minimization as minimizing the quantity of waste produced and its impact on the environment through material conservation or reuse. They added that preventing waste by designing it out or lowering it at its source is the primary goal of waste minimization. Thus, careful planning throughout the design phase will result in the requirements being perfected to the point where little to no modification may be needed during the construction phase. It will also help to identify aspects that have little to no functional impact on the design and take action to remove them. Moreover, Shant and Daphene (2014) proposed that different materials and construction techniques might be used in the design process to get rid of or minimize waste produced throughout the building process. For concrete building, for instance, they recommended using modular metal form systems rather than wood because they can be disassembled and reused for future projects.

Eze et al. (2017) investigated respondents' perceptions of the best ways to reduce waste from construction materials. According to the results, the top 10 measures for minimizing material waste as perceived by construction workers and craftsmen are: appropriate site management and supervision techniques (4.81), sufficient material storage (4.74), staff waste management awareness training (4.62), use of low-waste technology (4.62), appropriate procurement management (4.60), just-in-time work operations and material delivery (4.58), appropriate waste management plan implementation (4.58), hiring skilled workers to perform site operations (4.56), mechanical material handling (4.54), and prefabrication of building components off-site (4.52). According to the workers, the company's management approaches, along with those of the supervisors and site engineers, when combined with appropriate material storage, may significantly reduce waste and damage (Eze et al., 2017). They also thought that material waste would be significantly decreased if they had proper training on how to use contemporary tools and equipment and had sufficient understanding of waste management. Strict adherence to the waste management plan, appropriate worker supervision by the participating engineers and supervisors, and the use of skilled and experienced workers will all contribute to a decrease in the amount of material waste generated on site. The results of this investigation align with the findings of Odusami, Oladiran, and Ibrahim (2012). Construction material waste can be reduced with effective site supervision, control, and material planning and storage, according to Odusami, Oladiran, and Ibrahim (2012). Reducing the amount of material delivered to landfills requires effective site management techniques such as material logistic management, waste segregation, maximizing material reuse, and contractual provision (Ajayi et al., 2017). The top-ranked strategies in managing construction wastes, according to Adewuyi and Odesola (2016), are training and retraining supervisors on material waste minimization strategies, using a modular design system, introducing incentives to motivate labor to

minimize material wastage on site, purchasing raw materials that are just sufficient, and training and retraining personnel on handling, storage, and transportation. To achieve on-site waste minimization, it is also crucial to raise worker awareness and educate them about construction waste management, adopt off-site products and components, establish waste management procedures for particular materials, standardize design and material handling, and standardize design and material. (Muhammad et al., 2020). According to Lemlem Temesgen (2016), the most crucial steps taken to reduce material wastes are verifying that the materials are supplied in the correct quantities, storing them properly, accurately defining their specifications, changing the way employees handle materials, and designating a waste management officer. By using specific tactics for every building material, the amount of material wasted could be decreased. Research indicates that putting various waste minimization techniques into practice enhances environmentally friendly building practices and sustainable building (Adewuyi and Odesola, 2016). The project site's waste management system aids in preventing and minimizing trash generation.

Research methodology

In order to gather and analyze quantitative data, this work used a survey research approach. In order t improve the performance of building projects in Abuja, Nigeria, the study intends to evaluate th opinions of contractors, consultants, and clients on material waste on construction site The study's population consisted of public building construction sites located in Abuja, Nigeria, as it i one of the country's largest metropolitan centers with the highest concentration of built environmer specialists. The study's population consists of construction professionals who work on a few chose building sites in the research area and are classified as consultants, contractors, and clients. To choos forty (40) building sites in Abuja with a value of at least 250 million Naira, the purposive samplir technique was used. Building construction projects of this value and above are often anticipated to ha construction materials waste in a substantial proportion compared with projects of lesser value, whi is the reasoning behind the intentional non-probability (typical case sampling selection). From the forty construction sites with ongoing projects located inside the Abuja city, a total of three (respondents per site were sampled. This amounts to one hundred and twenty (120) samples altogeth one sample for each of the three groups at each site the purpose of the questionnaire was to collect d regarding the projects' attributes, organizational background, and responders. In order to gat respondents' thoughts on the amount of material wasted on building sites, the reasons for material wa the elements that contribute to material waste, and the best ways to reduce material waste on build sites, the survey also includes Likert scale questions. The causes, contributing variables, and tac were taken from and adjusted from three earlier studies conducted by Garba and Shiferaw (20 Oyebanjo et al. (2023), and Eze et al. (2017). To physically determine the techniques employed at construction sites to manage the streams of garbage generated, site visits were conducted.

One hundred and twenty (120) structured questionnaires were given to practitioners (cl representatives, consultants, and contractors) on construction sites who were aware of the t produced throughout the building process.

Statistical techniques for inferential and descriptive analysis were applied to the acquired data. study's variables are ranked and their mean items score (MIS) is utilized to determine their rel relevance. On the other hand, data about the features of the projects, organizations, and respondent analyzed using frequency and percentage.

The MIS is computed as follows:

$$\frac{5n5+4n4+3n3+2n2+n1}{n5+n4+n3+n2+n1}$$

Where n5=very high, n4=high, n3=average, n2=low and n1=very low

Data analysis, Results and Discussion

The Demographic Characteristics of the Respondents

One hundred and one (101) of the 140 completed questionnaires were collected, and this should help illustrate the problems with trash development during the building process. Table 4.1 displays the total number of questionnaires distributed to the client, consultant, and contractor groups of respondents. About 38% of the respondents worked for domestic companies, and 62% for international companies. Approximately 27% of the participants had experience ranging from 0 to 5 years. The remaining participants had experience spanning 6 to 10 years (38%), 11 to 15 years (23%), and 16 to 20 years (12%). Approximately 74% of the participants were employed by medium-sized construction companies, with the other 12% working for small-sized companies and the remaining 14% for large-sized companies. Based on their yearly sales and amount of capitalization, small, medium, and large-sized businesses are divided into several categories (BOIS, 2016; Wahab and Lawal, 2014). Additionally, it was learned from the interview that roughly half of the respondents had completed a sizable number of projects within the previous four years.

This implies that they would have reasonable understanding on issues concerning waste generated on construction sites.

Table 4.1: Number of questionnaire sets

Distribution of Questionnaire	Clients	Consultants	Contractors	Total
Numbered distributed	40	40	40	120
Number received	34	35	32	101
Response rate (%)	83	86	80	84

Source: Researcher's Analysis (2021)

Most wasteful materials in construction site

The table 4,2 reveals that the most wasteful material on was formwork with mean 21.70%, follow by concrete 21,48%, mortar for blockwork/rendering 21,45% and sand crete block/bricks 20.16%, ranked first, second, third and fourth respectively. While the least wasted material on site was PVC pipes 14,71%.

Table 4.2: Most wasteful materials in construction site

		Scores of wastage of materials					Mean
	Material Type	0-10	11-20	21-30	31-40	41-50	%
1	Formworks (from wood/timber)	23	30	24	15	9	21.70
2	Concrete	27	30	18	14	12	21,48
3	Mortar for blockwork/rendering	32	26	20	17	9	21.45
4	Sandcrete block and Brickwork	30	27	24	13	7	20.16
5	Sand	32	31	19	13	6	19.20
6	Coarse aggregate	37	30	20	8	6	17.92
7	Steel reinforcement	40	22	18	10	6	17.87
8	Tiles ceramic for floor and walls surfaces	38	28	20	11	4	17,80
9	Ceiling board	40	33	15	10	3	16,69
10	Aluminium roofing sheet	45	26	14	11	3	16,39
11	Paint	50	26	11	10	4	15,79
12	PVC pipes	55	24	11	8	3	14.71

Source: Researcher's Analysis (2021)

Factors Influencing material waste generation on construction work

The results of an investigation into the several reasons causing material waste are displayed in Table 4.3. Six categories are used to group the factors: customer, consultant, contractor, and so on. The respondents' perceptions of the variables influencing the development of material waste during construction were examined. With a mean index score of 4.91, Design (frequent design modifications and bad design) was ranked top out of the twenty (20) elements impacting construction waste generation. In contrast, the following were ranked second, third, fourth, and fifth, respectively: poor site conditions (4.65), theft and vandalism (4.78), inadequate materials storage system (4.88), and poor waste minimization plan (4.52). Furthermore, the average MIS for all the factors impacting material waste on site was found to be 4,13 in the result.

Table 4,3: Factors Influencing material waste generation on construction work

S/NO	Factors Influencing material waste production during construction work	MIS	SD	Rank
1	Design (Frequent design changes and poor design)	4.91	0.453	1
2	Poor materials storage system	4.88	0.501	2
3	Theft and vandalism	4.78	0.536	3
4	Poor site condition	4.65	0.756	4
5	Poor strategy for waste minimisation	4.52	0.796	5
6	Inclement weather	4.36	0.863	6
7	Poor and insufficient implementation of waste management plan	4.28	0.937	7
8	Poor procurement management (wrong purchasing order – quality, number, time of order)	4,24	1.065	8
9	Poor material handling on site	4.22	1.246	9
10	Site Management	4.20	0,794	10
11	Poor quality and non-availability of equipment's	4.18	1.055	11
12	Use of unskilled labour	4.14	0.803	12
13	Poor coordinated document	4.10	0.925	13
14	Lack of incentive for contractors to improve their practices	4,08	1,364	14
15	Traditional construction methods (labour intensive nature)	3.86	1.200	15
16	Lack of workers' awareness and training on waste management practices	3.83	1,223	16
17	Long project duration	3.80	1.229	17
18	Time Pressure	3.60	1.373	18
19	Poor segregation	3.56	1.333	19
20	Waste resulting from poor packaging, delivery and transport	2.50	1.036	20
	Average MIS	**4.13**		

Source: Researcher's Analysis (2021)

Strategies of minimising material wastage on construction site

Table 4.4 presents the measures that are thought to be most effective in reducing waste from construction materials on site. Out of the 18 strategies for material waste minimization that the respondents perceived, the findings showed that appropriate site supervision and management techniques with a MIS (4.90), staff training and waste management awareness (4.84), adequate material storage (4.73), appropriate procurement management (4.68), and use of low waste technology (4.64) were the most effective. These came in order of preference: first, second, third, fourth, and fifth.

Additionally, the results showed that the average MIS for techniques to reduce material waste on building sites was 3.99 overall.

Table 5: Strategies of minimising material wastage on construction site

S/No	Strategies of minimising material wastage on construction site	MIS	SD	Rank
5.1				
1	Proper site supervision and management techniques	4.90	0.487	1
2	Staff training and awareness on waste management	4.84	0.649	2
3	Adequate storage of material	4.73	0.618	3
4	Proper procurement management	4.68	0.520	4
5	Use of low waste technology	4.64	0.568	5
6	Proper implementation of Waste Management Plan	4.62	0.743	6
7	Just in time operations of works/delivery of materials	4.60	0.638	7
8	Employment of skilled workmen to carry out site operations	4.58	0.640	8
9	Prefabrication of construction components off-site	4.54	0.921	9
10	Mechanical handling of materials	4.52	0.576	10
11	Use of more efficient construction equipment	4.40	0.906	11
12	Segregation of waste on site	3.70	0.597	12
13	Appointment of waste officer/manager on site	3.66	0.736	13
14	Recycling of some waste off site and on site	3,34	0.527	14
15	Careful handling of tools and equipment	2.60	0.775	15
16	Recording and measuring different streams of waste	2.53	0.718	16
17	Effective communication among project team and skilled labour	2.50	0.725	17
18	Improve security	2.40	0.745	18
	Average MIS	**3.99**		

Source: Researcher's Analysis (2021)

Construction Waste Management Activities/Approaches

The replies in Table 4.5 are the result of the inquiry on building waste materials management activities and methodologies. With a relative importance index (RII) of 0.96, reuse comes on top, followed by reduction (0.87), deconstruction (0.84), disposal (0.79), waste avoidance (0.77), and recycling (0.68). However, the average RII for waste material management activities and approaches in the construction industry was 0.82.

Table 4.5: Construction Waste Management Activities/Approaches

Construction Waste Management Activities/Approaches		RII	Rank
1	Reuse	0.96	1
2	Reduction	0.87	2
3	Disposal	0.84	3
4	Deconstruction	0.79	4
5	Waste Avoidance	0.77	5
6	Recycling	0.68	6
	Average RII	**0.82**	

Source: Researcher's Analysis (2021)

Discussion of Results

Most wasteful materials in construction Site

Table 4,2 shows that formwork (made of wood or lumber), concrete, mortar for block/brick work/rendering, and sand Crete block/brick were the four materials that were most wasted at the site. Their respective percentages ranged from 20.16% to 21.70%. This suggests that there was significant material waste on the locations. The outcome is consistent with a study by Eze et al. (2017) that found that formworks made of wood or lumber, mortar from rendering or plastering, sand Cret blockwork and brickwork, and concrete were the materials most frequently wasted on building sites in Nigeria. However, in this instance, there is a significant waste of concrete. According to the previous argument, the three ranking cause groups of waste are site management, site operation and design, and documentation elements.

Moreover, the results presented here are consistent with those of Odusami, Oladiran, and Ibrahim (2012). They found that the most waste produced on site is from concrete, blockwork, rendering mortar, and formwork. Similar findings were made by Adewuyi, Idoro, and Ikpo (2014), who found that the two materials that generate the most trash on construction sites in the southern states of Nigeria are lumber (14.54%) and blocks (12.10%).

Factors Influencing material waste generation on construction work The five primary factors impacting the respondents' generation of material waste during construction activity were determined based on Table 4.3. These factors, whose MIS ranges between 4.52 and 4.91, can be interpreted as having a high influence in construction material wastage on site, include frequent and poor initial design, poor storage facilities on site, poor materials storage system, theft and vandalism, poor site conditions, and poor waste minimization strategy. This study's findings concurred with those of Eze et al. (2017), whose five variables and MIS ranged from 4.42 to 4.81. This result is consistent with the findings of Adewuyi and Otali (2013), Odusami et al. (2012), and Adewuyi and Odesola (2015). Furthermore, the total MIS score was 4.13, indicating that all the factors taken into account have a significant impact on the production of material waste on building sites.

Strategies of minimising material wastage on construction site

Table 4.4's results showed that the five most effective strategies for minimizing material waste were: appropriate site supervision and management techniques; staff training and waste management awareness; adequate material storage; use of low-waste technology; and appropriate procurement management, with a MIS range of 4.64–4.90 and an average MIS of 3.99 overall. According to the customers, consultants, and contractor, appropriate management and supervision practices used by the supervisors, site engineers, and corporate management procedures, when combined with appropriate material storage, will significantly reduce waste and damage. Additionally, they stated that material waste would be significantly decreased if they had proper training on how to use contemporary tools and equipment and sufficient understanding of waste management. Furthermore, the findings of this investigation align with the findings of Odusami et al. (2012), who noted that adequate site management and oversight, along with suitable material scheduling and storage, can reduce the wastage of building resources. Odusami et al. (2012) reinforce this point of view by emphasizing that site supervision and control may be the cause of the variations in materials waste generation levels among construction sites. Meghani et al. (2011) suggested that strong material supervision and control, staff education on the negative effects of waste, increased security, efficient site management, and better storage facilities should be the main steps towards cutting down on waste on site.

Reuse, reduction, deconstruction, and disposal rank first, second, third, and fourth, respectively, among the main construction waste management activities/approach results on Table 4.5. With relative indices of 0.93 and 0.925, respectively, it is evident that recycling construction waste is a part of both construction waste management and the construction waste management activities carried out by the respondent's organizations. Construction waste materials ought to be reused as frequently as feasible, according to Yashim et al. (2023). The following building waste materials are most frequently recycled on site: bricks, rubbles, glass, tiles, and concrete. Yashim and others (2023). Construction waste reduction, or reducing the amount of waste produced, is ranked second in the activities involved in construction waste management with a relative index of 0.96; however, disposal of construction waste is ranked second with a relative index of 0.87 in the activities carried out by the respondent's organization. Geographic information system technology and popular building information modeling can be used to provide real-time monitoring, intelligent management, and control for construction waste information management platforms (Wang et al. 2021). Australia's best chance to reduce construction waste is through legislative reform; however, this needs to be combined with new policies and guidelines that give priority to preventative efforts (Doust et al. 2021).

Conclusions

In order to improve the performance of building projects in Abuja, Nigeria, this study set out to evaluate the opinions of contractors, consultants, and clients on material waste on construction sites. Ultimately, the following deductions were made:

I. The study found that, in Abuja, Nigeria, the four materials that are thrown away the most on construction sites are: formwork (made of wood or lumber), concrete, mortar for block/brick work/rendering, and sand Crete block/brick, with percentages ranging from 20.16% to 21.70%

II. The five most significant factors that impact the generation of construction waste are: frequent and subpar initial design; inadequate on-site storage facilities; inadequate materials storage system; theft and vandalism; poor site conditions; and inadequate waste minimization strategy. These factors have MIS ranges ranging from 4.52 to 4.91, indicating a very high influence.

III. The study concludes that the following five strategies were the most effective in minimizing material waste: adequate storage of materials, staff training and waste management awareness, proper site supervision and management techniques, use of low-waste technology, and proper procurement management with a MIS range of 4.64–4.90. This suggests that it has a significant impact on lowering the waste of building materials on the job site.

IV. Since waste not only costs contractors' money but also harms the environment and uses client resources inefficiently, waste material management is ultimately within the responsibility of construction stockholders. Therefore, waste management and control require the full participation of all stakeholders.

REFERENCES

Aadal, H., Rad, K. G., Fard, A. B., Sabet, P. G. P., & Harirchian, E. (2013). Implementing 3R concept in construction waste management at construction site. *Journal of Applied Environmental and Biological Sciences,* 3, (10), 160–166.

Adams, M. P., Fu, T., Cabrera, A. G., Morales, M., Ideker, J. H., & Isgor, O. B. (2016). Cracking susceptibility of concrete made with coarse recycled concrete aggregates. *Construction building material,* 102, 802–810. http://dx.doi.org/10.1016/j.conbuildmat.2015.11.022.

Adeagbo, D. O., Achuenu, E., & Oyemogun, I. M. (2016) Construction material waste management practices in selected construction sites in Abuja, Nigeria. *Journal of Management and Technology,* 1, (2), 69–104.

Aderibigbe, Y. A., Ataguba, O. C., & Sheyin, Y. (2017). Minimisation of wastage of material on construction sites in Nigeria. *International Journal of Advanced Academic Research/Sciences, Technology and Engineering,* 3, (9), 1–15.

Adewuyi, T. (2014). Evaluation of causes of construction material waste -case of rivers state. *Ethiopian Journal of Environmental Studies and Management,* 266-343.

Adewuyi, T., & Otali, M. (2013). Evaluation of causes of construction material waste -case of rivers state. *Ethiopian Journal of Environmental Studies and Management,* 746-753.

Adewuyi, T. O., & Odesola, I. A. (2016). Factors affecting material waste on construction sites in Nigeria. *Journal of Engineering and Technology (JET),* 6(1), 82-99,2015.

Afolabi, A. O., Tunji-Olayeni, P. F., Ojelabi, R. A. & Omuh, O. I. (2018). Construction waste prevention as a sustainable tool in building mega cities: a theoretical framework. *IOP Conference Series: Earth and Environmental Science,* 146, 012013.

Agyekum, K., Ayarkwa, J., & Adjei-Kumi, T. (2013). Minimizing Materials Wastage in Construction- A Lean Construction Approach. *Journal of Engineering and Applied Science* 5, (1) 125-146.

Ajayi, S. O., Oyedele, L. O., & Akinade, O. O. (2017). Optimising material procurement for construction waste minimisation: an exploration of success factors. *Sustainable Materials and Technologies,* 11, 38–46.

Ameh, J. O., & Itodo, E. D. (2013). Professionals" views of material wastage on construction sites and cost overruns. *An international journal of organization, technology and management in construction,* 5, (1), 20-53.

Ashwini, R., & Patil, S. V. (2013). Analyzing Material Management Techniques on. *International Journal of Engineering and Innovative Technology (IJEIT).*

Babatunde, S. O. (2012). Quantitative Assessment of Construction Materials Wastage in the Nigerian Construction Sites. *Journal of Emerging Trends in Economics and Management Sciences* (JETEMS), 3, (3), 238-241.

Chukwumaobi, N. I. (2023). Construction Material Waste Causes and their Contribution Levels: A Case Study of Construction Projects in Abuja, Nigeria. *Proceedings of the International Conference on Industrial Engineering and Operations Management Manila, Philippines.*

Dania, J. O., Patil, S., & Frank, J. (2013). *A Study of Construction Material Waste Management Practices by Construction Firms in Nigeria.* Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

Defra (2019). *UK Statistics on Waste.* See https://assets.publishing service.gov.uk/government/uploads/system/uploads/attachment_data/file/784263/UK_Statistics_on_Waste_ statistical_notice_ March_2019_rev_FINAL.pdf (accessed 05/03/2020).

Doust, S. V., Deodhar, S V., & James, O. (2021). Identification and Eliminating Waste in Construction by Using Lean and Six Sigma Principles, *International Journal of Innovative Research in Science, Engineering and Technology,* 3(4), 285-296.

Esa, M. R., Halog, A., & Rigamonti, L. (2017). Developing strategies for managing construction and demolition wastes in Malaysia based on the concept of circular economy. *Journal of Material Cycles and Waste Management,* 19, (3),1144–1154.

EUROSTAT (2017). Generation of Waste by Waste Category, *Hazardousness and NACE* Rev 2 Activity.

Eze, E. C. (2017). Assessment of materials waste in the construction industry: A view of Construction Operatives, Tradesmen and Artisans in Nigeria. *The International Journal of Engineering and Science (IJES),* 6 (4), 32-47.

Gálvez-Martosa, J. L., Stylesb, D., Schoenbergerd, H. & Zeschmar-Lahl, B. (2018). Construction and demolition waste best management practice in Europe *Resources, Conservation & Recycling,* 136, 166–178.

Ghanim, A. B. (2014). Study of the Causes and Magnitude of Wastage of Materials on Construction Sites in Jordan. Hindawi Publishing Corporation. *Journal of Construction Engineering, Volume 2014, Article ID 283298,* http://dx.doi.org/10.1155/2014/283298

Huang, B., Wang, X., & Kua, H. (2018) Construction and demolition waste management in China through the 3R principle. *Resources, Conservation and Recycling* 129: 36–44.

Huang, T., Shi, F., Tanikawa, H., Fei, J. & Han, J. (2013). Materials demand and environmental impact of buildings construction and demolition in China based on dynamic material flow analysis. *Resources, Conservation and Recycling,* 72, 91–101.

Ikau, R.., Joseph, C., & Tawie, R. (2016). Factors influencing waste generation in the construction industry in Malaysia. *Procedia-social and behavioral sciences*, 234, 11-18, 2016.

Jaillon, L., Poon, C. S. & Chiang, Y. H. (2009). Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong. *Waste Management,* 29, (1), 309–320.

Jain, S., Singhal, S., & Jain, N. K. (2018). Construction and demolition waste (C&DW) in India: generation rate and implications of C&DW recycling. *International Journal of Construction Management* 21(3): 261–270.

Koshy, R., & Apte, E. M. (2012). Waste minimization of construction materials on bridge site (cement and reinforcement steel) a regression and correlation analysis, *International Journal of Engineering and Innovative Technology*, 2 (1) 6–14.

McKinsey Global Institute (2017). Reinventing construction: a route to higher productivity. https://www.mckinsey.com/~/media/McKinsey/Industries/Capital Projects and Infrastructure/Our Insights/Reinventing construction through a productivity revolution/MGI-Reinventing-Construction-Executive-summary.ashx.

Nagapan, I. A. (2012). Issues on Construction Waste: The Need for Sustainable Waste Management. *IEEE Colloquium on Humanities, Science & Engineering Research (CHUSER 2012)*, 329-334.

Meghani, M. D., Vyas, C. M., Bhavsar, J. J. & Hingu, R. J. (2011). A study of basic material waste in building industry: Main causes and prevention. *National conference on Recent Trends in Engineering and Technology.* 13-14.

Odusami, K. T., Oladiran, O. J. & Ibrahim, S. A. (2012). Evaluation of Materials Wastage and Control in Some Selected Building Sites in Nigeria. *Emirates Journal for Engineering Research,* 17 (2), 53-65.

Ogunmakinde, O. E. (2019). *Developing a Circular-Economy-Based Construction Waste Minimisation Framework for Nigeria.* Doctoral dissertation, University of Newcastle, Newcastle, UK.

Ola-Adisa, E., Sati, Y. C., & Ojonugwa, I. I. (2015). An architectural approach to solid waste management on selected building construction sites in Bauchi Metropolis. *International Journal of Emerging Engineering Research and Technology* 3(12): 67–77.

Oladiran, O. J., Ravash, U., & Kalu, U. (2019). Causes and minimization techniques of materials waste in Nigerian construction process. *Proceedings of the 5th International Conference on Construction in the 21st Century (Collaboration and Integration in Engineering, Management and Technology),* 20-22 May, Istanbul, Turkey. Miami, Florida: CITC-V, 1686-1692.

Oko, J. A., & Emmanuel, I. D. (2013). Professionals' views of material wastage on construction sites and cost overruns. Organisation, Technology and Management in Construction: *An International Journal,* 5, (1), 747–757.

Oyebanjo, O. O., Bidemi, O., Posun, O. A., & Sofolahan, O. (2023). *Materials wastage on construction sites in Lagos Nigeria,* Doctoral dissertation, University of Birmingham, Birmingham, UK.

Persson, F., Bengtsson, J., & Gustad, Ö. (2010). Construction Logistics Improvements Using the SCOR Model Tornet Case, Paper presented at the Advances in Production Management Systems. *New Challenges, New Approaches,* Berlin, Heidelberg, 19, (2), 123-128.

Poon, C. S., Wan Yu, A. T., Wong, S. W., & Cheung, E. (2004). Management of Construction Waste in Public Housing Projects in Hong Kong. *Journal of Construction Management and Economics,* 22, (5), 461-470.

Rakesh, N. R. G. (2016). *Management of Construction Materials on Project Site.* 4 (2).

Ugochukwu, S., Agugoesi, S., Mbakwe, C. & Abazuonu, L. (2017). An onsite quantification of building material wastage on construction projects in Anambra State, Nigeria: comparison with the literature. *Journal of Architecture and Civil Engineering,* 3, (6), 12–23.

Yashim, S. V., Mathew, J. K., & Samuel. R. (2013). Material Management in Construction – A Case Study, *International Journal of Research in Engineering and Technology*, 400-403.

Wahab, B., & Lawal, A. F. (2011). An evaluation of waste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology,* 5, (3), 246-254.

Wahab, B., & Lawal, A. F. (2014). An evaluation of waste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology,* 6,

Wang, L. Y, Tam, V. W, Tam, C. M, & Drew, D. (2014), Mapping Approach for Examining Waste Management on Construction Sites, *Journal of Construction Engineering and Management*, 130, (4), 472-481.