MODEL FOR PREDICTING THE QUANTITY OF PLASTER OF PARIS (POP) WASTE IN BUILDING CONSTRUCTION WORKS IN ABUJA, NIGERIA

Umar Abdulkadir[1] and Ibrahim Saidu [2]

[1]NOUN Headquarters, National Open University of Nigeria, Jabi, Abuja, Nigeria
[2]Department of Quantity Surveying, Federal University of Technology, Minna, Nigeria
Corresponding author: everlyumar2000@yahoo.com

ABSTRACT

Quantification of material waste is very important for construction waste management; accurate estimation can be completed by developing waste quantification model that is applicable for national or regional construction waste generation. Statistical data relating to the quantities of material waste for building works have not been well documented, and there is no known model for predicting the quantities of onsite material waste for different materials, such as Plaster of Paris (POP). This research aims to develop a model for predicting the volume of POP waste in building works. The population for the study consisted 555 residential(3-bedroom) construction project sites within Abuja, Nigeria. The sample frame constituted a total of twenty 3-bedroom bungalow buildings and twenty 3-bedroom duplex buildings using stratified random sampling method. The data for this research were sourced from the field investigation including measurement of the volume of the POP waste and POP used are determined by the use of tap and measuring rule on site. Linear-regression analytical tool was used for the analyses. The study revealed a statistically significant relationship exists between the variables considered in the study. The study concludes that a statistically significant relationship exists between the volume of POP waste and volume of POP used in both bungalow and duplex works with R^2 values of 52% and 33% respectively. This implies that any change in the either of the variables would lead to a corresponding change in the other variables. Based on these, the research recommends the use of these models by the building construction professionals at the early stage in order to have an idea on the likely volume of waste to be recorded, so that adjustment could be made in the areas of management and supervision of project at hand.

Keywords: Model, Nigeria, Plaster of Paris waste, regression analysis and used Plaster of Paris.

INTRODUCTION

The construction industry plays very crucial role in the socio-economic development of any country by improving the quality of life, generating employments and providing the infrastructures, such as roads, hospitals, schools, and other basic facilities (Saidu and Shakantu, 2016; Nagapan *et al.,* 2012). The industry's rapid growth is as a result of increase in standard of living, demands for infrastructure projects, changes in consumption habits and increase in population rate (Katz and Baum 2011; Begum *et al.,* 2007; Nagapan *et al.,* 2011 and Nagapan *et al.,* 2012).

On the other hand, the construction industry is a major exploiter of natural non-renewable resources and a polluter of the environment, as construction activities contribute to environmental degradation through resource depletion, land use and deterioration, power consumption, air pollution, and the generation of waste in the acquisition of raw materials (Dania *et al.,* 2007: Saidu and Shakantu 2016; Lachimpadi *et al.,* 2012).Construction waste has been identified as a global environmental problem which can have a significant impact on time, quality and sustainability, as well as the success of projects (Nagapan *et al.,* 2012; Hassan *et al.,* 2012; Saidu, 2016; Saidu *et al.,* 2017). According to the world statistics, construction and demolition debris frequently make up 10–30% of the waste received at many landfill sites around the world (Hassan *et al*., 2012). For instance, the United State (US) generates 164million tonnes of construction waste annually representing 30-40% of the country's municipal solid waste (Saidu *et al.,* 2017). Osmani (2011) argues that the European countries generate more than 450 million tonnes of construction and demolition waste every year, of which 75 percent is sent to landfills. Moreover, China alone generates 30 percent of the world's municipal solid waste of which construction and demolition waste represents 40percent of the country's municipal solid waste (Osmani, 2011; Wang *et al.,* 2014). In Malaysia, 28.34 percent of the total waste sent to landfills originates from construction activities (Begum *et al.,* 2007). material wastage has become a serious challenge all over the world, which needs immediate action in the construction industry and it has affected the completion of many projects (Adewuyi and Otali, 2013; (Saidu *et al.,* 2017).

The problem of material waste all over the continent remains unresolved in the construction industry. For instance, 10% of the materials supplied to construction sites in the United Kingdom (UK) end up as waste that may not be accounted for (Osmani, 2011). Ameh and Itodo (2013) highlighted that in Nigeria in every 100 houses built, there is sufficient waste material to build another 10 houses. The quantity of material waste generated on some construction sites is to some extent over the 5 percent allowance for material wastage in the course of preparing an estimate for a project (Adewuyi and Otali, 2013; Saidu, 2016). Thus, quantification of material waste is very in important for construction waste management, accurate estimation can be completed by developing waste quantification model that is applicable for national or regional construction waste generation (Masudi *et al.,* 2012; Saidu and Shakantu, 2017a). Material wastage on construction sites can have impact on the quantity of materials delivered/used but objective researches to provide evidence of such impact are suboptimal in construction industry (Saidu and Shakantu, 2017a). Saidu (2016) asserted that despite the fact that construction estimators allow wastage figures in pricing a bill of quantities, but experience has revealed that wastage can often exceed, by a large amount the figure allowed in the tender document, if site management is not tight. Wahab and Lawal (2011) also stated that in the Nigerian construction industry management of waste generated has received less attention in the last decade. This could be as a result of the low level or lack of proper quantification of material waste and this is evident in the amount of waste generated at construction sites; low level of awareness of the construction workers; a low level of available means of waste disposal; or the slow adoption of environmentally sustainable practices (Saidu and Shakantu, 2017b). Yuan and Shen (2011) emphasised that in past decades inadequate attention given to material-waste generation in developing countries leads to non-availability of statistical data on the quantity of material-waste generation in the construction industry. This is back up by that of Babatunde (2012), who considered that the situation is the same in the Nigerian construction industry and these are important for the building practitioners to properly managed their disposal thereof.

The statistical data relating the quantities of material waste for different projects have not been properly documented in the construction industry (Saidu, 2016; Saidu and Shakantu, 2017b). There is no known model for predicting the quantities of onsite material waste for different materials, such as POP and so forth; and also, statistics on the waste generated are minimal in the Nigerian Construction industry (Babatunde, 2012). Adewuyi and Otali (2013) contended that despite the 5% allowance made to take care of material waste when preparing estimate for project is usually inadequate because waste is seen in many ways in construction project in Nigeria. Katz and Baum (2011) developed a model that can help site managers in discovered the quantities of waste take away from the site, thus supplying clear sign of any un usual wastage that happen in the process of carrying out the work. Jingkuang *et al*. (2012) also developed model for the quantification of construction waste volume that enhance management level in the industry, as well as to minimized the waste generation in the construction process. Saidu and Shakantu (2017b) however, developed model for suggesting the volume of material waste in lump sum. The main problem of this study is that there is no known research-based evidence or any existing model for predicting the quantities of material waste separately. Because most existing models predict the quantities of material waste in lump, without making allowance for segregation and this has become a major problem to estimators and building professionals. Research evidence has shown that previous studies from different parts of Nigeria centered mostly on waste and waste-management practices in the construction industry; as well as the necessary tools, and techniques for their management. Nonetheless, these studies have failed to develop a model for predicting material waste in building construction works. Hence, this research seeks to develop model for predicting the volume of plaster of paris (POP) waste in building works. To achieve this aim, null hypothesis was set as: there is no statistically significant relationship between the volume of POP material to be used and the volume of POP waste recorded.

LIETERATURE REVIEW

Construction Waste in Building Construction Industry

The construction industry can be defined as that sector which undertakes construction works for private or public organizations and contributes substantially to the national economy (Nnadi, *et al.,* 2017). According to Nugroho *et al.* (2013) Construction Industries become a key player in economic growth in each country, which is absorbing most finance and man power.The magnitude of these activities in the construction industry serves as gauge for measuring the overall development of a nation (Bayliss *et al.,* 2004; Oso, 2017).Activities of the Construction industry has a direct impact on the productivity of a country's economy; Its accounts for 3-4% of Gross Domestic Product (GDP) of most countries (Brown, 2013; Olaleye *et al.*, 2017). Also, construction activity contributes to the generation of waste in the acquisition of raw materials (Saidu, 2016). The majority of this waste has not been well managed, thus causing substantial health and environmental problems (Imam *et al.*, 2008) and affecting the performance of many projects in Nigeria (Adewuyi and Otali, 2013; Saidu and Shakantu 2016). Construction waste is a well-known issue internationally and has adverse impact on overall progress of a project as well as the building society and nature (Nagapan *et al.*, 2012). According to Al-Hajj and Hamani (2011) construction waste is described as 'the difference between materials supplied to construction site and those materials placed for use on construction projects. Nagapan *et al.* (2012) therefore, confirm that waste is any surplus or unwanted material constantly causing environmental difficulties and global warming.

On other hand, several scholars viewed construction waste as any human activity that consumes resources but creates no value, such as mistakes that require rectification, waiting time/ waste of time, cost, unwanted production/overproduction, incorrect choice, management of work programme and poor constructability that leads to wase generation in construction sites (Ma, 2011; Nagapan *et al.*, 2012; Nagapan, Abdul Rahman and Asmi, 2012; Chikezirim and Mwanaumo, 2013 and Saidu, 2016).The generation of construction waste is mostly due to lack of appreciation of the value of material, cutting and application waste, transporting delivery waste, residue waste, succeeding trade waste, specification, and design waste, learning waste, supervisory waste and management waste (Idris *et al*.,2015). Idris *et al.* (2015) further concluded that it can be seen that certain factors are responsible for waste on site and the result obtained from the analyses of data shows that the waste mostly occurs during the process of incorporating these materials into the construction structures such mixing, cutting and laying. Nagapan *et al.* (2012) concluded that the most significant factors causing construction waste are Poor site management and supervision, Lack of experience, inadequate planning and scheduling, Mistakes and errors in design and Mistakes during construction. Rameezdeen (2004) found that Cutting waste and Management waste are the two most important causes of waste in construction sites. Nugroho *et al.* (2013) also noted that construction waste is leftover material as the residue of construction activities and is caused by many factors, such as over production, handling error, accidents. Baldwin *et al.* (2010) further considered construction waste as the difference between the materials ordered and those material placed on construction sites. Gulghane and Khandve (2015) later said that construction waste consists of unwanted material produced directly or incidentally by the construction or industries which leads to waste generation in the construction sites. Formoso *et al.* (1999) and Swinburne *et al.* (2010) also argued that there can be unavoidable waste (or natural waste), in which the investment necessary to its reduction is higher than the economy produced; and avoidable waste, when the cost of waste is significantly higher than the cost to prevent it.

Construction material waste was categorized as cutting waste, application waste, transit waste and theft and vandalism (Muhwezi *et al.*, 2012; Iqbal and Baig,2016). The Plaster of Paris (POP) waste causes environmental damage that results from generating waste material and the economic and social aspects of waste that have an effect on the construction sites (Alencer *et.al.*, 2010). Ameh and Itodo (2013) also identified POP as the most wasteful material on construction sites. Eze *et al.* (2017) concluded that waste from POP has the most wasteful materials on construction sites. Material waste can also have a significant effect on the progress of a construction project, since it specifically has a major impact on the construction estimates (Nagapan *et al.*, 2012). Madhavi *et al.* (2013) and Gulghane and Khandve (2015) later noted that, if the material management in construction projects is not controlled properly it will create a major project cost variance which also leads waste generation on construction sites. Babatunde (2012) indicates that Plaster of Paris (POP) ceiling has the highest cost of materials wastage on site. Babatunde (2012) further concluded that POP accounted for an average of 15.32% cost in the Nigerian construction sites.

RESEARCH METHODOLGY

The research employed the use of field study design approach by collecting quantitative data. It is quantitative because, the data were generated from the direct measurement of the quantity of on-site Plaster of Paris (POP) waste and Plaster of Paris (POP) to be used for 20 number 3-bedroom bungalow and 3-bedroom duplex respectively, all converted to cubic metre (volume) and numbers. The table containing these details is presented in Appendix 1 of this study. The population for the study consisted 555 residential (3-bedroom) construction project sites within Abuja, the Federal Capital Territory (FCT), Nigeria. Table 1 shows the details on the population of residential building(3-bedroom) types within Abuja.

Table 1: Population of residential building types

SN	Residential building types	Number
1	Three bedroom bungalow	258
2	Three bedroom duplex	297
TOTAL		**555**

Source: Development Control Office,2022.

Table 2 shows the details on the location of three-bedroom bungalow and three-bedroom duplex.

Table 2: Location of three-bedroom bungalow

SN	Location	Number
1	Abaji Area Council	33
2	Kwali Area Council	45
3	Gwagwalada Area Council	59
4	Abuja Municipal Area Council	77
5	Bwari Area Council	39
6	Kuje Area Council	44
	TOTAL	**258**

Source: Development Control Office (2022).

In this research, a total of twenty (20) 3-bedroom bungalow buildings and twenty (20) 3-bedroom duplex buildings were sampled. These were the active 3-bedroom construction projects as at the time of collecting the research data and to which access was made easier. 3-bedroom bungalows and duplexes were selected, because they were the most convenient forms of residential buildings for average Nigerians today. In order to guarantee equal representation for each of the identified groups/strata in the population, stratified random sampling method was adopted. The respondents were first categorised into two different strata (3-bedroom bungalow and 3-bedroom duplex) before they were selected and randomly sampled accordingly. For the purpose of this study, data was generated from primary sources. This study collected primary data through quantitative research approaches which included the use of on-site observation, measurements of quantity of plaster of paris (POP) waste and recording on site was employed.

Table 3: Location of three-bedroom duplex

SN	Location	Number
1	Abaji Area Council	39
2	Kwali Area Council	37
3	Gwagwalada Area Council	67
4	Abuja Municipal Area Council	83
5	Bwari Area Council	30
6	Kuje Area Council	41
	TOTAL	**297**

Source: Development Control Office (2022).

This study also focused mainly on primary data, which included: the field investigation on the POP waste only as material considered in this research. The data on the quantity of on-site material waste was generated by physical on-site measurements with the aid of measuring instruments, such as tape and measurement rule. The volume of the POP waste was first instant measured with tape and measurement rule to get square area and finally converted to cubic metre (volume) on site. The study employed the use of inferential methods of analysis to analyse the collected data and the results were presented in Tables. Regression analyses are used to describe data and to explain the relationship between one dependent variable and one or more independent variables. They are also used as a basic predictive analysis. This study was conducted between January 2022 to June 2022.

RESULTS AND DISCUSSSION

This section presents relationship between the volume of Plaster of Paris (POP) waste and the volume of Plaster of Paris (POP) used and discusses the results of the regression analyses performed in this research. Also, before running the regression analyses, test for normality was performed to ensure that the data were normally distributed using the Shapiro Wilks Test and the results revealed a normally distributed data. Based on the results, some of data were considered to be normally distributed, because their Kurtosis values divided by the Standard error values fall within the range of "+/- 1.96". However, those that were not normally distributed (those that did not fall within the range of +/- 1.96) passed through the transformation process and until all the data were normally distributed and this allows for further regression analyses to be conducted.

Relationship between volume of Plaster of Paris (POP) waste and volume of POP used

Linear regression analysis was employed to test if volume of POP used for 3-bedroom bungalow buildings significantly predicted the volume of POP waste that would occur. The result of the regression shown that the predictor expressed 52% of the variance (R^2=0.52, F (1, 18) = 19.711, p<0.01); this implied that the volume of POP used for 3-bedroom bungalow buildings significantly predicted the volume of POP waste.

Linear regression analysis was employed to test if volume of POP used for 3-bedroom duplex buildings significantly predicted the volume of POP waste that would occur. The result of the regression shown that the predictor expressed 33% of the variance (R^2=0.33, F (1, 18) = 8.752, p<0.01); this implied that the volume of POP used for 3-bedroom duplex buildings significantly predicted the volume of POP waste.

Therefore, the following models were developed for Predicting the quantity of POP waste materials for 3-bedroom bungalow and duplex buildings:

i. $Y_1 = -0.893 + 0.886(x_1)$, where Y_1 = volume of POP waste materials for 3-bungalow buildings and x_1= volume of POP used for 3-bedroom bungalow;
ii. $Y_2 = 13.992 + 2.480(x_2)$, where Y_2 = volume of POP waste materials for duplex buildings and x_2 = volume of POP used for 3-bedroom duplex;

Table 4: Relationship between volume of POP waste and the volume of POP used for bungalow and duplex buildings

SN	Variables		Type of model	Observation		Inference			
	X	Y		Regression equation (Y=a +bx)	R²	Probability value	Strength of relationship	Remarks	Action on Hypothesis
1	POP materials used for bungalow	POP waste from bungalow	Linear regression	POP waste = -0.893 + 0.886 POP used	52.30%	0.000	Strong	Statistically significant	Reject Ho
2	POP materials used for duplex	POP waste for duplex	Linear regression	POP waste =13.992 + 2.480 POP used	32.70%	0.000	Weak	Statistically significant	Reject Ho

Findings of this study reveals that quantity of onsite material waste generated and quantity of materials used in 3-bedroom bungalow and duplex building projects were statistically significant for POP works. These imply that any change in one variable would result to a corresponding change in the other variable. These results are in line with the findings of Saidu and Shakantu (2017) who observed that increase in the volume of materials used would result in an increase in the quantity of material waste and would also increases the cost of materials waste for project. Also, Ameh and Itodo (2013), Teo *et al.* (2009) and Saidu and Shakantu (2016**)** observed that on-site wastage of material leads to increase in the final cost of a building project. As materials are wasted, more is required, thereby affecting the estimated cost of the project.

CONCLUSION AND RECOMMENDATIONS

Quantification of material waste is very in important for construction waste management, accurate estimation can be completed by developing waste quantification model that is applicable for national or regional construction waste generation. Statistical data relating to the quantities of material waste for building works have not been well documented, and there is no known model for predicting the quantities of onsite material waste for different materials, such as POP and so forth. The main problem of this study is that there is no known research-based evidence or any existing model for predicting the quantities of material waste separately. Because most existing models predict the quantities of material waste in lump, without making allowance for segregation and this has become a major problem to estimators and building professionals.

This research aims to develop a model for predicting the volume of POP waste in building works. The study concludes that a statistically significant relationship exists between the volume of POP waste and volume of POP used in both bungalow and duplex works. This implies that any change in the either of the variables would lead to a corresponding change in the other. The model was developed from the regression analysis. Based on these, the research recommends the use of these models by the building construction professionals at the early stage in order to have an idea on the likely volume of waste to be recorded, so that adjustment could be made in the areas of management and supervision of project at hand. The more materials are used, the more waste is generated: the study also recommends that building professionals must ensure adequate adoption of the current waste management techniques, in order to reduce the rate of waste generation in the use of materials on building construction sites. The model was limited to 3-bedroom buildings and POP material waste, the model was also limited to prediction of POP material waste in segregation not in lump sum and further studies could be conducted to look at other forms of buildings and materials waste as well.

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APPENDIX I

TOTAL DATA COLLECTED USING TABLE PROFOMA

Plaster of Paris 3-BED BUNGALOW			**Plaster of Paris 3-BED DUPLEX**		
S/n	Volume of materials used (m^3)	Volume of waste (m^3)	S/n	Volume of materials used (m^3)	Volume of waste (m^3)
1.	4.93	0.81	1.	20.40	3.30
2.	11.13	1.80	2.	23.52	3.81
3.	5.22	0.84	3.	16.68	2.70
4.	8.46	1.38	4.	13.53	2.19
5.	3.21	0.51	5.	20.40	1.17
6.	11.01	0.64	6.	23.52	1.35
7.	11.01	0.69	7.	16.68	0.96
8.	11.13	0.64	8.	13.53	0.78
9.	8.46	0.49	9.	20.40	1.20
10	5.22	0.30	10	23.52	1.38
11.	16.80	2.73	11.	16.80	2.73
12.	8.10	1.32	12.	8.10	1.32
13.	20.76	3.36	13.	20.76	3.36
14.	21.12	3.42	14.	21.12	3.42
15.	32.13	5.22	15.	32.13	5.22
16.	21.12	1.22	16.	21.12	1.22
17	20.76	1.20	17	20.76	1.20
18	8.10	0.47	18	8.10	0.47
19	16.80	0.97	19	16.80	0.97
20	21.12	1.22	20	21.12	1.22

Source: Researcher ‘s field survey, 2022.