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CONTENT

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Effects of material-waste causes on project-cost overrun in Abuja, Nigeria: A site management perspective

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ABSTRACT

Purpose of this paper: To examine the effects of material-waste and their control measures on project-cost overruns at the site-management stage of a project

Design/methodology/approach: The study covers building-construction professionals in Abuja, Nigeria, from which a purposive sample of 30 professionals was drawn. Interviews were conducted with the sampled professionals; and in the process, quantitative data were generated by using a tick-box questionnaire. The tick-box questionnaire contained literature-based information, which was personally perused by the researcher – when the respondents mentioned any of the issues contained in the tick-box. The results from the tick-box were the only data utilised in this research. The data were analysed by using the descriptive and inferential methods.

Findings: The research analysis indicated that material waste and its control measures have significant effects (very high, high, medium, low, and very low) in causing, or minimising, cost overruns on construction projects at the site-management stage of a project. There were no significant differences in the views of the professionals on these issues.

Research limitations/implications: The research was limited too private and public-building projects in Abuja, Nigeria.

Practical implications: The management of material waste on construction sites, most importantly, those with "very high and high effects on cost overruns" should translate into a reduction in the amount of cost overruns for various projects.

Value of the paper: The recommendations forthcoming from this research, if properly implemented, should achieve the best value for money to the client; a reduction in the amount of waste that would be sent to landfills; and a reduction in the number of cost overruns on projects.

KEYWORDS: Cost Overruns, Control Measures, Material Waste, Construction Site Management

1. INTRODUCTION

The construction industry contributes to the socio-economic development of any nation; but it is faced with problems of time overruns, cost overruns and material waste (Abdul-Rahman *et al.,* 2013). Cost overruns and material waste are global problems, which make it difficult for many construction projects to be completed within budget (Saidu and Shakantu, 2015; Ameh and Itodo, 2013; Abdul-Rahman *et al.,* 2013; Nagapan *et al.,* 2012a). Studies

from different parts of the world have shown that material waste represents a relatively large percentage of the production costs. For instance, a United Kingdom (UK) study reported an additional cost of 15% to construction projects cost overruns, because of material wastage (Tam *et al.,* 2007).

A study conducted by the Hong Kong Polytechnic and the Hong Kong Construction Association (1993) disclosed material waste contribution to cost overruns at 11%. Bossink and Bounwers (1996) in a similar study of material wastage in the Netherlands concluded that material wastage accounts for between 20% to 30% of project-cost overruns. In a recent study, Saidu and Shakantu (2016c) concluded that the average percentage contribution of material waste to project-cost overrun is 4%. Thus, poor management of materials and waste leads to an increase in the total cost of building projects (Ameh and Itodo, 2013).

The problems of material waste and cost overruns are occasioned by several causes at the different stages of projects. These include: the planning stage, the estimating stage, the design and design management stage, as well as the construction stage. Identification of these causes at different stages and the application of the relevant control measures to minimise their occurrence is a step towards alleviating the consequences (Mou, 2008; Oladiran, 2009; Nagapan *et al.,* 2012a; Saidu and Shakantu, 2015).

The problem of construction material waste remains unresolved. For instance, Ameh and Itodo (2013) highlighted that in every 100 houses built in Nigeria, there is sufficient waste material to build another 10 houses. Furthermore, 10% of materials delivered to construction sites in the UK end up as waste that is not be accounted for (Osmani, 2011).

Similarly, cost overruns are persistent problems, which have plagued the construction industry for decades; and the argument on how to reduce or totally remove these problems from projects has been ongoing among the built-environment professionals, project owners and users for the past seventy years (Apolot *et al.*, 2010; Allahaim and Liu, 2012). However, there has been no substantial improvement, nor significant solution in mitigating the detrimental effects thereof (Allahaim and Liu, 2012).

Ameh and Itodo (2013) believed that building material wastage on construction sites accounts for cost overruns. This is because most managers of construction projects pay little attention to the effects of the generated material waste on cost overruns. Many studies have been conducted in this field, for instance, those of: Tam *et al.* (2007); Ameh and Itodo (2013); Saidu and Shakantu (2015); Saidu and Shakantu (2016a); and Saidu and Shakantu (2016b). There is still a need for research that provides an empirical assessment of the material waste causes, which affect cost overruns at the site-management stage of a project. Moreover, Saidu and Shakantu (2016a) recommended further research on these issues in the construction industry. This recommendation led to the development of the problem posed in this study, namely, that the empirical study on the effects of material waste and the control measures on cost overruns at the site management stage of a construction project remains at the suboptimal level.

On this basis, this paper reports the findings of an empirical investigation into the effects of material waste and the control measures on cost overruns at the site-management stage of a project.

2. MATERIAL WASTE AND COST OVERRUNS

Construction waste is a global challenge facing both construction professionals and researchers. It has a significant impact on time, cost, quality and sustainability (Nagapan *et al.,* 2012a). Construction waste is generally classified into two main classes, namely: the physical and the non-physical waste (Nagapan *et al.,* 2012b). The physical construction waste is the waste from construction, renovation activities, including civil and building construction, demolition activities, and roadwork. It is, however, referred to by some directly as solid waste (Saidu and Shakantu, 2015). This type of waste consists of material waste from recovery (re-use and recycling) or the complete loss of materials for landfill disposal (Saidu, 2016).

Conversely, the non-physical waste normally occurs during the construction process. By contrast with material waste, the non-physical waste relates to time overruns and cost overruns for a construction project. Ma (2011) defines waste as not only that, which is associated with the wastage of materials, but also to other activities, such as repair, waiting time, and delays. Saidu and Shakantu (2015) emphasise that since the term 'construction waste' entails both the physical and the non-physical waste, there is a relationship between material waste originating from physical waste and cost overruns from the non-physical waste; since they both emanate from the same waste family.

This classification is shown in Figure 2.1.

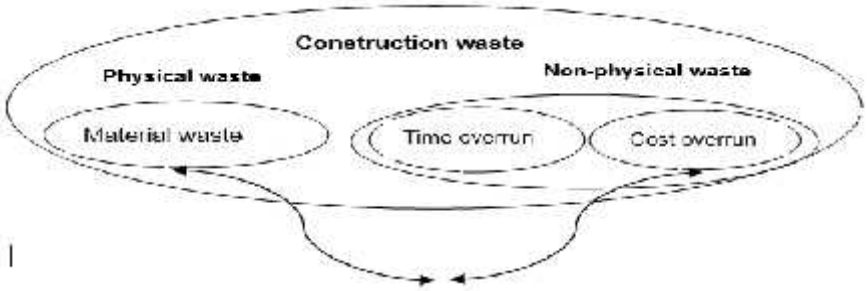

Figure 2.1 Classification of construction waste
Source: Nagapan, Abdul-Rahman & Asmi (2012)

Linking material waste to cost overruns, Ameh and Itodo (2013) assert that material wastage on site leads to an increase in the final cost of the building project. Teo *et al.* (2009) believe that as materials are wasted, more are procured; and this consequently affects the estimated cost. Studies from different parts of the world have revealed that poor management of materials and waste leads to an increase in the total cost of building projects (Ameh and Itodo, 2013; Saidu, 2016). Saidu and Shakantu (2016a) concluded through a desktop research that material waste also causes cost overruns at the pre-contract and post-contract stages of a project. However, 96.88% and 81.81% of the cost overruns also cause material waste at the pre-contract and post-contract stages, respectively (Saidu and Shakantu, 2016a).

Generally, an overlap of 86.74% exists between material waste and those of cost overruns at all stages of a project. Other causes, which are not related, are mostly the micro-economic and macro-economic factors.

3. RESEARCH METHODOLOGY

The study covered building construction projects in Abuja, the Federal Capital Territory of Nigeria. Abuja was selected because it is one of the metropolitan cities of Nigeria that has the highest population of professionals in the built environment; and it also has many ongoing construction projects.

Interviews were conducted with construction professionals using purposive sampling techniques. These were purposive; as only building-construction professionals handling projects worth more than 1.6 billion Naira/R100 million were consulted/interviewed. Projects valued at more than R100 million were likely to be handled by more experienced professionals, who might be more familiar with the issues leading to material waste and cost overruns than the projects of lesser value.

Furthermore, Leedy and Ormrod (2014) maintain that the size of a purposive sample usually ranges between 5 and 25 participants. For this research, thirty (30) professionals were interviewed (15 Project Managers {PMs}, 9 Quantity Surveyors {QSs}, 5 Site Engineers {SEs}, and 1 Senior Technical Officer {STO} of a waste-management department). The interviews were based on the issues relating to material waste and cost overruns at the site-management stage of a construction project.

The research method is quantitative, which is in line with the positivist paradigm. It is quantitative; because in the course of the interviews, a tick-box structured questionnaire containing a list of literature-based information (waste causes and control measures that relate to cost overruns) was ticked/marked by the interviewer/researcher as the respondents mentioned or commented on any of the issues in the tick-box. This was done to validate the literature-based information by determining the frequencies and percentages of occurrence. The results of the tick-box questionnaire were the 'only research data' utilised in this study. The, study is therefore quantitative rather than qualitative or mixed-method research.

The research employed the descriptive and the inferential analyses. The descriptive tool that was used to analyse the data (tick-box structure questionnaire) was the cross-tabulation method. The responses from the tick-box questionnaires are rated on the basis of the cut-off points highlighted by Morenikeji (2006) in a five-point Likert scale; the material-waste causes and the control measures that have a percentage of "90% to 100%" are rated "Very High (VH) effect"; 70% to 89% are rated "High (H) effect"; 50% to 69% are rated "Moderate (M) effect"; 30% to 49% are rated "Little (L) effect"; and 1% to 29% are rated "Very Little (VL) effect" on cost overruns.

Inferentially, the analysis of variance (one-way ANOVA) was used to compare the means of the results/views of the different respondents/professionals, to determine whether there is a statistically significant difference on the effects of material waste on cost overruns at the site-management stage of a building-construction project.

4. RESULTS AND DISCUSSION

This section presents and discusses the results of the tick-box questionnaires and the ANOVA analyses on the effects of material waste and their control measures on cost overruns at the site-management stage of projects.

4.1 Material waste that affects the cost overruns at the site-management stage of a project

It is clear from Table 4.1 that the causes of material waste that have 'very high effects' on cost overruns at the site-management stage of a project were: (i) Rework; (ii) site accidents; (iii) inadequate site security/fencing; (iv) poor site organisation and discipline; and (v) construction-site disputes. The respondents believed that inadequate site security would lead to pilfering and damage/sabotage of materials on site. When the site is not properly organised and disciplined, accidents are bound to occur; and these might affect the workers, the structure, or even both. When accidents occur onsite, the workers leave their work; and some materials, such as mortar, harden; and this results in waste. Also abortive work (rework) is already a waste,

which would require the same materials, the same labour, and the same costs to re-build.

Consequently, rework contributes significantly to material-waste generation, which subsequently affects the final cost of a project. The respondents also believed that major disputes between a client and a contractor, or between the managers/contractors and workers, could lead to the abandonment of the work for some time, which could result in waste generation and cost overruns. Furthermore, (a) lack of experience; (b) poor construction planning and control; (c) theft; and (d) the lack of co-ordination among parties, were the causes of material waste deemed to have high effects on cost overruns.

These results support the findings of Azhar, Farooki and Ahmed (2008); Malumfashi and Shuaibu (2012); Shanmugapriya and Subramanian (2013); and Jackson (2002) on the major causes of cost overruns for projects. The results also corroborate the findings of Osmani *et al.* (2008); Odusanmi *et al.* (2012); Ameh and Itodo (2013) on the major causes of material waste on construction sites.

Moreover, the material-waste causes that have moderate effects on cost overruns were: (i) poor site-storage areas; (ii) lack of waste-management plans; (iii) communication problems; and (iv) poor site supervision. These were deemed by the respondents to have moderate effects on cost overruns; because they fall between 50 and 69 per cent.

The material-waste causes that have very little effect on cost overruns are: (1) Difficulties in accessing the construction site; (2) long storage distance from application point; (3) late delivery of materials; and (4) late information flow among parties. They have very little effect on cost overruns; because they fall between 1 and 29 per cent. These findings corroborate the results of Saidu and Shakantu (2016a) on the identified causes of material waste that relate to the causes of cost overruns from the literature review.

Table 4.1 Results of the material waste on cost overruns at the site-management stage of a project

S/n	Material waste causes that have effects on cost overrun at the site management stage of a project	PM	QS	SE	STO	Total (% & frequency)	Ranking	Decision
a	***Storage source***							
1	Wrong material/equipment storage/stacking	6	3	2	0	11 (36.7%)	19	L
2	Transfer of materials from storage to application	0	0	0	0	0 (0%)	49	NR
3	Damage by other trades	0	0	0	0	0(0%)		
4	Poor site storage area	8	7	4	1	20 (66.7%)	12	M
5	Long storage distance from application point.	0	1	0	0	1 (3.3%)	35	VL
6	Damage by weather	2	2	1	0	5 (16.7%)	28	VL
b	***Security source***							
7	Inadequate site security/Fencing	15	9	5	1	30 (100%)	1	VH
8	Theft	9	7	4	1	21 (70)	10	H
9	Vandalism, sabotage pilferage, and material damage	10	7	4	1	22 (73.3%)	8	H
10	Power and lighting problems on site	5	2	1	1	9 (30%)	21	VL
c	***Site conditions***							
11	Poor site management of the 5Ms	13	8	4	1	26 (86.7%)	6	H
12	Poor site & unforeseen ground conditions	3	2	1	0	6 (20%)	25	VL
13	Leftover materials on site	0	0	0	0	0 (0%)	49	NR
14	Waste resulting from packaging	0	0	0	0	0 (0%)	49	NR

15	Lack of environmental awareness	5	4	0	1	10 (33.3%)	21	L
16	Difficulties in accessing construction site	1	2	0	1	4 (13.3%)	30	VL
17	Problems relating to on-site health and safety	8	3	1	1	13 (43.3%)	16	L
18	Site congestion and Interference of other crews	0	0	0	0	0 (0%)	49	NR
19	Inadequate site investigation	2	1	0	1	4 (13.3%)	30	VL
20	Disputes on site	13	8	5	1	27 (90)	5	VH
21	Extra materials ordered discarded instead of carrying over to next site	2	0	0	1	3 (10%)	31	VL
22	Equipment failure on site	3	3	1	0	7 (23.3%)	24	VL
23	Concurrent execution of numerous activities	2	0	0	0	2 (6.7%)	33	VL
24	*Poor site organization and discipline	15	9	4	1	29 (96.7%)	4	VH
25	*Wrong location of cranes on site	4	6	3	0	13 (43.3%)	16	L
26	*Wrong placement of equipment on site	1	1	1	0	3 (10%)	31	VL
27	Site accidents	15	9	5	1	30 (100%)	1	VH
28	*Site meetings	4	1	0	0	5 (16.7%)	28	VL
29	*Lack of adherence to program of work	1	0	0	0	1 (3.3%)	35	VL
30	*Late delivery of materials	1	0	0	0	1 (3.3%)	35	VL
d	***Operation source***							
31	Nature of construction process	0	1	0	0	1 (3.33%)	35	VL
32	Tools not suitably used	0	0	1	0	1(3.3%)	35	VL
33	Damage caused by third parties	0	0	0	0	0 (0%)	49	NR
34	Lack of waste management plans	10	5	5	0	20 (66.7%)	12	M
35	Communication problems	11	7	1	0	19 (63.3%)	14	M
36	Non-availability of appropriate equipment	2	1	1	0	4 (13.3%)	30	VL
37	Lack of construction knowledge and methods	2	5	4	0	11 (36.7%)	19	L
38	Scarcity of equipment	5	2	3	0	10 (33.3%)	21	L
39	Late information flow among parties	3	1	2	0	6 (20%)	25	VL
40	Lack of co-ordination among parties	13	5	2	1	21 (70%)	10	H
41	Poor construction planning and control	12	7	2	1	22 (73.3%)	8	H
42	Poor site supervision	8	6	4	0	18(60%)	15	M
43	Rework	15	9	5	1	30 (100%)	1	VH
44	Inappropriate records of materials	6	3	3	1	13 (43.3%)	16	L
45	*Lack of adherence to material waste regulations	0	1	1	0	2 (6.7%)	33	VL
46	*Inappropriate delegation of responsibilities	3	3	2	0	8 (26.7%)	23	VL
47	*Lack of experience	12	7		0	24(80%)	7	H
48	*Lack of learning from previous mistakes	2	2	2	0	6 (20%)	25	VL
49	Lack of quality control	4	1	1	1	7 (23.3%)	24	VL

The causes of material waste that started with the sign (*) in Table 4.1 were the newly identified causes during the interview session with the respondents, which were not originally in the interviewer's tick-box questionnaire.

4.2 Material waste-control measures that affect cost overruns at the site-management stage of a project

It was apparent from Table 4.2 that the material waste-control measures that have a "Very High (VH) effect'' on cost overruns with respect to the quality of site management of a project are: (i) Tight security onsite (security source); (ii) inadequate site organisation and discipline (operation source); and (iii) onsite and offsite reuse of waste materials (site conditions and management source).

Consequently, the material waste-control measures that have a "High (H) effect" on cost overruns with respect to the 'operation source' are: (i) Waste management throughout the entire lifecycle of a project; (ii) the use of inexperienced personnel; (iii) the promotion of construction waste re-use onsite; (iv) proper administration of the 5Ms (machine, materials, men, money and management) onsite; and (v) inadequate site planning and control. These findings corroborate the results of Saidu and Shakantu (2016a) on the identified causes of material waste that relate to the causes of cost overruns, according to the literature review.

On the other hand, the material waste-control measures that have "very little effect" on cost overruns are: (a) Issuing procedures for managing hazardous waste (operation source); (b) reducing material off-cuts and re-using (residual source); and (d) the implementation of onsite material-waste sorting (site conditions and management source).

Most of these findings are in line with the results of previous research studies, which highlighted that improving site management is very important in reducing cost overruns; as it significantly affects onsite productivity (Chan and Kumaraswamy, 1997; Fong *et al.,* 2006; Ibrahim *et al.,* 2010; Abdul-Azis *et al.,* 2013). Koushki *et al*. (2005) also stated that contractor-related factors are the main contributors to cost overruns.

Table 4.2 Results of material waste-control measures on cost overruns at the site-management stage of a project

S/n	Material waste control measures that have effects on cost overruns at site management	PM	OS	SE	STO	Total (% & frequency)	Ranking	Decision
a	***Site conditions and management sources***							
1	Proper materials inspection on delivery to site	8	7	4	1	20 (66.7%)	8	M
2	Proper records and documentation of materials	8	4	2	0	14 (46.7%)	13	L
3	Daily record taking	7	2	2	0	11(36.7)	14	L
4	Usage of materials request booklets	0	0	0	0	0 (0%)	31	NR
5	Regular site meetings on materials	8	7	3	1	19 (63.3%)	11	M
6	On-site material quality evaluation	5	1	1	1	8 (26.7%)	18	VL
7	On-site and offsite re-use of waste material	14	7	5	1	27 (90%)	2	VH
8	Separation of hazardous waste from others	0	0	0	0	0 (0%)	31	NR
9	Adherence to design and specifications	3	4	1	0	8 (26.7%)	18	VL
10	Good communication flow on site	11	7	1	0	19 (63.3%)	9	M

11	Implementing on-site material waste sorting	0	1	1	0	2 (6.7%)	23	VL
12	Recycle generated waste materials	0	0	0	0	0 (0%)	31	NR
13	*Proper administration of 5Ms on site	12	8	4	0	24 (80%)	5	H
b	***Security***							
14	Tight security on site	15	9	5	1	30 (100)	1	VH
15	Availability of workable security lighting on site	5	2	1	1	9 (30%)	16	L
16	*Adequate site temporary fencing	2	6	1	0	9 (30%)	16	L
c	***Operation source***							
17	Issuing procedures for managing hazardous waste	2	0	0	0	2 (6.7%)	23	VL
18	Prepare a list & record of salvageable waste	1	2	0	0	3 (10%)	22	VL
19	Site meetings on waste management	8	8	3	1	20 (66.7%)	8	M
20	Adherence to waste management regulations	9	7	3	1	20 (66.7%)	8	M
21	Encouraging management of the environment	0	0	0	0	0 (0%)	31	NR
22	Waste management throughout the entire lifecycle of a project	13	7	4	1	25 (83.3%)	4	H
23	Promotion of waste re-use on construction sites	12	7	4	0	23 (76.7%)	7	H
24	Research and development in waste management	0	0	0	0	0 (0%)	31	NR
25	*Use of experienced personnel	1	7	5		24 (80%)	5	H
26	*Adequate site organization and discipline	14	9	3	1	27 (90%)	2	VH
27	Adequate site supervision	5	8	3	1	17(56.7)	12	M
28	*Learning from previous mistakes	5	3	1	1	10 (33.3%)	15	L
29	*Proper site planning & control	11	7	2	1	21 (70%)	9	H
c	***Residual sources***							
30	Reducing material off-cuts	0	3	1	0	4(13.3%)	21	VL
31	Mixture of appropriate quantity of mortar	3	3	0	0	6 (20%)	20	VL

4.3 Comparative views of respondents on the effects of material waste and control measures on cost overruns with respect to the site management of a project

The results in Table 4.2 show that the values of f-calculated (0.259 and 1.28) were less than the tabulated value (1.701), respectively. The probability values (0.774 and 0.309) were greater than the significance value (0.05) at the 95 per cent confidence level within the mean-squared groups (6.61 to 25.54 and 11.31 to 38.95), respectively.

The evidence here is not statistically significant (different). These results imply that the respondents were of the same view on the effects of material-waste sources, cause, and control measures on project-cost overruns.

Table 4.3 Test of difference in professional views on the effects of material-waste causes and control measures on cost overruns at the site-management stage of a project

S	Variables	F > F	Observation	Inferences

	X	X	X	X		Mean square within group	F-cal	F-tab	Probability value	Remarks
a	PM	QS	SE	STO	One-way ANOVA	6.61 25.54	0.259	1.701	0.774	Not statistically significant
	Material-waste causes									
b	PM	QS	SE	STO	One-way ANOVA	13.89 11.31	1.228	1.701	0.309	Not statistically significant
	Waste control measures									

5. CONCLUSION AND RECOMMENDATIONS

Material waste and cost overruns are global challenges facing the construction industry. These problems occur at different stages of a project, from planning, design, estimating, and construction to project completion. The purpose of this paper was to examine the effects of material waste and the control measures on cost overruns at the site-management stage of a project.

It was found that the causes of material waste and their control measures were found to have significant (very high, high, medium, low, and very low) effects in causing/controlling cost overruns at the site-management stage of a project. Also, there was no statistically significant difference in the

views of the respondents on these issues. The respondents have, therefore, the same views on the results of the effects of material waste and control measures on cost overruns at the site-management stage of a project.

Based on these findings, it may be concluded that the effective management of the causes of material waste on the construction site would translate into a reduction in the level of cost overruns for projects. The study recommends that the management of the causes of material waste causes should be adopted onsite; as they have the potential to minimise the rate of cost overruns on projects.

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