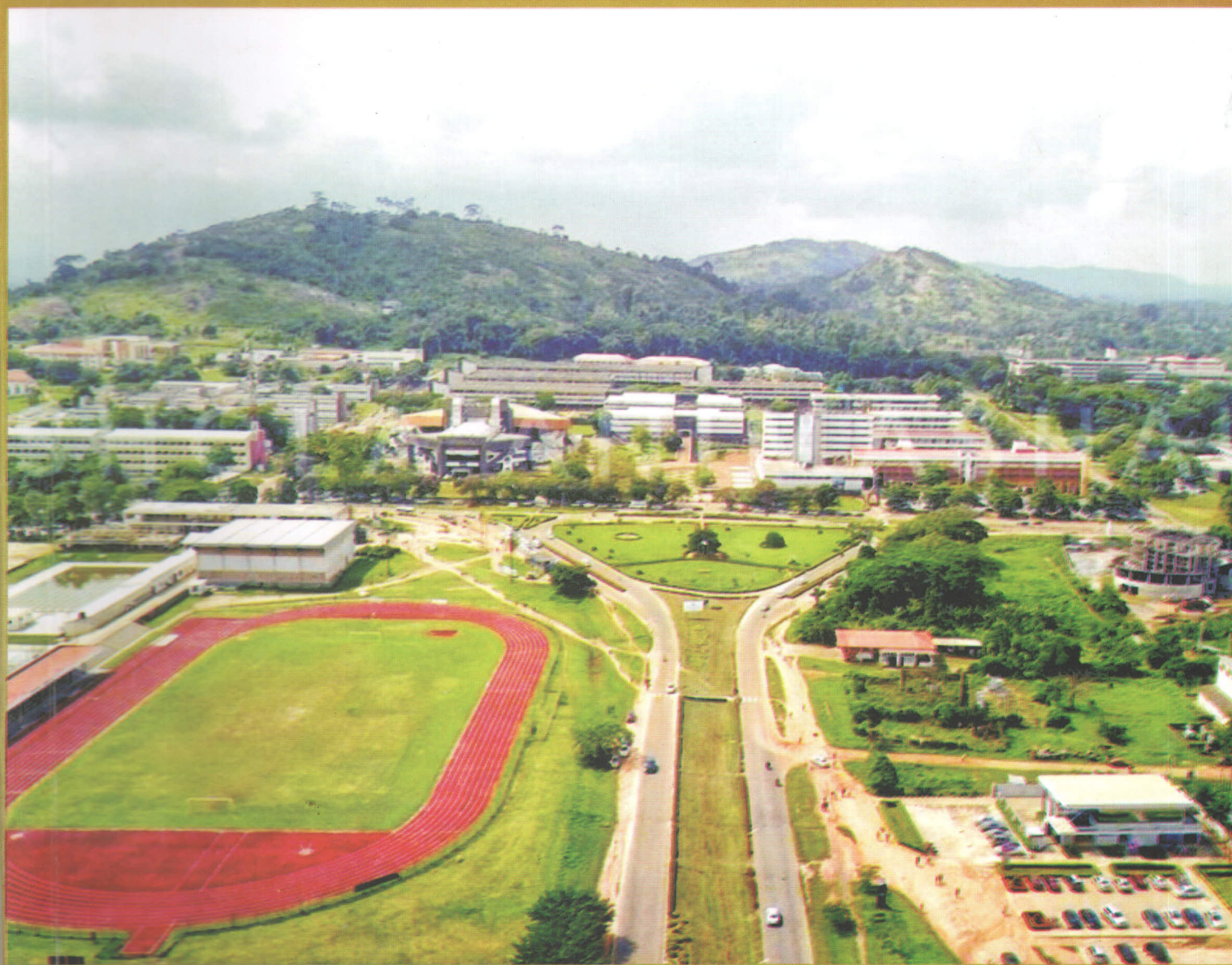




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PROMOTING SUSTAINABLE WASTE MANAGEMENT ON CONSTRUCTION SITES IN NIGERIA

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ABSTRACT

Construction activities generate an enormous amount of material waste and it is therefore essential that waste management is given due consideration. The problem of material wastage on construction sites is not only uneconomical but also an environmental concern. This paper addressed the study of materials waste generation on construction sites in Kwara state, Nigeria. Causes and wastage levels of construction materials were identified and investigated. The target population comprises contacting organizations. Primary data was obtained using structured questionnaires, interviews and site visits. Respondents were requested to rate the 25 variables identified from literature review. A total of sixty-five (65) questionnaires were returned and found useful out of one hundred and twenty (120) questionnaires that were administered to contractors and site operatives amounts to a return rate of 54.17%. The relative contribution index method (RCI) was used to analyze the respondents' perceptions of the level of contributions of the identified factors to material waste generation on sites. The research analyses revealed that incorrect estimated quantity is the highest contributor to waste generation with RCI of 0.765. Wrong handling of material is adjudged the second with RCI of 0.743. Inadequate supervision, impossibility to order small quantities and waste from uneconomical shapes are ascribed the third, fourth and fifth factors with RCI of 0.728, 0.713 and 0.708 respectively. The findings revealed that there was no significant difference between the perceptions of contractors and site operatives and there was no location effect in the level of contribution of the assessed factors to material waste generation as perceived by the respondents from different locality with a p-value of 0.469 with all the factors being scored with relative contribution index greater than 0.600. In view of the findings, this study recommends that contractors and other stakeholders on construction sites should jointly consider the use of waste minimization strategies by purchasing exact quantities of materials required. Trained personnel for monitoring and supervising the flow and handling of materials should be employed on every construction sites.

Keywords: Construction sites, Contractors, Kwara State, Material handling, Material waste

1. Introduction

Material waste is considered as one of the most important problems on construction sites especially in developing countries (Adewuyi, Idoro and Ikpo, 2014). Some degrees of waste materials are inevitable in the construction process. This problem has negatively affected the performance of many construction projects in Nigeria (Jayamathan and Rameezdeen, 2014). Every type of construction project is accompanied by enormous heaps of construction waste causing huge impact to the environment. All estimators

allow wastage factors in pricing a bill of quantities. Over the years, experience has shown, however, that unless site management control is tight, wastage can frequently exceed, often by a large margin, than the figure allowed in the tender document (Wahab and Lawal, 2011). Furthermore, Adewuyi, Idoro and Ikpo (2014) revealed that the levels of material wastes generated on site are in excess of estimator's allowance for some materials studied.

Construction material contributes significantly to the cost of construction project

(Koushki and Kartam, 2004). Therefore, material wastage has adverse impact on construction cost, contractor's profit margin, construction duration and can be a possible source of dispute among parties to a project (Akanni, 2007; Adewuyi and Odesola, 2015). Hoe (2005) stated that the extent to which waste can be prevented in the construction industry has been a long-debated issue. Whereas it is impossible to completely eliminate all wastage, the concern should be how practices in the local industry can be managed to minimize waste. The cost reduction achieved by preventing the generation of construction waste is equally of direct benefit to all stakeholders on a construction project.

It therefore follows that wastage of materials will lead to increase in total cost of building project. This assertion is supported by Adebisi and Bako (2015) who opined that building material wastage on construction sites contributes to cost overruns. This implies that in-depth review, identification of causative factors of waste, assessment of these factors and any improvement in material wastage management on construction sites will enhance the cost performance of projects in Nigeria. It was estimated from a study carried out by Adewuyi (2012), up to 1-10% of the purchased construction materials leave the sites as a waste. Al-Moghany (2006) found from a study in Gaza strip that the materials loss resulting from direct and indirect wastes were about 3.6 -11 %, which significantly higher than the values that were normally allowed (2-4.5%). In Nigeria, a recent research indicated that at least 10% of all raw materials delivered to most sites are wasted through damage, loss and over – ordering (Adebisi and Bako, 2015).

2. Literature review

There have been different definitions of construction material waste by different authors. For the purpose of this study, construction material wastage can be defined 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 (Shen, Tam and Tam, 2002). Singh (2015) described construction waste as the difference between the quantities of materials used in a project to that purchased. Furthermore, construction waste, according to Idris, Sani and Abubakar (2015) is the by-product generated and removed from construction, renovation and demolition or sites of construction and civil engineering works. According to Sridhar (2014) waste is regarded as any materials resulting from any activity or industrial operation for which there is no economic demand and which must be disposed of. However, Adewuyi and Odesola, (2015) see waste as left-over from production and consumption activities. Waste does not altogether apply to worthless substance but regarded as damage, defective or superfluous materials which in some cases may pose hazard, or something the owner no longer has a current or perceived use for.

According to Wahab and Lawal (2011), the construction waste is a growing problem in many countries. If the life cycle of the materials on construction sites, from transportation and delivery to the end fate is closely examined, it is generally known that there is a relatively large portion of the materials being wasted. Previous studies from various countries have confirmed that waste represents relatively larger percentage of production. According to the US Green Building Council (2001),

Construction waste accounts for up to 30% of total waste output in the United States alone, put at

about 136 million tons per annum. Ferguson, Kermode, Nash, Sketch and Huxford (1995) stated that over 50% of the waste in a typical United Kingdom landfill could be construction waste. Craven, Okraglik and Eilenberg (1994) reported that construction activity generates 20 to 30% of all waste deposited in Australian landfills. Serpell and Labra (2003) reported that of the 3.5 million tons of construction waste generated in Chile, only 10% is placed in authorized and controlled landfill sites. In the European Union, it is estimated that 0.5 to 1 ton per capital of construction waste is generated annually. At the project and corporate levels, material waste implies loss of profit and competitiveness for the contractor. Wastage may also lead to delays that cause costly idle time for other resources (Wahab and Lawal, 2011).

Tam et al. (2007) in another study in the United Kingdom reported an additional cost of 15% to construction project cost overruns as a result of material wastage. Bossink and Brouwers (1996) stated that material wastage accounts for between 20-30% project cost overruns. It is therefore glaring that the economic losses from construction material waste could pose a great threat to the economic growth of a nation.

In Nigeria, little consideration has been paid to the control of generation of construction waste in the last decade. This can be attributed to the availability of relatively low means of waste disposal and the generally, low environmental awareness of the construction industry wastes in the country. The construction industry in Nigeria, despite being a major generation of considerable waste, has been slow to embrace environmental friendly practices.

2.1 Construction Waste Generation

Waste normally emanates during different stages of construction (Adewuyi 2012). Waste can be classified according to its origin, i.e. the main root. Here, there are two main kinds of construction waste, structure waste and finishing waste (Bossink and Brouwers, 1996). Concrete fragment, reinforcement bars, abandoned timber plate and pieces are generated as structure waste during the course of construction. A great amount of concrete waste due to excessive material mixing, broken formwork and redoing due to poor concrete placement (De Souza, Agopyan and Paliari, 2004). Timber possesses a number of advantages that make it a popular construction material. It is relatively inexpensive, light in weight and with a high load bearing capacity. It is also pliable and can be readily cut that it can be shaped for producing and distinct forms of concrete elements. However its relatively low durability and reusability make it a material of high wastage. It was found that the majority of timber waste was generated from formwork with a smaller quantity resulted from cutting timber for internal finishings and fittings. In the case of formwork, most of the timber materials delivered to site would eventually be discarded as waste (100% wastage) after several reuses. Blocks/bricks are likely to be wasted at all the stages of the construction process, starting from the transportation to the completion of laying work on the site. Loss during loading and unloading, damage block during storage and laying due to over-stacking and poor products were all possible causes of wastes. There were even cases of over ordering that rendered the excess blocks/bricks to be waste (Dania, Kehinde and Bala, 2007).

Finishing waste, for instance, surplus cement mortar arising from screeding scatters over the floors

inside the building, broken raw materials like mosaic, tiles, ceramics, paints and plastering materials are generated during the finishing stage of a building. The production of plastering waste was primarily due to excessive mixing/left over of mixed plaster and lost during applying. Tiles were mainly lost during normal cutting, transportation, loading and unloading. Breakage also accounted for some of the wastage especially when some of the tiles were not properly stored. The packaging of household facilities such as bathtubs, water closets, window frames are also parts of the finishing wastes.

Ekanayake and Ofori (2000) examined and discussed 27 factors as causes of construction waste. According to Poon, Yu and Ng (2001), research in Hong Kong indicates that there are 13 factors that cause material waste in construction. Garas, Anis and El Gammel (2001) considered 10 important factors in the generation of construction waste in Egyptian construction industry. Alwi, Hampson and Mohamed (2002) and Formoso, Soibelman, Cesare and Isatto (2002) considered 31 and 11 factors respectively in their studies of causes of waste in construction. Polat and Ballard (2004) assessed 14 factors in his study to identify the main causes of material waste in the Turkish construction industry. Al-Moghany (2006) appraised 92 factors which cause material and time waste in construction in Gaza Strip. Adewuyi and Odesola (2015) measured and evaluated the causes of construction material waste using a large number of construction phase related factors such as design and documentation, materials procurement and management, operations, environmental conditions, site management practices and site supervision.

Most of the available literature mix up or combined the factors affecting material waste with those affecting time waste. Therefore, this study

scrutinised the available literature meticulously and extracted twenty-five (25) factors responsible for generation of material wastes on construction sites.

2.2 Construction Waste Management Strategy

The practice of waste management for construction activities has been promoted with the aim of protecting the environment and the recognition that wastes from construction works contribute significantly to the polluted environment (Dania *et al.*, 2007). This increasing awareness of environmental impacts from construction wastes has led to the development of waste management strategy as an important function of construction project management. The process of managing construction waste goes far beyond the disposal of the wastes itself. It is an all-encompassing strategy to effectively utilize construction resources, with the view to reducing the quantity of waste and also utilizing the generated waste in the most effective manner.

The strategy to manage construction material waste according to Adewuyi and Odesola (2015) comprises of three major tasks: reduce, reuse and recycle waste produced which are referred to as the three Rs of construction waste management. According to Dania *et al.*, (2007) there are two fundamental reasons for reducing, reusing and recycling waste: the economic advantages, and the environmental advantages. The environmental advantages include the minimization of the risk of immediate and future environmental pollution and harm to human health while the economic advantages include lower project costs, increased business patronage, lower risk of litigation regarding wastes amongst others.

2.2.1 Reduce

According to the study of Akanni (2007), elimination of waste on construction sites is not

completely possible. The study therefore recommended waste management practise and system to be explored. In Nigeria, not all the materials procured are used during construction and this indicates that the left-overs may remain as waste that may not be accounted for. Therefore, a critical control of materials on site should be adopted. Materials wastage on site cannot be treated fully without materials control (Adewuyi *et al.*, 2014). Decisions taken at the initial stage of any project are capable of increasing waste level. Design is the first stage of the project that material control can be exerted. There are always cases that the design specifications do not agree with the practice material dimensions causing large amounts of off-cuts during construction. If detailed technical information about the construction materials or construction process can be taken account by the designers, a significant amount of waste can be avoided.

2.2.2 Reuse

When properly sorted, material such as clean concrete and asphalt can be recycled for use in construction. Public fill included substances such as debris, rubble, earth and concrete which are suitable for land reclamation and site formation and large proportion of the public fill can be reused (Adewuyi *et al.*, 2014).

2.2.2 Recycle

Building materials waste is not easy to recycle due to high levels of contamination and a large degree of heterogeneity (Lawson and Douglas, 2001). Recycling of construction waste involves the sequence of activities, including collection and separation of construction waste generated from construction projects and transforming them into secondary materials for construction use. The further use of waste materials in their original form after

repairing or modification and thus avoid material waste, save raw material purchase and reduce waste transportation cost.

3. Methodology

The target population comprises contracting organizations within Kwara State, Nigeria. Primary data was obtained using structured questionnaires, interviews and site visits. The questionnaire was structured and divided into two categories: the first category was designed to get information about personal data of the respondents such as education, profession, roles and year of experience in construction industry. The second set of questions was designed with the purpose of establishing the most important factors that contribute to construction material waste generation on a five-point Likert scale namely: nil, low, moderate, high and very high. Respondents were therefore requested to rate each of the 25 variables identified from literature review. Respondents were also requested to state and rate other factors considered not included in the questionnaire that affects and contribute to construction material waste generation on construction sites in the study area. One hundred and twenty (120) questionnaires were administered to contractors and site operatives through convenience and snowballing sampling.

The reliability and validity of the questionnaire is based on the use of measurement scale to assess the causes of construction waste, and a total of sixty-five (65) questionnaires were returned and found useful which amounts to a return rate of 54.17%. Personal interviews were conducted to complement the questionnaires administered to the respondents. The interviews were conducted among construction site personnel namely brick

layer/plasterer; carpenter/joiner; roofer; painter/decorator; welder; electrician; plumber; glazier and foremen by covering issues related to the construction waste management strategy: waste handling methods, waste reduction measures, extent of re-use and likely suggestions to avoid or minimize waste.

The relative contribution index method (RCI) was used to analyze the respondents' perceptions of the level of contributions of the identified factors to material waste generation on sites. The RCI was computed as shown in the following equation:

$$\text{Relative Contribution Index (RCI)} = \frac{\sum W}{A * N}$$

where:

W is the weight given to each factor by the respondents and ranges from 1 to 5;

A is the highest weight = 5; and

N is the total number of respondents.

The questionnaire was validated by the criterion-related reliability test which measures the Cronbach's alpha coefficient (which ranges from 0.792 to 0.977) between the factors affecting the generation of waste on construction sites using statistical inference validity and external validity test. Two hypotheses derived were posited for the study as follows:

H₁: There is no significant degree of agreement between the perceptions of contractors and site operatives.

H₂: There is no significant variation among the contributions of the factors to material waste in different locality.

To determine the significant difference between the perceptions of the two groups of

respondents, Mann-Whitney U test is used while the variation among the perceptions of contractors and site operatives across the cities selected in the state for the study is tested with the use of Kruskal-Wallis test at $p \geq 0.05$ (95% level of significance). The rule for the rejection of the hypothesis is that when the p-value > 0.05, the test fails to reject the hypothesis, however, when the p-value ≤ 0.05, the test rejects the hypothesis.

4. Results and Discussion

Out of sixty-five (65) questionnaires that were returned, 38% of the respondents were contractors while 62% were site operatives. The years of construction experience of the respondents are 1-5 years (11%); 6-10 years (6%); 11 – 15 years (28%); 16 – 20 years (33%); and 20 years and above (22%). In summary, about 83% of the respondents have more than 10 years construction experience. This observation suggests that the data collected from these respondents are reliable.

The RCI and rank of factors contributing to construction material waste is presented in Table 1. The research analyses revealed as perceived by contractors and site operatives that incorrect estimated quantity is the highest contributor to waste generation with RCI of 0.765. This could be as a result of non-involvement of professionals in purchase of materials on construction sites or where one purchasing department is authorized and made responsible to make all types of purchases for all the departments. Ekanayake and Ofori (2000) described the factor as ordering errors (too much or too little). Al-Moghany (2006) also found the same factor among the factors generating waste on construction sites.

Table 1: Relative contributions of factors affecting material waste on site

S/N	Factors	RCI	Rank
1.	Design changes	0.662	16
2.	Site conditions	0.639	23
3.	Ignorance about types and sizes of materials on design documents	0.641	22
4.	Ambiguities, mistakes, and changes in specifications	0.685	10
5.	Errors and incomplete contract documents	0.647	20
6.	Incorrect estimated quantity	0.765	1
7.	Impossibility to order small quantities	0.713	4
8.	Purchase of materials contrary to specification	0.654	18
9.	Waste from uneconomical shapes	0.708	5
10.	Damage of materials on site	0.675	13
11.	Wrong handling of materials	0.743	2
12.	Overproduction	0.679	12
13.	Manufacturing defects	0.659	17
14.	Poor and wrong storage of materials	0.683	11
15.	Poor quality of materials	0.688	9
16.	Government authority instruction/policy	0.622	25
17.	Damage during transportation	0.644	21
18.	Poor workmanship	0.671	14
19.	Lack of coordination among crews	0.638	24
20.	Severe weather conditions	0.695	7
21.	Ambiguities, mistakes, and inconsistencies in drawings	0.693	8
22.	Ordering of materials that do not fulfill project requirements	0.701	6
23.	Incompetent technical staff	0.669	15
24.	Lack of strategy to waste minimization	0.651	19
25.	Inadequate supervision	0.728	3

Wrong handling of material is adjudged the second highest contributor to waste generation by the respondents with RCI of 0.743. If a construction site is not manned by professionals who understand practices of material handling, materials may be poorly stored, double handling of materials may be prevalent, and material planning may not be given due attention. Transportation and handling of materials, being mostly manual among the categories of small and medium size construction firms as reported by Adewuyi and Odesola, (2015) may result to material wastage.

Inadequate supervision, impossibility to order small quantities and waste from uneconomical shapes are ascribed the third, fourth and fifth factors with RCI of 0.728, 0.713 and 0.708 respectively. The result suggests that the respondents are of the opinion that with improvement on quality of supervision on

site, and capable supervisors, the volume of material waste may be reduced. Impossibility to order small quantities may be significant in situations where materials are supplied in bulk like fine and coarse aggregates but the quantity of job to be executed is small. This may as well be applicable to purpose-made or imported materials which were procured in excess of quantities required in anticipation of preventing short supply, unavailability or reduction of associated costs in the event of insufficiency. The left over may lead to waste where it cannot be transferred to other project nor resold.

It is observed that irregular shapes of design to achieve aesthetic appreciation of buildings are given more attention nowadays by both clients and designers and conformance to this demand may lead to excessive cutting waste. This type of waste is commonly found in timber, blocks, tiles and other

materials supplied in sheets. The phenomenon of excessive waste from cutting uneconomical shapes has been reported by several authors (Polat and Ballard, 2004; Al-Moghany, 2006; Adewuyi, 2012; Adewuyi and Odesola, 2015)

The site visit revealed that the construction activities were closely related to the amount of waste generated (Table 2). Timber formwork was the major contributor to construction waste, accounting for 30% of all waste identified on sites. The wet trade of finishing work such as screeding, plastering and tile laying collectively were identified as the second major waste generator, at 23%. Concrete work and masonry work were third and fourth, each accounting for 15%. Over purchases was the fifth most significant, at 12%. This gives a good indication of the site activities need to be focused on in order to reduce building waste.

Table 2: Average Percentage Wastage of Various Trades on construction sites

Trade	Average Percentage waste
Formwork	30%
Floor and wall finishing	23%
Concrete	15%
Masonry	15%
Over purchases	12%
Reinforcement	5%

4.1 Degree of Agreement between Respondents Groups

To explain whether there is significant difference in the perceptions of the two groups (contractors and site operatives), Mann-Whitney U test is used at $p \geq 0.05$ (95% level of significance) as a measure to test hypothesis one, H_1 . Hypothesis one states that there is no statistical significant degree of agreement between the perceptions of contractors and

site operatives. The rule for the rejection of the hypothesis is that when the p -value > 0.05 , the test fails to reject the hypothesis, however, when the p -value ≤ 0.05 , the test rejects the hypothesis. For all the factors, the p -values are greater than 0.05 (0.142 – 0.681); indicating that there is no significant difference between the perceptions of the two groups of respondents. Hence hypothesis one, H_1 , is accepted and conclusion is drawn that there is no significant difference between the perceptions of contractors and site operatives.

4.2 Degree of Variation among Respondents from Different Locality

To establish if there is location effect on the contributions of the factors to material waste generation; hypothesis two (H_2), which states that there is no significant variation among the contributions of the factors to material waste in different locality, was tested with the use of Kruskal-Wallis test at $p \geq 0.05$. The test reveals that there is no significant variation in the contributions of the identified factors to material waste as perceived by both the contractors and site operatives in different locality; hence, hypothesis two was accepted. It follows therefore that location has no effect on the contributions of the identified factors to material waste generation on site.

5. Conclusion

Several factors contribute to generation of construction material waste. This study provided evidence on the level of contribution of each of 25 factors to material wastage in Nigerian construction industry. Notable among the most important factors are: incorrect estimated quantity; wrong handling of material; inadequate supervision; impossibility to

order small quantities and waste from uneconomical shapes. This study reveals that there is no significant difference between the perceptions of contractors and site operatives about factors contributing to waste generation. Furthermore, the assessment of the factors shows that there is no variation among the different locations within the state where the perceptions of contractors and site operatives were sought with respect to their contributions to material wastage as reflected by the results of Kruskal-Wallis tests. It is noticed that all the factors were scored with $RCI > 0.600$; indicating that all the factors are important. Hence, it is concluded that material waste generation is a critical and complex issue in the Nigerian construction industry.

In view of the findings, this study recommends that contractors and other stakeholders on construction sites should jointly consider the use of waste minimization strategies to reduce the level of waste generated on site by purchasing exact quantities of materials required.

Trained personnel for monitoring and supervising the flow of materials should be employed on every construction sites. Training programme should be provided by contractors for the operatives about the proper handling, storage and transportation of materials on site.

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