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Assessment of materials waste in the construction industry: A view of Construction Operatives, Tradesmen and Artisans in Nigeria.

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----------**ABSTRACT**----------

Material waste generated by the activities of the construction industry poses serious danger to both the construction projects concerned and the environment at large. Previous researches both at local and international level have neglected construction operatives and craft men who are the majority stakeholder. The study was aim to assess the perception of construction operatives, Tradesmen and Artisans on materials waste generation in the construction industry, with a view to encouraging better performance of construction projects in Nigeria. The study employed questionnaire survey. Tables and figures where used to present the collected data and Mean item score (MIS) and percentage were used to analyze the data collected. Kruskal-Wallis test and Mann-Whitney U-Test were used to test the hypotheses. It was discovered that formwork from wood/timber, Mortar from Rendering/plastering and Blockwork/ Brickwork are the most wasteful material generated on sites; Design (Frequent design changes and poor design), Poor materials storage system and Theft and vandalism are the most important factors that influence material waste generation during construction; Proper site supervision and management techniques, Adequate storage of material, and Staff training and awareness on waste management are the measures of minimizing construction material waste; and saving cost of disposal and transport, increased profit and save construction time loss are the most important benefits of material waste minimization. It was recommended that site operatives and craft men should be carried along in every management decision regarding waste management plan development as they constitute the major stakeholders on sites.

Keywords: *Construction Industry, Construction Operatives, Material waste, Nigeria, Tradesmen and Artisans*

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I. INTRODUCTION

The construction industry is the backbone of every nation, as it is one of the forces driving the socio-economic growth and development of nations of the world [1]. It improves the quality of live through the provision of infrastructure like roads, schools, hospitals, and other necessary basic facilities [2]. Construction industry is the leading sector in any country [3]. In spite of the benefits derived from this industry, the activities of the industry generates increasing quantities of waste which has created a bad image for the industry; and also deplete the limited natural resources [3]. [4] described the construction industry as one of the largest and most important industries; and at the same time the major consumer of natural resources and one of the largest polluters. The wastes generated by the industry have not been well managed, thereby causing considerable health and environmental problems [5]. Also these wastes have affected the performance of many projects in Nigeria ([6], [7], [8]). [9] opined that ineffective material planning and control on construction sites could result to poor performance and unplanned outcomes of construction projects. Construction projects are faced with severe problems of time and cost overruns, as well as construction waste ([10], [11], [12]).

According to [13] 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 byproduct of the construction process is regarded as construction waste. [14] defined building 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. [15] see construction waste as the difference between what was purchased and what was actually used. Waste is any surplus or unwanted material persistently causing environmental issues and global warming [16]. Construction waste can have a significant impact on cost, time, quality and sustainability, and also on the success of projects [16].

Construction materials significantly contribute to the total cost of construction, and the wastage of these materials will negatively impact on the contractors profit, construction cost and duration, and can cause dispute among key project participants [17].

[18] carried out an Investigation into Waste Management on Construction Sites in South Western Nigeria. The study focused on the dangers posed by material waste in the construction industry, ways of minimizing construction waste, ways of keeping proper site records for accountability sake. And recommend effective waste management measures. This research adopted questionnaires to collect data from construction professionals, and employed tables and statistical indices for the data analysis. The study revealed that material wastage increase the cost of construction project and reduce contractor's profit. And attributed construction was to poor management and lack of effective waste management awareness. The study recommended that construction waste management should be recycled and reused. And through giving incentives to workers for proper handling, material wastage is reduced; and trained personnel should be used as supervisors.

[19] evaluated waste control measures in construction industry in Lagos, Nigeria. The study assessed the forms, causes and factors incidental to waste and measures to effectively control construction waste. The study adopted questionnaire, interview and site visit to collect it data from construction professionals. Study used Relative Important index, frequency and percentages to analyze its data. The study reported that factors incidental to waste, design variation are caused by last minute client requirement; cost of construction materials was major factor influencing construction materials selection; and construction cost factor leads to method of construction. The study revealed that most firms do not calculate waste indices which could assist them to determine the amount of waste generated, and no proper sorting exercise of waste during construction. Also, most firms do not incorporate "waste management plan" in their tender documents. To control waste, designers should coordinate dimensions between materials specified and those procured, proper material handling, storage and usage were advocated and that "waste management plan" should be incorporated in tender submission of contracting firms.

[20] carried out a study on Quantitative Assessment of Construction Materials Wastage in the Nigerian Construction Sites. The study's purpose was to quantitatively assess construction materials wastage in construction sites with a view to providing background information at the design stage on allowable percentage of construction materials waste that will enhance construction project delivery. The study used structured questionnaires to collect data from construction professionals in Abuja municipal, Nigeria. The study analyzed its data using average, percentage and relative significant index (RSI). The study found out that the most type of waste on construction site is theft and vandalism, cutting waste, transit waste and application waste. The study concluded that 15.32% are construction materials waste in the Nigerian construction sites; and recommended 15-20% allowance for all types of construction materials waste in Nigeria.

[8] evaluated the causes of construction waste generation on building sites in rivers state, South-South of Nigeria. The study studied the factors affecting construction material waste generator; and determine if there is a statically significant difference in perceptions about the factors between the contractors and consultants. They adopted literature review and structured questionnaire in the collection of data. And analyzed the collected data using mean score method, ranking method and Mann-Whitney U test. The study focused on consultants and contractors as their key respondents. The study revealed that rework contrary to drawing and specification, design changes and revision and waste from uneconomical shapes, were the most important factors contribution to construction material waste. The study also showed that there is no significant difference between the consultants and contractors regarding the factors affecting construction material waste.

[21] carried out a study on Materials Waste In The Egyptian Construction Industry. The study which whose aim was to identify and quantify waste generation rates and their causes in the Egyptian Construction Industry used a survey questionnaire as a diagnostic tool for collection of data. The questionnaires were distributed among construction professionals. The study discovered that 'late information' and 'Changes to design' were among the most fundamental causes of material waste.

[22] studied Non Value-Adding Activities In Australian Construction Projects. The study was aimed at determining the incidence of non value-adding activities that occurred within contracting organizations in Australia. They adopted a quantitative approach and used questionnaire for its data collection. The questionnaires were administered to construction professionals. The study revealed that there was no significant difference between respondents' perceptions towards waste. Also, the key waste cause variables of non value-adding activities are; waiting for instruction, poor quality site documentation, weather, unclear drawings, poor design, design changes, slow drawing revision and distribution and unclear specifications.

[23] carried out a study which was aimed to Evaluate Materials Wastage and Control in Some Selected Building Sites in Nigeria. They used questionnaires which were administered via accidental sampling technique to construction professionals in the selected building sites. The data collected was analyzed using descriptive statistics tools. Also, [10] carried out a study on Construction Material Waste Management Practices by Construction Firms in Nigeria. They used of structured questionnaires for data collection, and administered them to senior construction-professional personnel of construction firms. The study showed that Block work has the highest level of waste generation and adequate site supervision and control is the most important strategy for minimizing materials wastage on sites. And also the estimators' allowances for materials wastage are exceeded for most materials on sites.

[24] Studied the Causes and Magnitude of Wastage of Materials on Construction Sites in Jordan. The research aims to study the causes and magnitude of wastage of construction materials on construction projects sites in Jordan. The researcher used a questionnaire form which was designed to help achieve the research aim. The questionnaire form was distributed to 240 participants (clients, contractors, and consultants) who are mainly construction professionals. The study discovered that the most important causes of wastage of materials on construction sites in Jordan 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. They concluded that the percentage of wastage materials is accounted for by values between 15% and 21% on Jordanian construction sites.

[3] studied Factors Affecting Material Waste on Construction Sites in Nigeria. Their study assessed the level of contribution of several factors to construction material waste generation; and used structured questionnaires which were administered to two groups of stakeholders (consultants and contractors) in construction industry. These two groups of stakeholders are construction professionals. They used Relative contribution index, Mann-Whitney U and Kruskal-Wallis tests was used to analyze the collected data. They found that the highest contributors to materials waste are reworks due to non-conformance to specifications, waste from cutting uneconomical shapes, and design changes and revisions. Also, location of site has no effect in the level of contribution of the assessed factors to material waste generation. And they concluded that material waste generation is a critical and complex issue in Nigerian construction industry.

[25] researched on Material Control Strategies In Some Selected Construction Firms In Nigeria. The purpose of the study was to assess the various strategies utilized by building construction firms for controlling materials on construction sites. Also, to identify the stages of in the course of the project execution in which adequate material control adopted; to assess the impact of building construction firms' adherence to standard material control strategies on building project performance and delivery. They used well-structured questionnaire administered to construction professionals to collect data. They found out that recognition of material control practice and implementation of the strategies involved by building construction firms would ensure timely project execution and standard work delivery within reasonable cost, time and quality.

[7] carried out a study on Professionals' views of material wastage on construction sites and cost overruns in Lagos state, Nigerian South-West. The purpose of the study were to identify the most wasteful building material during construction operation; to assess the level of material wastage with various subcontracting options; to identify factors contributing to material waste on building sites; to determine the percentage contribution of material wastage to project cost overrun, and to examine the relationship between the level of waste generated from building material, subcontracting options and project cost overrun. The study employed a survey research design and focused on construction managers, site managers, chief estimators, site engineers, projects managers and other key personnel within the construction industry. Data collected for the study were analyzed using Frequency, percentages, mean score, Pearson correlation coefficient, and Chi-square. The study revealed that mortar from plastering/rendering is most wasteful building material during construction operations on site; the subcontracting option that is the highest contributor to building material wastage is 'labour only' subcontracting options; an Average of between 21-30% of project cost overrun in construction is attributable to building material wastage; Factors that dominate among the contributors to material wastage on site are poor supervision, re-work, and poor material handling; and there is a significant relationship between waste generated from building material during construction, subcontracting options and cost overrun.

[26] carried out a study on Material Waste Management In Construction Industries of India. The stud investigated the cause of waste, waste prevention method and the wastage level in construction site. The study adopted a questionnaire survey. Questionnaires were administered to construction professionals. The study adopted weighted average and coefficient of variation criteria and T-test statistical technique of comparing means. The study reported that Design Changes during construction, weak material management, poor site storage facilities, errors by tradesmen and severe weather conditions were the major factors affecting waste

generation. Adequate storage of material is one of the major minimization measures. The study recommended a holistic and analytical approach to construction waste management problems.

[27] examine the effects of material-waste and their control measures on project-cost overruns at the site-management stage of a project. The study employed interview and purposive sampling techniques in the collection of data from respondents who mostly construction professionals. The data collected were analyzed using descriptive statistics (frequency and percentages) and inferential statistical method. The study revealed that Rework, site accidents, inadequate site security/fencing, poor site organization and discipline, and construction-site disputes; are the causes of material waste that have the greatest effect cost overruns at the site-management stage of a project. The study also reported that; Tight security onsite (security source), inadequate site organization and discipline (operation source), and onsite and offsite reuse of waste materials (site conditions and management source); are material waste-control measures that have the greatest effect on cost overruns with respect to the quality of site management of a project. The study also revealed that there were no significant differences in the views of the professionals on these issues.

It is evident that previous studies have focused only on the perception of construction professionals, leaving out the site supervisors, operatives and craft men who are the ones that are both physically and directly involved in the carrying out the construction works and the production of the finished building. An effort to carry the site supervisors, operatives and craft men, who are the majority stakeholder in construction, will help improve the performance of construction activities and reduce waste production and other related losses during the construction stage of the projects. [8] describe the site supervisors and the site operatives as people who are directly involved in the art of putting the raw materials together to form the building envelope. [28] refers to this group as 'project staff', and defines them as the member of the project team who carry out the work of creating the deliverables.

However, it is clear from previous researches both at local and international level that these groups of stakeholders have been neglected. It is against this backdrop that this study is predicated. The outcomes of this study will enable the clients, consultants, contractors, and construction professionals know that site operatives and craft men are aware of material waste and are conscious of contributing to their reduction during construction. The outcome will also add to the body of knowledge available on construction waste management. Overall, construction operatives and craft men will be considered important stakeholders in the scheme of things regarding making decision in construction operations that relate to construction waste generation and management.

1.1 Aim and Objectives

The aim of this study is to assess the perception of construction operatives, Tradesmen and Artisans on materials waste in construction, 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 identify the most wasteful material produced during construction operations
ii. To determine the most important factors that influence material waste production during construction work
iii. To assess measures of minimizing construction material waste
iv. To identify the most important benefit of material waste minimization.

1.2 Research Hypothesis

The followings are the hypothesis that guide the study and they stems from objectives (i), (ii) and (iii)

H_1: there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the most wasteful material produced during construction operations

H_2: there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the factors affecting material waste in construction

H_3: there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the measures of minimizing construction material waste

II. RESEARCH METHODOLOGY

Relevant literatures on construction waste were reviewed to retrieve factors that influence material waste production during construction work, measures for material waste minimization and benefit of material waste minimization. Based on the review, 20 factors responsible for material waste were selected, 16 measures to minimizing material waste and 10 benefit of material waste minimization were selected. Based on initial pilot survey and discussion with some professionals in construction, a list of 10 most common types of building

construction waste was drawn up. Construction operatives, artisans and tradesmen were grouped for convenience into;

1) Group 1 - Concreters/Mason/Bricklayers
2) Group 2 - Steel benders/fixers
3) Group 3 - Carpenters
4) Group 4 - Services Operators (Plumbers & Electricians)
5) Group 5- Finishers (Tillers, Painters, etc)

Five (5) samples each from these groups from five (5) different construction sites with on-going construction projects within the Abuja metropolis were sampled. This represents 25 samples each for the groups and a total of 125 samples. Because of their level of engagement, the researchers sort the assistance of research assistants in the administration and collection of questionnaires in order to gather the data for this study. The questionnaires were read to a few of the respondents and explanation given where needed. This is to ensure 100% response rate. Convenient sampling technique was adopted in the administration and collection of data. [29] states that convenience sampling is used when population elements are selected for inclusion in the sample based on the ease of access.

2.1 Questionnaire design

The questionnaire was divided into five (5) main parts. Part A- is related to demographic information of the respondents and their companies. The artisans, operative and tradesmen were requested to answer questions pertaining to their experience in building construction projects. Part B includes the list of the identified Building materials types that are wasted during construction. Part C includes the list of the selected factors responsible for material waste in construction. Part D contains the list of the measures to minimize material waste during construction. And Part E contains the list of important benefit of material waste minimization

2.2 Pilot study

In order to verify that the questionnaire is appropriate to meet the study objectives, a pilot study was carried out to ensure that the information that would be collected from the artisans, operatives and tradesmen suite the study. Draft questionnaire with a forwarding letter were sent to four construction professionals and six site supervisors and superintendents; to assess the content validity of the questionnaire and to give constructive criticism. The questionnaires were received from the selected experts and modified based on their feedback.

2.3 Data presentation and Analysis

The collected data were presented in Tables and charts, and Mean Item scores (MIS) was used to analyze and rank the data collected on type of material waste, factors that influence material waste generation, measures to minimize construction waste and the benefits of material waste minimization.. The responses were base on a 5-point Likert scale and ranges from 1 to 5.

Kruskal-Wallis test was used to test the three (3) hypotheses in order to determine if there are statistically significant differences in the opinions of the five (5) groups of respondents. Kruskal-Wallis test was found to be appropriate according to [30] who states the conditions suitable for using The Kruskal-Wallis test. These conditions are; (i) there are three or more conditions that you want to compare; (ii) each condition is performed by a different group of participants; (iii) the data do not meet the requirements for a parametric test (or if the data are measurements on an ordinal scale). Furthermore, Mann-Whitney U-Test was used to test for differences between two independent groups, where the overall Kruskal-Wallis test is significant. According to [31] who states that if the overall K-W test is significant; Mann-Whitney tests should be conducted to compare the groups (to investigate which groups significantly differ). The decision rules for acceptance or rejection of the hypothesis are;

i. If P-value ≥ 0.05, then accept the hypothesis, and
ii. If P-value <0.05, then reject the hypothesis.

These analyses were done using statistical package for social science (SPSS) Version 20.

2.4 Reliability Check - Cronbach's Alpha

SPSS was used to check the consistency of the data. Generally, reliability coefficient of 0.70 and above is good and acceptable ([32], [33]). Supporting these views, [34] state that Cronbach's alpha value of 0.80 or more is significant and reliable. Furthermore, [35] opined that the alpha value is expected to be greater than 0.7, and that higher alpha value means greater reliability of data. Data for this study is therefore, reliable and consistence, s**ee Table 2.1**

Table 2.1 Cronbach's Alpha for Questionnaires

No	Items Evaluated	Cronbach's Alpha	N of Items
1	Type of Building Materials Waste	0.832	10
2	Factors Influencing material Waste	0.934	20
3	Measures for Minimizing Waste	0.771	16
4	Benefits of Waste Reduction	0.713	10

Source: Researcher's Analysis, 2017

III. DATA ANALYSIS, RESULTS AND DISCUSSION

3.1 The Demographic Characteristics of the Respondents

Fig. 3.1 to 3.5 shows the demographic characteristics of the respondents. The analysis of the respondents' position/rank revealed that 33% are General foremen/foremen, 23% are headmen and 20% are site supervisors as shown in Fig. 3.1. Also, Fig 3.2 indicated that 36% of the respondents have spent between 16-20years in the construction industry, 26.4% of them 11-15years, and only 45 spent 1-5years in the industry. These imply that the respondents occupy high positions on the sites and are experience enough to give reliable responses.

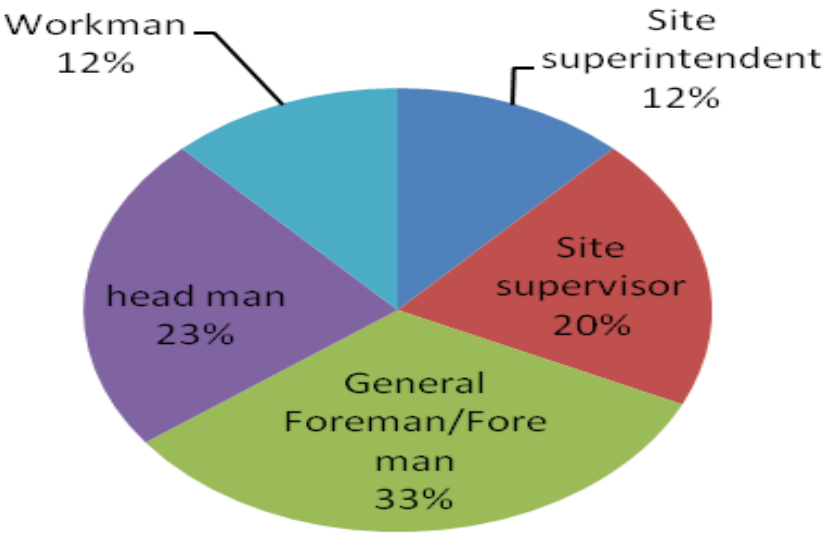

Fig. 3.1 Post/rank of respondents

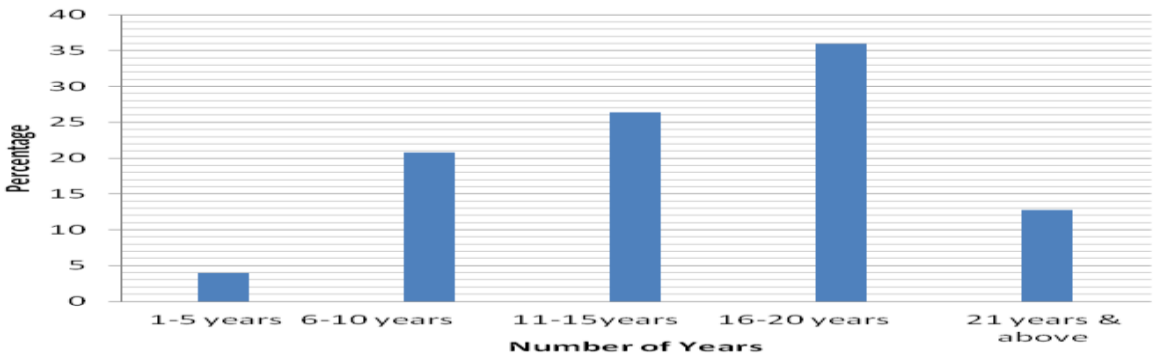

Fig. 3. 2 Number of years respondents have spent in the construction industry

Fig. 3.3 indicates that 43.2% of the respondents have worked for between 1-5 companies, 39.2% have worked for 6-10 companies, and only 0.8% worked for 21 companies and above. And Fig. 3.4, shows the maximum number of years they have spent in a construction firm as the journey in the construction industry. 65.6% have spent a maximum of 1-5years, 29.6% have spent 6-10 years. Fig. 3.5 indicates that 100% of the respondents have knowledge about materials waste generation in the construction industry. These imply that the respondents

are experience on the workings and operations of the construction industry, and a aware of the construction material waste generation.

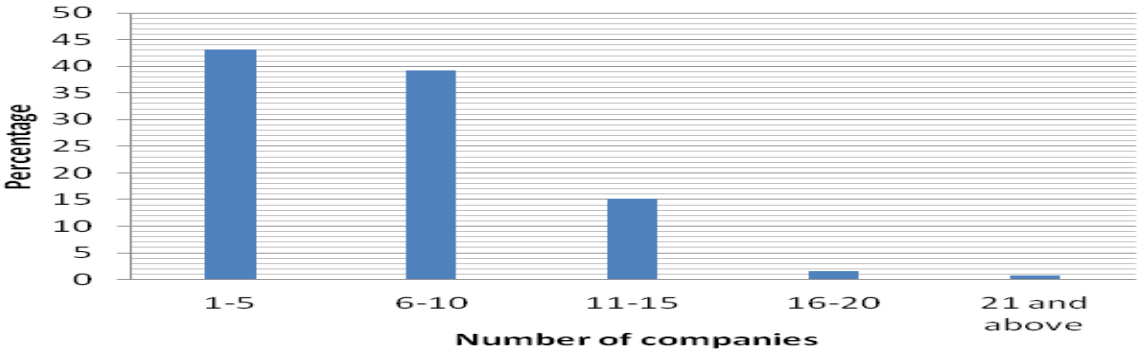

Fig. 3.3 Number of companies before present employment

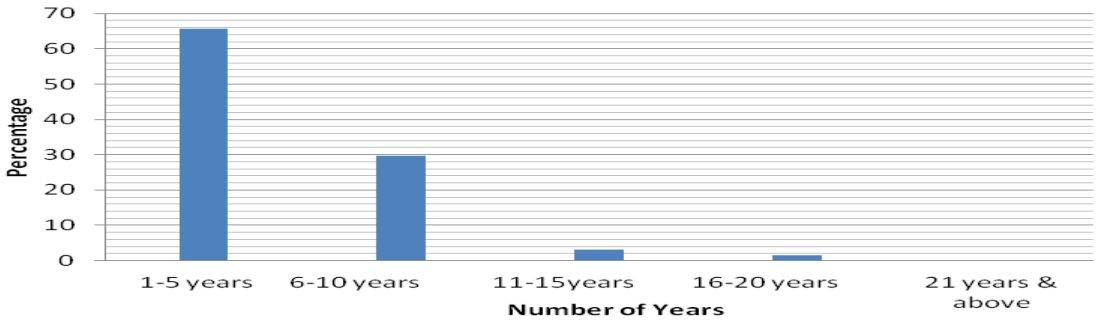

Fig. 3.4 Maximum Number of years spent in a company

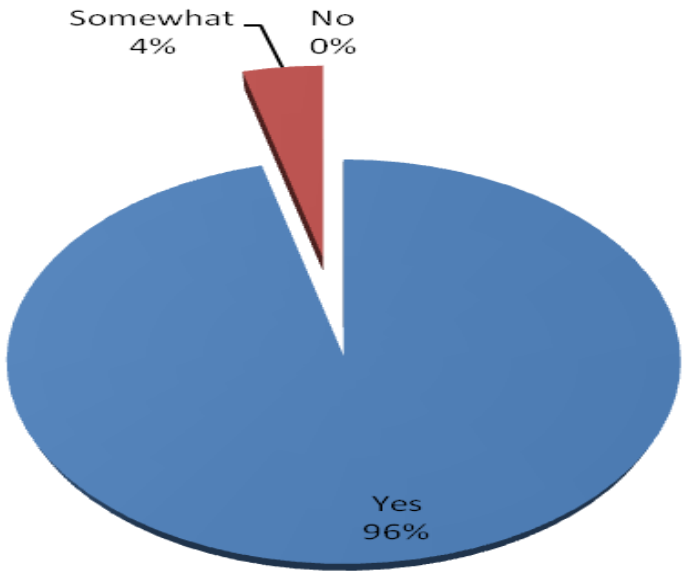

Fig. 3.5 Knowledge of material waste produced by construction work

3.2 Most wasteful materials during construction

The overall perception of the various groups of respondents on the degree and contributions of construction materials to waste generation on site are shown in Table 3.1. It can be seen from the table that formwork from wood/timber with mean item score of (4.49) has the highest level of waste generation on site and its ranked 1st. This was followed by Mortar from Rendering/plastering with mean item score of 4.47, and then Blockwork and

Brickwork with mean item score of 4.40, and concrete was fourth with mean item score of 4.37. The table also shows that Formworks (from steel/metal) and Aluminum roofing Sheets were the least wasteful materials on site with mean item score of (2.82) and (2.56) respectively.

Table 3.1: Material Waste in Construction

S/No	Material Type	MIS	SD	Rank
1	Sandcrete Blockwork & Brickwork	4.40	0.751	3
2	Formworks (from wood/timber)	4.49	0.703	1
3	Mortar from Rendering/plastering	4.47	0.725	2
4	Concrete	4.37	0.735	4
5	Reinforcements	4.02	0.902	5
6	Tiles from walls, floors and other surfaces	3.94	1.002	6
7	Paint	3.59	1.122	8
8	Aluminum roofing Sheets	3.56	1.073	9
9	Formworks (from steel/metal)	2.82	1.024	10
10	Ceiling boards	3.79	1.102	7

Source: Researchers' Analysis (2017)

The result reported in this study is consistent with the findings of [23]. They reported that blockwork, rendering mortar, formwork and concrete generate the most of waste on site. Similarly, [7] found out that mortar from plastering/rendering, timber formwork, sandcrete block and concrete were the most wasteful construction materials out of 14 most commonly used building materials on site. [17] reported that on the average, timber (14.54%) and blocks (12.10%) are the most waste generation on building sites across south-south States of Nigeria. The major causes of wastage in formwork (made from timber) are due to the natural ability of timbers to deteriorate and wastage from cutting [36]. Formwork from wood/timbers cannot stand the test of time when used and left in the open without proper storage. Timber formworks contribute up to 20% of wastage in foundation works due to wet nature of works at foundation level [7]. Microbes in the soil aids deterioration of timber formworks since they are of biodegradable materials. [20] reported that hardwood and softwood materials have high percentages under theft and vandalism waste. And that mortar through screeding and rendering, and concrete through columns, beams, lintels and walls, has high percentage to application waste. Mortar through screeding contribute (14.91%), mortar through rendering had (11.97%) and concrete though columns, beams, lintels and walls (14.13%). [37] assert that a percentage of mortar is wasted during application to soffit of suspended slab (ceiling).

According to [38] the high level of waste of mortar from plastering/ rendering is attributed to departure from the original design and lack modular coordination in the structural elements of the building. This departure leads to excessive thickness of plaster [20]. The mortar used on such columns, beans and walls which has departed from its original design will increase [23]. Also, when the blocks are of not of uniform sizes, excessive mortar could be used in jointing of blocks [23]. [39] identified various percentages of contribution of different construction materials to waste during construction activities. These materials are concrete 4%, packaging 5%, blockwork 10%, and mortar from plastering/screeding 15%. According to by [40] and [41] waste from blocks and mortar can be minimized but are unavoidable in construction. According to [41] design complexity of buildings aids mortar wastage; if the standard sizes of block were not considered during design, more waste could be experienced. [38] opined that concrete waste results from failure in formwork and weak adhesion of concrete materials in the design mix.

Formwork (from steel/metal) and Aluminum roofing Sheets are the least wasteful construction materials on site. This could be attributed to the ability to withstand elements of weather. [7] opined that the low level of wastage from materials made of steel are due to their durability property and ease of being used severally over a long period of time.

3.3 Factors Influencing Material Waste Generation during Construction Activities

Table 3.2 show the perception of the factors influencing material waste generation during construction work by the respondents. The top 10 factors affecting construction waste generation are; Design (Frequent design changes and poor design) (4.81), Poor materials storage system(4.78), Theft and vandalism (4.71), Poor site conditions (4.55), Poor strategy for waste minimization(4.42), Poor procurement management (wrong

purchasing order – quality, number, time of order) (4.26), Inclement weather (4.24), Poor materials handling on site (4.21), Poor and insufficient implementation of waste management plan (4.21), Poor quality and non-availability of equipment (4.18) and Site Management (4.18). In the opinion of the respondents' unnecessary, frequent and poor initial design, poor storage facilities on site, the act ivies of criminals and miscreant among the operatives, poor condition of the sites, poor meaningful measures to reduce waste, enhances waste generation on site. This finding is similar to that of ([23], [8], [7], [3], [10], [24]). [24] reported that change to the design, rework due to worker's mistake, poor contract documents and wrong and lack of storage of materials are the major cause of wastage of materials. Changes to designs during the construction process can result in waste [24]. [24] claimed that 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. According to [24] a change in a structure which has already been constructed will result to partial demolition, thereby generating material wastage. And this is supported by [42] who reported that design changes are most significant source of construction waste. In same vein, [43] discovered that design changes were the most significant factor leading to waste in construction site. [41] reported that in Gaza strip, one of major factors causing material waste in construction was inadequate stacking and insufficient storage of materials. Similarly, [42] and [44] the main cause of wastage on construction projects are inappropriate storage of material. [18] also identified site storage; transport and delivery to site and intra-site transit are the major causes of material waste on site. [37] identified lack of material management system, poor housekeeping and storage, theft and pilferage as being among the general factors causing waste generation. Poor strategy for waste minimization and site management has been identified to cause waste (45]. Most contracting companies usually have a plan to manage the materials and other resources in construction projects. But often times, these plans such as the plan to manage material purchasing plan, delivery, inventories, stockiest, handling, and transportation; are neglected by site managers [24]. According to the study carried out in Hong Kong by [45], they reported that lack of strategy for waste minimization was the major source of construction waste.

The least factors affecting material waste generation are Traditional construction methods (labour intensive nature) (3.83), Time Pressure (3.81), Waste resulting from poor packaging, delivery and transport (3.71), Lack of incentive for contractors to improve their practices (3.59) and Poor segregation (2.54).

Table 3.2: Factors Influencing material waste generation during construction work

S/No	Factors Influencing material waste production during construction work	MIS	SD	Rank
1	Design (Frequent design changes and poor design)	4.81	0.4525	1
2	Poor materials handling on site	4.21	1.2463	8
3	Poor coordinated documents	4.04	1.3643	14
4	Poor strategy for waste minimization	4.42	0.7958	5
5	Poor site conditions	4.55	0.7562	4
6	Theft and vandalism	4.71	0.5361	3
7	Poor quality and non-availability of equipment	4.18	1.0554	10
8	Poor materials storage system	4.78	0.5014	2
9	Waste resulting from poor packaging, delivery and transport	3.71	1.3726	18
10	Time Pressure	3.81	1.2293	17
11	Poor procurement management (wrong purchasing order – quality, number, time of order)	4.26	0.8627	6
12	Site Management	4.18	0.7938	10
13	Inclement weather	4.24	0.9367	7
14	Long project duration	3.86	1.2004	15
15	Use of unskilled labour.	4.13	0.8030	12
16	Lack of workers' awareness and training on waste management practices	4.09	0.9247	13
17	Traditional construction methods (labour intensive nature),	3.83	1.2230	16
18	Lack of incentive for contractors to improve their practices	3.59	1.3326	19
19	Poor and insufficient implementation of waste management plan	4.21	1.0648	8
20	Poor segregation	2.54	1.0360	20

Source: Researchers' Analysis (2017)

3.4 Measures for Minimizing Materials Wastage

The ranking of the respondents' perception on the measures for minimizing construction materials waste if shown on table 3.3. The Table revealed that the top 10 measure for material waste minimization as perceived construction operatives and craftsmen are; Proper site supervision and management techniques (4.81), Adequate storage of material (4.74), Staff training and awareness on waste management (4.62), Use of low waste

technology (4.62), Proper procurement management (4.60), Just in time operations of works/delivery of materials (4.58), Proper implementation of Waste Management Plan (4.58), Employment of skilled workmen to carry out site operations (4.56), Mechanical handling of materials (4.54), and Prefabrication of construction components off-site (4.52). The operatives were of the opinion that proper supervision and management techniques both the supervisors and site engineers and the management techniques of the company; couples with proper storage of materials will reduces damage and waste tremendously. They also believed that when they are well trained on the use of modern tools equipment, with adequate knowledge on how waste are managed, materials waste will seriously be reduce. Strict adherence to waste management plan, Proper workmen supervision by the engineering's and supervisors involved and employment of experienced and skill workers, will help reduce materials waste generation onsite. The finding of this study is consistent with ([18], [23]). [23] reported that proper site supervision and control, and appropriate material planning and storage can minimize materials wastage of construction materials. According to [41] adequate site supervision and control is the most effective strategy for minimizing materials waste in building sites in Nigeria. In the same vein, [46] in [23] confirmed that site supervisors and engineer are the most important personnel for material control on site. In buttressing this view, [23] assert that site supervision and control is probably reason why materials waste generation levels differ from one building site to the other. [37] suggested that to reduce waste, there should be strict supervision and control of materials, creating an awareness of consequences of waste and educating staff, intensifying security, effective site management and improving storage facilities as toping the major measures to reducing wastage on site.

The least three important measure as revealed on table 4.3 are; Recycling of some waste materials off site and on site (3.30), Recording and measuring different streams of waste (2.11) and Careful handling of tools and equipment (2.03). This finding indicates that the importance of material waste recycling is yet to be appreciated and the know-how is still lacking in Nigeria. According to [23] stakeholders in Nigeria have not seen the potentials for recycling of materials wastes as done in developed countries. Careful handling of tools and equipment is ranked among the least important measure probably because every operative should have known how to handle simple tools and equipment. This is so as it form part of the pre-requisite for their employment for construction work.

Table 3.3: Measures for Waste Minimization in Construction Work

S/No	Measures	MIS	SD	Rank
1	Adequate storage of material	4.74	0.6494	2
2	Proper site supervision and management techniques	4.81	0.4869	1
3	Staff training and awareness on waste management	4.62	0.6178	3
4	Recording and measuring different streams of waste	2.11	0.7748	15
5	mechanical handling of materials	4.54	0.9206	9
6	Segregation of waste on site	3.82	0.5965	12
7	Prefabrication of construction components off-site	4.52	0.5764	10
8	Recycling of some waste materials off site and on site	3.30	0.5271	14
9	Just in time operations of works/delivery of materials	4.58	0.6383	6
10	Appointment of waste officer/manager on site	4.39	0.9060	11
11	Use of more efficient construction equipment	3.68	0.7362	13
12	Proper procurement management	4.60	0.5680	5
13	Employment of skilled workmen to carry out site operations	4.56	0.6401	8
14	Use of low waste technology	4.62	0.5203	4
15	Proper implementation of Waste Management Plan	4.58	0.7434	6
16	Careful handling of tools and equipment	2.03	0.7177	16

Source: Researchers'' Analysis (2017)

3.5 Importance of Minimizing Construction waste

The ranking of the respondents' perception on the benefits of minimizing construction waste generation is shown on Table 3.4. The top 5 benefits derived from minimizing construction waste both to individuals and firms involved are; saving cost of disposal and transport (4.70), increased profit (4.61), save construction time loss (4.58), Protection of the environment (4.50), and Cleaner and safe site conditions (4.48). The respondents are of

the opinion that when construction waste are minimized, the extra cost incurred in transporting material waste away from the site is reduce or avoided. In most cases companies are required to pay certain fee for their waste to be deposited at a central waste collection point either within or outsides the cities. The cost incurred for waste materials to be deposited is avoided or reduced where there are effective waste reductions measures in place. The profit of the construction firms is sustained where there is a meaningful control of waste generation on site. Also, the extra time required to prepare another material for example where there is excessive waste of mortar during plastering is reduces as result of proper waste control measures. [1] advised that for cost overruns caused by project waste to be minimized, there should be an Effective Waste management (EWM) at all stages of projects development and at the waste sources.

The respondents are of the opinion that when waste generation is minimized, the environment is protected and there will be cleaner and safe site conditions for optimum performance of the workers. This is true as [47] confirmed that the construction industry while encouraging socio-economic development of any nation, contribute to pollution of the environment and aids the exploitation of the natural non-renewable resource. According to them the activities of the construction industry contributes to degradation of the environment through depletion of resource, air pollution and energy consumption and generation of waste in the acquisition of raw materials. According to [38] material waste generation is recognized as the main problem in the construction industry and this have affects both on the efficiency of the industry and impact the construction project environmental. According to [48], most construction wastes which were inert have been found to produce harmful leachates which have negative effects on the environment. As a result of this, [44] advocated the adoption of ecologically sound planning and construction practices for the purpose of creating a healthy and sustainable built environment, by the construction industry. [49] assert that there are enormous economical and environmental benefits to be gained from waste minimization and recycling. [50] posit that waste minimization measures can increase contractors' competiveness and better public image. The respondents are of the opinion that Giving bonus to workers (3.43), Careful and hardworking workers getting commendation (3.08) and Promoting good handlers (2.80) are the least benefits of minimizing construction waste.

Table 3.4: Importance of Minimizing Construction waste

S/No	Benefits of Waste Reduction	MIS	SD	Rank
1	Saving cost of disposal and transport	4.70	0.710	1
2	Increased profit	4.61	0.851	2
3	Enhancing the corporate image of the company	3.97	0.177	6
4	Protection of the environment	4.50	0.858	4
5	Save construction time loss	4.58	0.785	3
6	Cleaner and safe site conditions	4.48	0.980	5
7	Giving bonus to workers	3.43	1.034	8
8	Promoting good handlers	2.80	0.660	10
9	Prompt payment of workers' salaries/medicals	3.81	0.668	7
10	Careful and hardworking workers getting commendation	3.08	0.768	9

Source: Researchers' Analysis (2017)

3.6 Test of Hypothesis

3.6.1 Level of Differences among the Various Groups of Operative and Craft Men Concerning the Most Wasteful Material Produced During Construction Operations

Hypothesis (H_1) which states that there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the most wasteful material produced during construction operations was performed using Kruskal-Wallis Test at $p \geq 0.05$. The test revealed that there is a significant statistical difference in the perceptions of the various operatives and craft men concerning the most wasteful material produced during construction activities. Therefore, the hypothesis (H_1) was rejected as $p < 0.05$ (Table 3.5). This implies that the various operatives and craft men disagree on the most wasteful materials type of generated on construction sites. And this could be attributed to differences in the level of site supervision and waste management techniques in the various constructions sites.

Table 3.5 Results of Kruskal-Wallis Test for Material Waste in Construction

Labour Category	N	Means Rank	P-value	Decision
Group 1 - Concreters/Mason/bricklayers	25	79.68		
Group 2 - Steel benders/fixers	25	43.76		
Group 3 - Carpenters	25	33.62	0.0000	Reject
Group 4 - Services Operators (plumbers & electricians)	25	72.3		
Group 5- Finisher (tillers/painters, etc)	25	85.64		

Source: Researchers' Analysis (2017)

3.6.2 Level of Differences among the Various Groups of Operative and Craft Men Concerning the Factors influencing material waste generation during construction work

Hypothesis (H_2) which state that there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the factors affecting material waste in construction, was tested using Kruskal-Wallis Test at $p \geq 0.05$. The test revealed that there is no significant statistical difference in the perceptions of the various operatives and craft men concerning the factors affecting material waste generation during construction activities. Hence, the hypothesis (H_2) was accepted as p-value > 0.05 (Table 3.6). This implies that there is a relationship in the opinions of the various groups of operatives and craft men regarding the factors affecting material waste generation onsite.

Table 3.6 Results of Kruskal-Wallis Test for Factors Influencing material waste generation during construction work

Labour Category	N	Means Rank	P-value	Decision
Group 1 - Concreters/Mason/bricklayers	25	64.86		
Group 2 - Steel benders/fixers	25	65.78		
Group 3 - Carpenters	25	60.12	0.9820	Accept
Group 4 - Services Operators (plumbers & electricians)	25	62.12		
Group 5- Finisher (tillers/painters, etc)	25	62.12		

Source: Researchers' Analysis (2017)

3.6.3 Level of Differences among the Various Groups of Operative and Craft Men Concerning the Measures of Minimizing Construction Material Waste

Hypothesis (H_3) which state there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the measures of minimizing construction material waste was tested using Kruskal-Wallis Test at $p \geq 0.05$. The test revealed that there is no significant statistical difference in the perceptions of the various operatives and craft men concerning the measures of minimizing construction waste during construction work. Therefore, this led to the acceptance of hypothesis (H_3) since p-value > 0.05 (Table 3.7). This implies that the various operatives and craft men agrees to the various measures of minimizing construction waste generation on construction sites.

Table 3.7 Results of Kruskal-Wallis Test for measures of Waste Minimization in Construction Work

Labour Category	N	Means Rank	P-value	Decision
Group 1 - Concreters/Mason/bricklayers	25	63.38		
Group 2 - Steel benders/fixers	25	61.1		
Group 3 - Carpenters	25	64.1	0.9730	Accept
Group 4 - Services Operators (plumbers & electricians)	25	66.46		
Group 5- Finisher (tillers/painters, etc)	25	59.96		

Source: Researchers' Analysis (2017)

3.7 Degree of Agreement between Respondents Groups

3.7.1 Mann-Whitney U Test for Factors Influencing Material Waste Generation and Measures for Waste Minimization in Construction Work

Since the overall Kruskal-Wallis test is significant at p = 0.05 for all combined groups of respondents; a series of Mann-Whitney U tests was conducted to compare perceptions between pairs of the groups. Mann-Whitney U test was performed at $p \geq 0.05$ (95% level of significance) and in all it was observed that in every pairs of the groups, the P-value > 0.05 and these led to the acceptance of the hypothesis (H_2) (Table 3.8). Hence, it is concluded that there is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the factors affecting material waste generation in construction activities.

Similarly, the P-value for the perceptions of the various groups concerning the measures for minimizing construction material waste was found to be greater than 0.05, and these led to the acceptance of the hypothesis (H_3) (Table 3.9). This therefore, showed that there is no significant difference between the perceptions of the various groups concerning the measures for minimizing construction material waste.

Table 3.8 Result of Mann-Whitney U Test for Factors Influencing material waste Generation during construction work

Target Group	N	Z(calculated)	Z (critical)	P-value	Decision
Group 1 vs Group 2	25	-0.099	211	0.921	Accept
Group 1 vs Group 3	25	-0.442	211	0.659	Accept
Group 1 vs Group 4	25	-0.285	211	0.776	Accept
Group 1 vs Group 5	25	-0.285	211	0.776	Accept
Group 2 vs Group 3	25	-0.560	211	0.576	Accept
Group 2 vs Group 4	25	-0.354	211	0.724	Accept
Group 2 vs Group 5	25	-0.354	211	0.724	Accept
Group 3 vs Group 4	25	-0.205	211	0.837	Accept
Group 3 vs Group 5	25	-0.205	211	0.837	Accept
Group 4 vs Group 5	25	0.000	211	1.000	Accept

Source: Researchers' Analysis (2017)

N = Number of respondents in each group (i.e Group 1 =25; Group 2 = 25)

Table 3.9: Result of Mann-Whitney U Test Measures for Waste Minimization in Construction Work

Target Group	N	Z(calculated)	Z (critical)	P-value	Decision
Group 1 vs Group 2	25	-0.245	211	0.807	Accept
Group 1 vs Group 3	25	-0.098	211	0.922	Accept
Group 1 vs Group 4	25	-0.293	211	0.769	Accept
Group 1 vs Group 5	25	-0.332	211	0.740	Accept
Group 2 vs Group 3	25	-0.293	211	0.769	Accept
Group 2 vs Group 4	25	-0.508	211	0.611	Accept
Group 2 vs Group 5	25	-0.117	211	0.907	Accept
Group 3 vs Group 4	25	-0.234	211	0.815	Accept
Group 3 vs Group 5	25	-0.381	211	0.703	Accept
Group 4 vs Group 5	25	-0.654	211	0.513	Accept

Source: Researchers' Analysis (2017)

N = Number of respondents in each group (i.e. Group 1 =25; Group 2 = 25)

IV. CONCLUSION

From the findings of the analysis of the perception of construction operatives and craftsmen, the study concludes that;

i The most wasteful material generated during construction activities are formwork from wood/timber, Mortar from Rendering/plastering, Blockwork and Brickwork and concrete

ii The most important factors that influence material waste production during construction work area; Design (Frequent design changes and poor design), Poor materials storage system, Theft and vandalism, Poor site conditions, Poor strategy for waste minimization, Poor procurement management (wrong purchasing order – quality, number, time of order), Inclement weather, Poor materials handling on site, Poor and insufficient implementation of waste management plan, Poor quality and non-availability of equipment and Site Management.

iii Measures of minimizing construction material waste are Proper site supervision and management techniques, Adequate storage of material, Staff training and awareness on waste management, Use of low waste technology, Proper procurement management, Just in time operations of works/delivery of materials, Proper implementation of Waste Management Plan, Employment of skilled workmen to carry out site operations, Mechanical handling of materials and Prefabrication of construction components off-site.

iv The most important benefits of material waste minimization are saving cost of disposal and transport, increased profits, save construction time loss, Protection of the environment, and Cleaner and safe site conditions.

v There is a significant statistical difference in the perceptions of the various groups of operatives and craft men regarding the most wasteful material produced during construction operations.

vi There is no significant statistical difference in the perceptions of the various groups of operative and craft men concerning the factors affecting material waste and measures of minimizing construction material waste in construction

V. RECOMMENDATION

From the conclusion of this study, it is recommended that there should be improved and better storage and handling of materials delivered to site, a sale back contract should be entered with suppliers of building materials, there should be proper site supervision, materials control and security on site. Also, site operatives and craft men are aware of material waste generation and should be carried along in management decision regarding waste management plan development, as constitute the major stakeholders on sites.

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