Fifth International Conference on Construction in the 21st Century (CITC-V)
"Collaboration and Integration in Engineering, Management and Technology"
May 20-22, 2009, Istanbul, Turkey

Causes and Minimization Techniques of Materials Waste in Nigerian Construction Process

Olatunji Joseph Oladiran
Faculty of Environmental Sciences, Department of Building, University of Lagos, Akoka Yaba, Lagos, Nigeria
tungybox2000@yahoo.com

Abstract
A major characteristic of average construction sites in Nigeria is the presence waste materials in various forms and large quantities. This culminates to ***inter alia,*** high construction costs and great hindrance to affordability of good houses to the citizens. In this regard, a survey research was embarked on; it focuses on identifying the causes of materials waste incidence and their various minimization techniques in Nigerian construction process. The population of the study is the construction professionals in selected firms in Nigeria. It involves the usage of a designed questionnaire administered via convenience sampling technique. Certain predetermined causes coined from literatures are included in the questionnaire while open-ended questions are employed to elicit the actual materials waste minimization techniques in the firms. Descriptive statistics tools are used to analyze the data. The study reveals causes of materials waste as: uneconomical shape of materials and components due to design; building failure/defects; workers' mistakes; theft; vandalism; inconclusive specifications; estimators' errors; ineffective communication; unfamiliarity with alternative products; design changes; lack of proper supervision; loading and unloading of materials; various forms of materials' packaging; substandard materials; poor site layout; misinterpretation of drawings; poor site conditions; setting out errors; and improper transportation of materials. It also sheds light on the materials waste minimization techniques as: materials inspections on arrival on sites; documentations of materials in and outflows; adherence to design details; effective communications; good transportation systems for materials; good storage facilities; training of storekeepers/site personnel; reuse of materials; daily stock taking; usage of materials requisition booklets; ensuring sub-soil investigations before projects commence; and regular site meetings. Conclusions are made based on these findings in the study. However, the study recommends that practitioners should employ all the techniques discovered in the study to minimize materials waste in their projects. This study will therefore contribute to materials waste minimization both in Nigerian and global construction processes.

Keywords
Materials waste, Causes, Minimization techniques, Nigeria

1. Introduction

Materials wastages are evident in construction projects and are occasioned by several sources and causes (Enshassi, 1996). Alwi *et al.* (2000) identify several causes of materials waste while Polat and Ballard (2005) reveal six sources and 15 causes of materials waste Turkish construction projects. Oladiran (2008) evidence 13 causes of materials waste in Nigeria. These incidences pose a lot challenges and negative implications to the stakeholders inform of high transportation cost to landfills and so on. Identification of

these causes and application of relevant control techniques to minimize their occurrence is a step towards alleviating the consequences. The aim of this study is to reveal these causes and useful minimization techniques using some selected construction firms in Nigeria. The specific objectives are to identify the causes of materials waste; to find out minimization techniques that are used in these firms for these causes; to examine the contributions of these techniques to materials waste minimization; and to evaluate the contribution of material waste minimization to certain projects' outcomes.

2. Causes and Minimization Techniques of Materials Waste

Waste occurrences on sites are diverse but the most common causes of waste in construction projects are materials. The consequences of materials waste are enormous because materials account for about 50% to 60% construction cost and they are scarce resources. Lot materials that get to sites end up as waste through several sources (Enshassi, 1996). In this regard, Oladiran (2008) reveals cause of materials waste in Nigerian projects as poor supervision, design error, defective materials, unskilled labour, wrong quality materials, changes in design, specification errors, poor storage facilities, poor handling process, poor material scheduling, poor product information, wrong suppliers advice and bulk purchase which leads to excess. They all contribute significantly to materials waste generation. Similarly, Ballard and Polat (2005) identify seven sources and 14 causes of material waste in Turkish construction projects as shown in Table 1.

Table 1: Main Causes of Material Waste (Ballard and Polat, 2005)

Source	Causes of material Waste	Frequency (%)
Design	Lack of information about types and sizes of materials on design documents	13
	Design changes and revisions	12
	Error in information about types and sizes of materials on design documents	10
	Determination of types and dimensions of materials without considering waste	3
Procurement	Ordering of materials that do not fulfill project requirements defined on design documents	86
	Over ordering or under ordering due to mistakes in quantity surveys	8
	Over ordering under ordering or due to lack of coordination between warehouse and construction crews	4
Material Handling	Damage of materials due to deficient stockpiling and handling of materials	16
	Imperfect planning of construction	61
Operation	Workers' mistakes	32
	Damage caused by subsequent trades	3
Residual	Conversion waste from cutting uneconomical shapes	22
Other	Lack of on site materials control	23
	Lack of waste management plans	10

The Table evidences that ordering and receiving of materials that do not fit into the project according to the design documents is the chief causes of waste in material. They discover that this is consonance with five housing projects in the Netherland by Bossink and Brouwers (1996).On the other hand, waste minimization can take different forms. According to Greenwood *et al.* (2003), waste minimization connotes reducing the amount and environmental effect of waste generated via reducing the amount of materials used or re-using existing materials. They note that the top priority in minimizing waste is to avoid waste through designing out waste or reducing waste at source. However, reuse or recycling can minimize the impacts of waste once it is generated. As a result, the client, architect and contractor are the major players in minimizing waste though the success is dependent on site operatives and involvement of all the project team. They conceptualize this idea into "sustainable waste hierarchy" that seeks to minimize the volume of raw materials consumed by promoting the reuse and recycling of materials. This is corroborated by waste minimization hierarchy highlighted in their executive summary which has

avoidance of waste as top priority and followed by waste reduction; the reuse of waste can then also limit waste generation while recycling and disposal are the last priorities. Greenwood *et al*. (2003) further indicate that the assessment of waste arising can support the development of a benchmark to manage waste according to the sustainable waste hierarchy. Waste stream identification and its volume at various stages will assist to uncover factors, which influence waste production. They then propose three key project stages where waste minimization initiatives should be introduced (i.e. contractual, design and site operation stages). Architects have key roles reducing waste at the three levels; clients also play major role at the design and contractual stages while the contractor is concerned at the contractual and site operation stages as highlighted in their study. In the same vain, Enshassi (1996) and partly corroborated by Agapiou *et al.* (1998) recommend the following, as measures for controlling materials and to minimize wastages:

- Materials control should start at the design stage. Late design variations should be avoided and effective materials handling on site should be designed for.
- Specification of standard sizes to minimize cutting.
- Accurate scheduling of materials to programmed delivery dates
- Documentation should set out size, quality and delivery form of materials for estimators' consideration.
- Procurement must specify quality, quantity, delivery time and method, and packaging.
- Effective communication between suppliers and recipient.
- Preparation of effective planning programmes.
- Management must establish on sites procedures for the reception of goods and plan for storage in advance. Materials of high value have to be held off-site until the last moment.
- Effective procedures for issuing of material on site.
- Training of both management and other staff.

3. Research Method

The empirical study involves a structured questionnaire, administered via convenience sampling technique to construction professional in selected building firms in Nigeria. It includes questions on the respondents' and organizations' profiles; the causes of materials waste - measured on a 5-point Likert scale where 1 represents Strongly Agree, 2 is Agree, 3 is Neutral, 4 is Disagree and 5 is Strongly Disagree; control techniques adopted by the firms via open-ended questions; the contributions of the control techniques to waste minimization measured on a 4-point Likert scale; and the contribution of materials waste minimization to projects' outcome measured on a 5-point Likert scale. Mean, ranking and frequency were used to analyze the data. A total of 50 copies of the questionnaire were distributed and 46 copies were duly filled and returned representing 92% response rate.

The organizations' profile reveals that 26 of them are contracting organizations, 7 apiece and 6 are consulting, client organizations and developers respectively; 38 of them are private while 7 are public organizations; 18 of them are between 6 to 10 years old in the Nigerian construction industry while 10, 8, 6 and 4 are above 20 years, 11-15years, less than 5 years and 16-20 years respectively; 14 of them have 1-10 staff strength, 27 have 11-600 and 5 have above 600 staff. This means that the targeted organizations can supply the required information for the study.

On the other hand, the respondents' profile shows that 11 of them are Builders while 10,14,4 and 5 are Architects, Civil Engineers, Safety Officers and Quantity Surveyors respectively; 16 of them are B.Sc degree holders while 17, 10 and 2 are HND, M.Sc and NCE/OND holders; 22 of them have less than 15 years work experience, 20 have 6 to 10 years, 5 have 11 to 16 years and only 1 has above 20 years. This again can be inferred that the respondents' are qualified to provide the information used for the study.

4. Findings and Discussions

4.1 Causes of Material Waste

The various causes of materials waste in the Nigerian construction process as identified by the respondents are shown in Table 2. The respondents "Agree" that all the causes generate materials waste in construction process because their mode for all the causes is 2 i.e. "Agree" from the Table. However, the respondents have varying level of agreement on these causes as indicated from their different means. Their highest level of agreements is on design changes because it ranks first in the Table and this could also suggest their order of importance. This is closely followed in descending order by loose delivery, workers' mistakes, ineffective communication, uneconomical shape of materials and components due to design, inconclusive specification, designers' unfamiliarity with alternative products, lack of proper supervision, misinterpretation of drawings, vandalism, poor site conditions, improper transportation of materials, building failure/defects, loading and unloading, poor site layout, theft, substandard materials, bulk delivery, setting out errors, palleted delivery, bagged delivery, estimators' errors and packed delivery.

Table 2: Causes of Material Waste

S/N		Total (N)	Level of Agreement					MEAN	RANK
			1 SA	2 A	3 N	4 SD	5 D		
1	Design changes	43	16	27	-	-	-	1.63	1
2	Loose delivery	46	22	15	6	-	2	1.78	2
3	Workers mistakes	46	8	34	4	-	-	1.91	3.5
4	Ineffective communication	44	9	30	5	-	-	1.91	3.5
5	Uneconomical shape of material & components due to design	45	12	27	2	4	-	1.96	5
6	Inconclusive specification	46	10	28	7	1	-	1.98	6
7	Unfamiliarity with alternative products	45	8	27	10	-	-	2.04	8
8	Lack of proper supervision	46	11	27	4	3	1	2.04	8
9	Misinterpretation of drawings	46	11	25	7	3	-	2.04	8
10	Vandalism	45	6	29	7	3	-	2.16	10
11	Poor site conditions	46	6	28	9	3	-	2.20	11.5
12	Improper transportation of materials	45	8	24	9	4	-	2.20	11.5
13	Building failure/defects	43	13	15	9	5	1	2.21	13
14	Loading and unloading	45	2	32	9	2	-	2.24	14
15	Poor site layout	45	7	24	9	5	-	2.27	15
16	Theft	45	4	19	15	1	6	2.29	16
17	Substandard materials	45	10	19	9	5	2	2.33	17
18	Bulk delivery	44	7	25	7	-	5	2.34	18
19	Setting out errors	46	2	28	7	3	6	2.63	19
20	Pallated delivery	46	2	21	18	1	4	2.65	20
21	Bagged delivery	46	5	18	12	7	4	2.72	21
22	Estimator's error	45	3	21	8	5	8	2.87	22
23	Packed delivery	46	3	17	13	5	8	2.96	23

Note: 1- Strongly Agree, 2- Agree, 3- Neutral, 4- Strongly Disagree & 5- Disagree

4.2 Materials Waste Control Techniques Adopted By Construction Firms

The respondents were asked in the questionnaires to list the various control techniques used by them for minimizing materials waste incidence by the identified causes. The result is shown in Table 3. The respondents highlighted 14 techniques. The Table reveals that 11 respondents signified good storage facilities as their control technique; 9 listed adherence to design details; 8 identified inspection on arrival on sites and daily stock taking; 5 apiece signified documentation of materials in and outflows with ensuring sub soil investigations before projects commence; 4 each suggested good transportation system, usage of materials requisition booklets, regular site meetings and training of storekeepers /site personnel; while 3 and 2 opined materials quality check and materials handling by workers respectively .

Table 3: Control Techniques

S/n	Control techniques	Total number of respondents (N)
1	Materials inspections on arrival on sites	6
2	Documentation of materials in and outflows	5
3	Good transportation systems for materials	4
4	Daily stock taking	6
5	Usage of materials requisition booklets	4
6	Regular site meetings	4
7	Material quality check	3
8	Material handling by workers	2
9	Good storage facilities	11
10	Effective communications	6
11	Ensuring sub-soil investigations before projects commence	5
12	Adherence to design details	9
13	Training of storekeepers/site personnel	4
14	Reuse of materials	8

The firms investigated are largely building construction firms and the adoption of these techniques is evident on their projects. A further investigation on the effects of these techniques on their projects reveals that it is highly rewarding. Figure 1 sheds light on the contributions of these techniques to minimizing materials waste according to the respondents. As many as 20 respondents out of 46 signified that the contribution is high on their projects while 8, 7 and 1 opined that it is average, very high and none respectively. This shows that the techniques' contributions towards materials waste minimization are high as denoted by majority of the respondents.

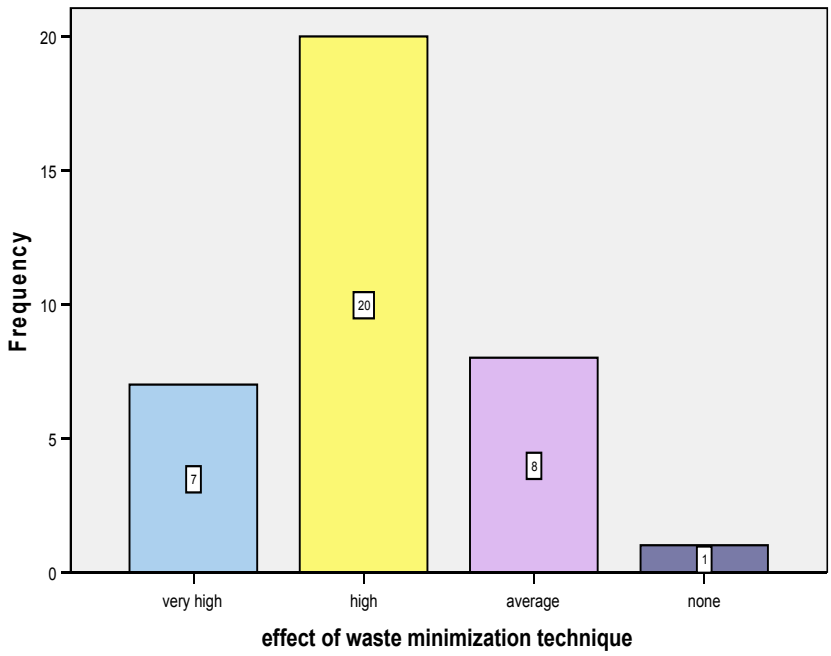

Figure 1: Contribution of Minimization Techniques to Material Waste

Furthermore, the dividends of materials waste minimization in the firms that adopt these techniques are expressed in increased profits, reduced materials shortage, reduced delay on projects' completion and final cost. However, Table 4 shows that materials waste minimization makes its contribution in descending order to increased contractors' profit, reduced materials shortage, reduced projects' delay and final cost.

Table 4: Contribution of Material Waste Minimization

S/n	Projects' outcomes	Level of contribution							
		Total (N)	1 VH	2 H	3 A	4 L	5 N	Mean	Rank
1	Increases contractors' profit	46	17	22	5	-	2	1.87	1
2	Reduced material shortage on site	45	7	26	10	1	1	2.18	2
3	Reduced delay on project completion	45	6	25	11	1	2	2.29	3
4	Reduced final cost on project	45	5	24	12	2	2	2.38	4

Note: 1 – Very High, 2 – High, 3 – Average, 4 – Low and 5 - None

This finding reveals the true situation of the techniques in Nigeria. It is not tailoring along the opinion of Enshassi (1996), who advocates that any effective control of waste and materials must involve those who design the buildings; those who design the merchandise and the plant tools used in construction; and those who specify, describe and account for the work. Enshassi (1996) argues that much waste occurs from decisions made by people with little direct involvement in site operations – hence any good technique must incorporate them. This study reveals that adequate efforts are not made by construction practitioners to minimize waste outside the sites, especially at the design stage according to the view of Enshassi (1996). This should be an integral part of their techniques in addition to the ones highlighted in this study to properly minimize the occurrence of materials waste.

5. Conclusions and Recommendations

The study reveals:

- 23 causes of materials waste in Nigerian construction projects. Design changes top the list of these causes while packed delivery of materials is last.
- 14 control techniques adopted for the causes of materials waste. As many as 11 respondents signified good storage facilities.
- That the contribution of the control techniques to materials waste minimization is high.
- That materials waste minimization contributes to increased contractors' profits, reduced materials shortage, reduced projects' delay and cost.

Due to the aforementioned conclusion, the study recommends that:

- Practitioners should be cognizant of these 23 causes and guide against them in their projects.
- Professionals should adopts these 14 control techniques and involve others that can minimize material waste outside site operations.
- Stakeholders should endeavour to improve on materials waste minimization to enjoy better projects' performance.

6. References

Agapiou, A., Clausen, L.E., Flanagan, R., Norman, G., and Notman, D. (1998). "The role of logistics in the materials flow control process". *Construction Management and Economics*, 16,131-137.

Akanni, P. O. (2007). "An empirical survey of the effect of materials wastage on contractors' profit level in construction projects". *The Professional Builders*, 35-46.

Alwi, S., Hampson, K., and Mohamed, S. (2000). "Waste in the Indonesian Construction Projects". *Proceedings CIBW107 –1*, November.

Bossink, B. A. G., and Brouwers, H. J. H. (1996). "Construction waste: Quantification and source evaluation". *Journal of Construction Engineering and Management,* 55-60.

Enshassi, A. (1996). "Materials control and waste on building sites". *Building Research and Information,* 24(1).

Garas, G. L., Anis, R. A., and Gammal, A. E. (2001). "Materials Waste in the Egyptian Construction Industry". *Proceeding of the 9th International Group for Lean Construction conference,* Rent Ridge Crescent, Singapore, 6-8 Aug.

Greenwood, R., Jones, P., Snow, C., and Kersey. (2003). "Construction waste minimization-Good Practice Guide".

Oladiran, O.J. (2008). "Materials wastage: Causes and their contributions' level." *Proceedings of CIB-2008*, 15-17 November, Dubai.

Olomolaiye, P. (1995). "Materials management practice and waste on Nigerian building sites". *Building Research and Information,* 19(1), 38-42.