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ASSESSING THE CAUSES OF MATERIAL WASTAGE AS IT AFFECTS VARIOUS BUILDING MATERIALS ON NIGERIAN CONSTRUCTION SITES

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There is an increase in quantity of waste being generated by construction activities and this has caused major concern for the construction industry. An ineffective planning and control of materials on site could lead to poor performance and undesirable project outcomes which in turn affects the overall cost of a project. Previous researchers have tried to study the most wasteful material on building construction site and also established general causes of material wastage. However, no attempt has been made to bring a synergy between the causes of waste and the type of materials been wasted. Hence, this paper aimed at studying the causes of material wastage as it affects each building construction material used on site with a view to having an effective cost control. A quantitative approach involving the use of a structured questionnaire was used to collect data on a five (5) point Likert scale of 1- strongly disagree to 5- strongly agree. Responses from the administered questionnaire were collated, interpreted and analyzed using descriptive statistics and results presented in tables. Results indicated that poor handling of materials is the major factor resulting to materials wasted during timber formwork, concrete works and ceramic/vitrified tiling works with mean value of 4.46, 3.74 and 3.64 respectively. Furthermore, poor supervision of operatives is the major factor causing material wastage in POP works and mortar for rendering with mean value of 3.87 and 3.85 respectively. Poor handling of materials, poor supervision of operatives and misuse of materials are the major causes of waste on construction sites irrespective of the building materials involved. These factors could result to cost overrun and undesirable project outcomes. Therefore, proper material handling and high level of supervision should be given consideration when using timber, concrete, ceramic tiles, plaster of paris (POP) and mortar in construction sites. The study has affirmed the need for studies to focus on developing viable strategies/techniques that would bring about improvements in material handling when using timber, concrete and ceramic tiles in construction sites.

Keywords: building materials, construction sites, plaster of Paris (POP), project, wastage

INTRODUCTION

Waste is defined as any unskillfulness resulting from lack of efficiency that results in the use of equipment's, materials, labour, or capital in larger quantities than those considered as necessary in the production of a building, in other words waste

is any losses produced by activities that generate direct or indirect costs but do not add any value to the product (Apte, 2012).

Odesola and Adewuyi (2015) view construction waste as construction Materials that are lost in transit on or off site, discarded without adding value to the project for which it was procured including over production or left over from newly constructed facility. A simple way to define waste according to Oladiran and Joseph (2009) is that which can be eliminated without reducing customer value, it can be activities resources or rule.

Rapid growth in construction activities as a result of increasing population and urbanization in many parts of the world generates a large amount of waste in construction. To minimize and effectively manage these wastes, a detailed understanding of the causal factors is required. (Luangcharoenrat et al., 2019).

Odesola and Adewuyi (2015) emphasized that the increasing quantities of waste have created a bad image for the construction industry, in addition, an ineffective planning and control of materials on sites could lead to poor performance and undesirable project outcomes.

According to Enshassi (2009) construction materials is the major cost of construction project; 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.

Materials constitutes a major cost component in any construction project, the entire cost of installed material may be 60% or more of the total cost of a project, so for a contractor to have more profit and to complete project on time there must be need to minimize waste to a minimal level. Waste on site can only be minimized but can never be eliminated completely (Aditya and Sabihuddin, 2015).

Ayodele and Alabi (2014) defined cost control as all methods of controlling the cost of building and civil engineering projects within the limits of a predetermined sum throughout the design and construction stages. Studies from different parts of the world has shown that material waste from the construction industry represents a relatively large percentage of the production cost.

Consequently, the poor management of materials and waste leads to an increase in the total cost of building projects (Ameh and Itodo, 2013).

Material wastage has become a serious problem and requires urgent attention in the Nigerian construction industry. The constraints negatively affects the delivery of many projects (Adewuyi and Otali, 2013). Ping, Omran and Pakir (2009) also observed that extra construction materials are usually purchased, due to the material wastage during the construction process.

(Chu, 2004; Formoso et al, 2002; Tam, Shen and Tam, 2007; Gihan, Ahmed and Adel, 2010) in their research have all tried to identify the percentage contribution of various construction material to waste on site. However in a more recent development Ameh and Itodo (2013) investigated building materials involved in waste and came up with the most wasteful ones where plastering/rendering topped the list.

In a separate development (Oladiran 2009; Otim, Nakacwa and Kyakula, 2011; Abdulazeez, 2000; Apte, 2012; Aditya and Sabihuddin, 2015) all tried to identify the causes of waste in construction sites.

However, based on literature search no research so far have tried to bring a synergy between the various types of building materials leading to waste and their causes. Hence the need to review the causes of material wastage as it affect various building materials on construction sites.

The objectives of this research are therefore to identify the causes of materials wastage on construction site and determine the effect of these causes on various building materials with a view to identifying the major causes of waste on varying building materials. For the purpose of this study, only building materials that had being previously identified by researchers as major waste contributors were considered. The impact of causes of waste on project cost was not considered in the study. The study could not consider construction professionals in all the states in Nigeria however, Abuja being the construction hub of the country was used.

LITERATURE REVIEW

Material wastage on construction site

According to Napier (2012), waste in construction occurs in various construction stages ranging from foundation works to finishing and they emanate from wooden materials, concrete, gravels, aggregate, masonry, metals, plastics, plumbing and electrical fixtures, glass and materials handling. A more recent study in the United State between (2009-2010) from the processing of 20,000 tons of construction and demolition waste identified the following percentage wastage of some building materials; wood 30%, concrete 5%, gravels, aggregate and fines, 20%, dry wall 3%, asphalt roofing 5%, ferrous and non-ferrous metals 9%, plastic 1%, cardboard and paper 3% and disposal as refuse 5%. Although the study concluded that the predominant waste stream in the United States comes from wood, wood however presents a high potential for reuse in construction and in other industry such as manufacturing. The US government in its effort to reduce the impact of building material waste on the environment has implemented the green rating criteria for all building project to further improve the environment performance (Amatruda, 2010).

According to Dania et al (2007), waste can never be eliminated but can be reduce to a minimum level, waste on construction site occurs whether directly or indirectly depending on the construction process. Waste occur at all stages of construction process right from design and documentation, excavation, renovation, refurbishment, ordering of materials, materials handling on site, up to the process of fixing. It has been observed that the construction industry remains a major economic sector, but the pollution generated from construction activities continuously present a major challenge to environmental management (Tam et al, 2007).

Abdul-azeez (2000) said there is a considerable waste allowance which is usually included when pricing, some material waste may occur under ideal conditions of production, but on many sites the waste of materials is far in excess of negligible

waste. He further stated that waste do occur in many ways but can be categorized into direct and indirect types, the most common materials being wasted on site are cement, reinforcement, timber, aggregate, bricks and blocks etc.

Review of building materials where wastage are predominant

Chu (2004) in a study in Hong Kong identified the percentage contribution of various construction materials to waste on site. These include mortar from plastering/screening 15%, concrete 4%, block work 4%, and packaging 5%. Wastage in concrete also occur as a result of failure in formwork and means of transportation. Non adherence to mix design can also contribute to wastage in concrete (Formoso et al, 2002). Tam et al (2007) noted that the cause of wastage in timber formwork is due to natural deterioration and waste from cutting. The wastage level in timber formwork can be as high as 20% in foundation works. The wastage level of timber formwork in foundation could be due to the wet nature of most foundation works, which encourage the deterioration of timber, it is worthy of note that both dry and wet weather has effects on timber formwork. The study also identified the building materials with low level of wastage are made from steel. This could be due to their durability and ease of re-use over time. This point is from a study from Egypt by Gihan, Ahmed and Abdel (2010) which reveal that steel reinforcement has low percentage of wastage of about 5% compared to 20% for sand in their study.

A study by Ameh and Itodo (2013) sought to know the most wasteful material during building construction activities on sites. The results reveals that out of 14 most frequently used building materials investigated, mortar from plastering /rendering top the list of most wasteful material. This was followed by timber formworks which is 2nd, sandcrete blocks comes 3rd and then concrete is 4th on the list and ceramics /vitrified tiles in that order. The results also revealed building materials that have low wastage level during construction activities on sites. These are steel formwork, long span aluminium roofing sheet, iron bar, paint and fibre cement roofing sheet. The findings reported in this study tends to support the outcome of earlier studies that the most wasteful building material on construction sites is mortar from plastering/rendering (Formoso et al, 2002). The study also attributed the high wastage level in mortar from plastering/rendering to lack of modular coordination in the structural elements and deviation from the actual design. This implied that more mortar will be used on such elements such as beams and column that have deviated from the initial design. Excessive mortar could also be used in block work joints if the blocks are not uniform in their sizes.

Another study by Bekr (2014) reveals quantitative assessment of wastage to 10 selected building materials due to cutting, transit, theft and vandalism, and application. The results indicate that sand has the highest percentage of waste of about 21% followed by aggregate with wastage of about 20.7%, PVC water pipes have 19.6% and similar results for timber formworks. On the other hands, facing stones had the least percentage wastage of 15.14%.

Causes of material waste on construction sites

Waste occurrences on sites are diverse but the most common waste in construction projects are materials. The consequences of materials waste are enormous because

materials account for about 50% to 60% of construction cost and they are scarce resources (Oladiran, 2009).

According to Otim et al (2011) the causes of material wastages on sites were found to include; poor supervision of operatives, poor handling of materials, misuse of materials, poor storage and stacking of materials, delivery of excess materials on site, poor site organization, late delivery of materials, poor coordination of management and technical side, poor time management, bad weather conditions and use of unskilled operatives. Construction material waste could also arises from design, logistics, and physical construction processes (Fadiya et al., 2014).

Some other researchers also identified some causes of material wastage which formed part of the review, these were however brought together and tabulated as shown in Table 1.

Table 1: A comprehensive summary of the causes of waste

Causes of Waste	Authors
Poor supervision of operatives	Oladiran, 2009; Otim, Nakacwa and Kyakula, 2011.
Poor handling of materials	Abdul-Azeez, 2000; Apte, 2012; Otim, Nakacwa and Kyakula, 2011.
Misuse of materials	Oladiran, 2009; Otim, Nakacwa and Kyakula, 2011.
Poor storage and stacking of materials	Abdul-Azeez, 2000; Aditya and Sabihuddin, 2015; Otim, Nakacwa and Kyakula, 2011.
Delivery of excess materials on site	Apte, 2012; Otim, Nakacwa and Kyakula, 2011.
Poor site organization	Abdul-Azeez, 2000; Otim, Nakacwa and Kyakula, 2011.
Late delivery of materials	Apte, 2012; Otim, Nakacwa and Kyakula, 2011.
Poor coordination of management and technical side	Otim, Nakacwa and Kyakula, 2011.
Poor time management	Otim, Nakacwa and Kyakula, 2011.
Bad weather conditions	Otim, Nakacwa and Kyakula, 2011.

METHODOLOGY

The study looks at causes of materials wastage at it affects various building materials. This requires eliciting knowledge from construction professionals who are directly involved in any construction project, in this case Architects, Builders, Quantity Surveyors and Engineers. Hence a quantitative research approach involving the use of a structured questionnaire was used to collect data on a five (5) point Likert scale of 1- strongly disagree to 5- strongly agree. Population size for the research is unknown as no data was available on the precise number of these construction professionals currently practicing in Abuja. This location was chosen as it is well known for its high rate of construction activities owing to the fact that it is the Federal Capital Territory of Nigeria. The sample size was therefore determined from a table developed by Louangrath (2014) that the minimum sample size for an unknown population at 95% confidence level with 5% allowable error is approximately 34. A total of 52 questionnaire was distributed amongst the construction professionals in Abuja using purposive sampling techniques. The sampling technique allowed the researcher to choose respondents from large construction firms who are perceived to have handled large construction projects and gotten requisite experience. A total of 39 respondents representing 75% of the

questionnaire distributed and exceeding the determined sample size were analyzed using descriptive statistics (mean) and results presented in tables.

RESULTS

Summary of background information of respondents

This section presents the personal details of the respondent to include; their profession, level of education and years of experience.

Table 2: Respondents profile

Items	Frequency (NO)	Percentage (%)
Profession		
Architects	8	20.5
Builders	9	23.1
Quantity Surveyors	14	35.9
Engineers	8	20.5
Total	39	100
Level of Education		
HND	16	41.0
Bachelor's Degree	12	30.8
Master's Degree	9	23.1
Doctorate's degree	2	5.1
Total	39	100
Years of Experience		
0-5 years	4	10.3
6-10 years	10	25.6
11-15 years	19	48.7
16-20 years	6	15.4
20 and above	0	0
Total	39	100

Table 2 indicates that all categories of respondents represented had at least 20% representation each with Quantity Surveyors having a higher representation of 35.9%. Architects and Engineers are having the least representation of 20.5% each. A cumulative of 71.8% of the respondents have at least a bachelor's degree. Table 4.2 also shows that 10.3% of the respondents had between 0-5 years of experience. A cumulative of 89.7% of the respondents have at least 6 years of experience working on construction projects and would therefore be able to make correct and valid judgment.

Causes of material waste as it affects building materials

The causes of wastage for each building material were scored by respondents based on a five Point Likert Scale of 1-stongly disagree to 5-stongly agree. Mean values were determined and standard deviation also determined to rank the causes that had the same mean values as shown in Table 3, 4, 5 and 6.

From Table 3, poor handling of materials was consistently agreed as the major factor leading to wastage when using materials such as timber, concrete and

ceramic/vitrified tiles in construction sites with a mean values of 4.46, 3.71 and 3.64 respectively.

Table 3: Causes of wastage on timber for formwork, concrete and ceramic/vitrified tiles.

	Building materials							
	Timber for formworks			Concrete			Ceramic tiles	
Causes of material wastage	Mean score	Std. Dev.	Rank	Mean score	Std. Dev.	Rank	Mean score	Rank
Poor handling of material	4.46	0.625	1st	3.74	1.117	1st	3.64	1st
Misuse of material	3.85	0.875	2nd	3.56	1.142	4th	3.62	2nd
Poor supervision of operatives	3.62	1.042	3rd	3.59	1.208	2nd	3.56	3rd
Poor storage and stacking of materials	3.62	1.091	4th	2.95	1.395	8th	3.13	8th
Poor site organization	3.54	1.448	5th	3.44	0.821	7th	3.41	5th
Bad weather condition	3.51	1.144	6th	3.49	1.211	6th	3.36	6th
Poor time management	3.49	0.885	7th	3.56	0.912	3rd	3.26	7th
Late delivery of materials	3.41	1.208	8th	2.77	1.327	10th	2.97	9th
Poor coordination of management and technical side	3.38	0.847	9th	3.49	0.885	5th	3.46	4th
Delivery of excess materials on site	2.95	1.450	10th	2.92	1.494	9th	2.77	10th

Poor time management ranked 7th in both timber and ceramic tiles with mean values of 3.49 and 3.26 respectively, however it is agreed as a major cause of waste in concrete material as it ranked 3rd with a mean value of 3.56. This has affirmed the need for proper time management whenever concrete is in use especially owing to the effect of setting time in concrete. As seen in Table 3 also, poor storage and stacking of materials is a major cause of waste when timber materials are used on construction sites by ranking 4th with a mean value of 3.62. The same cannot be said for concrete and ceramic tiles as the both ranked 8th with mean values of 2.95 and 3.13 respectively.

From Table 4, poor supervision of operatives was agreed to be the major cause of wastage in mortar and POP material with mean value of 3.85 and 3.87 respectively. This was closely followed by poor handling of material and misuse of material in both mortar and POP. Poor coordination of management and technical side is a causal factor in POP than that of mortar by ranking 4th and 7th respectively. However, poor storage and stacking of material ranked 8th and 5th in POP and mortar respectively.

Table 4: Causes of wastage on mortar from plastering/rendering and POP

	Building materials				
	Mortar from plastering/rendering			Plaster of Paris (POP)	
Causes of material wastage	Mean score	Std. Dev.	Rank	Mean score	Rank
Poor supervision of operatives	3.85	1.268	1	3.87	1
Poor handling of material	3.77	0.931	2	3.72	3
Misuse of material	3.64	1.328	3	3.85	2
Bad weather condition	3.62	0.990	4	3.41	6
Poor storage and stacking of materials	3.62	1.350	5	3.18	8
Poor site organization	3.41	0.993	6	3.67	5
Poor coordination of management and technical side	3.41	1.117	7	3.69	4
Poor time management	3.38	1.091	8	3.28	7
Late delivery of materials	3.36	1.063	9	2.85	10
Delivery of excess materials on site	3.31	1.360	10	3.08	9

Table 5: causes of wastage on sandcrete blocks and clay tiles.

	Building materials				
	Sandcrete blocks			Clay tiles	
Causes of material wastage	Mean score	Std. Dev.	Rank	Mean score	Rank
Misuse of material	3.85	0.779	1	4.51	1
Poor supervision of operatives	3.72	0.999	2	3.79	2
Poor site organization	3.41	0.785	3	3.49	5
Bad weather condition	3.41	1.117	4	3.59	4
Poor handling of material	3.38	1.206	5	3.62	3
Poor storage and stacking of materials	3.36	1.347	6	3.21	8
Poor coordination of management and technical side	3.15	0.875	7	3.28	7
Poor time management	3.05	1.191	8	3.44	6
Delivery of excess materials on site	3.05	1.450	9	2.69	10
Late delivery of materials	2.97	1.267	10	2.92	9

Table 5 shows that, misuse of material is the major cause of waste in sandcrete block and clay tile usage with a mean value of 3.85 and 4.51 respectively. Delivery of excess material and late delivery of material on site both ranked 9th and 10th as

the least waste causal factors when using sandcrete blocks and clay tiles in construction sites.

Table 6: Summary of causes of waste on various building materials.

	Building materials																	
	Cement mortar from plastering or rendering			Timber for formwork			Sandcrete Blocks			Concrete			Ceramic tiles		Clay tiles		Plaster of Paris (POP)	
Causes of material wastage	MS	SD	R	MS	SD	R	MS	SD	R	MS	SD	R	MS	R	MS	R	MS	R
Poor handling of material	3.77	0.93	2	4.46	0.63	1	3.38	1.21	5	3.74	1.12	1	3.64	1	3.62	3	3.72	3
Misuse of material	3.64	1.33	3	3.85	0.88	2	3.85	0.78	1	3.56	1.14	4	3.62	2	4.51	1	3.85	2
Poor supervision of operatives	3.85	1.27	1	3.62	1.04	3	3.72	1.00	2	3.59	1.21	2	3.56	3	3.79	2	3.87	1
Poor storage and stacking of materials	3.62	1.35	5	3.62	1.09	4	3.36	1.35	6	2.95	1.40	8	3.13	8	3.21	8	3.18	8
Poor site organization	3.41	0.99	6	3.54	1.45	5	3.41	0.79	3	3.44	0.82	7	3.41	5	3.49	5	3.67	5
Bad weather condition	3.62	0.99	4	3.51	1.14	6	3.41	1.12	4	3.49	1.21	6	3.36	6	3.59	4	3.41	6
Poor time management	3.38	1.09	8	3.49	0.89	7	3.05	1.19	8	3.56	0.91	3	3.26	7	3.44	6	3.28	7
Poor coordination of management and technical side	3.41	1.12	7	3.38	0.85	9	3.15	0.88	7	3.49	0.89	5	3.46	4	3.28	7	3.69	4
Late delivery of materials	3.36	1.06	9	3.41	1.21	8	2.97	1.27	10	2.77	1.33	10	2.97	9	2.92	9	2.85	10
Delivery of excess materials on site	3.31	1.36	10	2.95	1.45	10	3.05	1.45	9	2.92	1.49	9	2.77	10	2.69	10	3.08	9

MS=Mean Score; SD=Standard deviation; R=Rank

The study reveals that poor handling of materials is the major factor that caused material wastage when using timber for formwork, concrete and ceramic/ vitrified tiles with mean value of 4.46, 3.74 and 3.64 respectively. Poor supervision of operatives tops the list on plaster of Paris (POP) and mortar from plastering/rendering having a mean values of 3.87 and 3.85 respectively. And then misused of materials causes more wastage on clay tiles and sandcrete blocks with mean values of 4.51 and 3.85 respectively. Late delivery of materials and delivery of excess materials on site were ranked least amongst all the causes of wastage assessed, irrespective of the building materials been used on site.

CONCLUSIONS AND FURTHER STUDIES

The study concludes that the main causes of waste on construction sites irrespective of the building materials in use are poor handling of materials, poor supervision of operatives and misuse of materials. Also material handling should be prioritize to minimize wastages arising from the use of timber for formwork, concrete and ceramic/vitrified tiles in construction sites. Proper handling of

material and high level of supervision could significantly minimize the amount of waste generated when using building materials such as timber, concrete, ceramic tiles, POP and mortar thereby leading to an effective cost control in construction projects. The study has given credence to the need for studies to focus on developing viable strategies/techniques that would bring about improvements in material handling when using timber, concrete and ceramic tiles in construction sites. Researchers can now identify specific ways which proper supervision can be achieved during construction to minimize waste when mortar and POP are in use.

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