MATERIALS MANAGEMENT AND WASTE MINIMISATION ON CONSTRUCTION SITES IN LAGOS STATE, NIGERIA

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Abstract

The construction industry has been characterized as one that produces the highest amount of solid waste among all industries. Waste incurs additional cost either through it being carted away, or that which results from the actual rework. The aim of this study is to assess levels of selected materials waste and method of minimization of waste. The study was conducted in Lagos State, Nigeria. The random sampling technique was employed in the selection of respondents for the study. The sampling frame consists of professionals in the building construction industry, namely, Architects, Builders, Engineers, Project Managers, and Quantity Surveyors. A total of seventy-two (72) questionnaires were analysed for the study, using the descriptive statistics statistical tool.

Findings include that the main sources of construction waste are rework / improvement, materials handling and storage, damage to work by other trades, transportation, last minute client requirements, weather, equipment, and familiarity with construction technology. Conclusions include that materials wastage impacts on the contractor in the form of increased construction duration and cost, and it jeopardises the chances of a contractor winning further projects. Therefore, it is recommended that contractors should be conscious of the production of qualify products, plan well laid out sites before commencing work, and employ competent and trustworthy workers for their operations.

Keywords: Materials Management, Waste minimisation, Construction, Project sites

1. Introduction

Construction material waste can be defined as "any material, apart from earth materials, which need to be transported elsewhere from the construction site or used within the construction site itself for the purpose of landfilling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to material damage, excess, non-use, or non-compliance with specification or being a by-product of the construction process." (Ekanayake and Ofori, 2000). Materials contribute 70% of the total cost of a building project Seeley (1995). Approximately 136 Million tons of building related construction and demolition (C&D) debris is generated each year in the US Sandler and Swingle (2000), and in the UK 70 Million tons of C&D is generated DETR, (2000). Therefore, material management is an important element in project planning and control, and minimisation of waste should be given adequate attention. One of the primary focuses of a contractor is to deliver a project safely while maximising profit. Contractors need to survive, and this is based on the profit realised as a result of their expertise.

Poor materials management can also result in substantial, but avoidable costs during construction. This could result in contractor's use of insufficient materials and eventually non-conforming to specification, stemming from inadequate quantities of material usage for production. There are grave consequences that could result from poor materials management, which could result in insufficiency of material for production on site, forcing contractors to produce non-conforming products. Firstly, the use of insufficient quantities of materials could lead to the partial or entire collapse of a structure. Weak spots on a structure are liable to collapse, because of inadequate strength to withstand both the dead and imposed loads. Secondly, it could lead to lack of patronage of the contractor, implying that the contractor cannot secure contracts, and ultimately result in liquidation. This means that both the contractor and his / her employees will be non-operational and unemployed. Thirdly, it is a measure of a contractor's competence. A collapsed building, which is attributable to inadequate strength of components of a building, could either be as a result of lack of construction knowledge on the part of the contractor, or the contractor use of less quantity of materials for production. Fourthly, it exposes the level of competence of professionals in the industry at the instance of collapse of building, and that the industry is not safe. It must be understood that the infrastructure and development of a nation largely on the construction industry, and then mainly the building sector thereof. Therefore, it is of paramount importance that materials are well managed on site to minimise wastage and its associated problems.

2. Literature review

2.1 Sources of construction waste

The building construction process consists of activities. Each activity possesses its risk of failure or success. The eventual result of failure leads to waste of materials, time and money. Greenwood (2004) and Formoso *et al.* (2002) identifies twenty-six (26) sources of construction waste. They include, transit waste, stockpile waste, application waste, conversion waste, residual waste, cutting waste, design, ordering and non-delivery, materials handling and storage, inventory, damage to work done by other trades, buying materials, substitution, waiting time, transportation, processing, movement, production of defective product, last minute client's requirements, construction method, familiarity with the construction technology, rework/improve, site space, unforeseen ground condition, weather, and equipment.

2.2 Benefits of construction material waste management

An effective material waste management system can realise benefits for a contractor. Previous studies by the Construction Industry Institute (CII) concluded that labour productivity could be improved by 6% and can produce 4-6% additional savings (Bernold and Treseler, 1991). Tam and Tam (2006), Kartam et al. (2004), and Tam (2008) list a range of benefits from managing construction waste; they include reduction in the overall cost of materials, better handling of materials, reduction in duplicated orders, materials on site when needed and in the quantities required, improvement in labour productivity, improvement in project schedule performance, enhanced quality control, better field material control, better relations with suppliers, reduction in materials surplus, reduction in storage of materials on site, labour savings, reduction in purchasing costs, and better cash flow management.

Against these various benefits, the costs of acquiring and maintaining a materials management system has to be compared. However, based on the aforementioned advantages it can be concluded that investment in such systems can be quite beneficial.

3. RESEARCH METHODOLOGY

This study was conducted in Lagos State, Nigeria. The sample frame for this study consisted of architects, builders, engineers, project managers, and quantity surveyors. A structured questionnaire was administered to the sample frame, after selecting them by means of a simple random sampling technique. Descriptive statistics was employed for data analysis. Note, system means the number of respondents that did not indicate any value to this question in view.

3.1 Questionnaire Response and Characteristics of Respondents

A total of 100 questionnaires were administered and 72 were returned completed and included in the analysis of the data, which equates to a 72% response rate. The sample consisted of Architects, Builders, Engineers, Project Managers, and Quantity Surveyors.

Table 1 indicates the characteristics of the respondents surveyed. Based on the academic and professional qualifications, years of experience and number of projects handled by the respondents, it can be inferred that the data obtained from the respondents can deemed reliable. 91.7% of the respondents were involved with the building sector. Engineers, architects, and project managers predominated in terms of discipline. 54.2% of respondents had 6-10 years' experience, and a further 20.8% had 11-15years' experience. MSc / MTech level (37.5%) qualifications ranked marginally first in terms of qualifications followed by BSc / BTech (33.3%), and HND (20.8%). MNIQS (25%) predominated in terms of professional association. 33.3% of respondents had undertaken 6-10 projects, and 25% had undertaken 11-15 and also 16-20 projects.

Table 1: Background information of respondents

Sector involved with	**Frequency**	**Percentage (%)**
Type of organisation		
Building	66	91.7
Civil	6	8.3
Total	72	100.0
Discipline of respondents		
Project manager	15	20.8
Engineer	21	29.2
Quantity surveyor	9	12.5

Architect	15	20.8
Builder	9	12.5
Total	69	95.8
System	3	4.2
Total	72	100
Years of experience		
≤ 5yrs	12	16.7
6-10yrs	39	54.2
11-15yrs	15	20.8
16-20yrs	3	4.2
> 20yrs	3	4.2
Total	72	100
Academic qualification		
ND	3	4.2
HND	15	20.8
BSc / BTech	24	33.3
MSc/ MTech	27	37.5
PhD	3	4.2
Total	72	100
Professional affiliation		
MNIQS	18	25.0
MNIOB	6	8.3
MNSE	6	8.3
MNIA	9	12.5
FNIQS	3	4.2
FNIA	3	4.2
Total	45	62.5
Number of projects undertaken		
1-5	9	12.5
6-10	24	33.3
11-15	18	25.0
16-20	18	25.0
> 20	3	4.2
Total	72	100.0

3.2 Presentation and Discussion of Results

This section presents and discusses the results pertaining to material waste on construction sites.

Table 2: Extent of concrete wastage

Range of wastage	Frequency	Percent (%)
2.6-5.0%	9	12.5
5.0-7.5%	18	25
7.6-10%	37	51.4
above 10%	3	4.2
Total	67	93.1
System	5	6.9
Total	72	100

Table 2 presents the percentage concrete wastage on building construction sites. Approximately half of the respondents (51.4%) maintain that the percentage waste of concrete on sites ranges between 7.6-10.0%, and 25% that it ranges between 5.0-7.5%. Therefore, effectively 76.4% maintain that it ranges between 5.0-10.0%.

Table 3: Extent of cement wastage

Range of wastage	Frequency	Percent (%)
0-2.5%	9	12.5
2.6-5.0%	16	22.2
5.0-7.5%	31	43.1
above 10%	8	11.1
Total	64	88.9
System	8	11.1
Total	72	100

Table 3 presents the percentage cement wastage on construction sites. The highest percentage (43.1%) of respondents maintains that the level of percentage waste ranges between 5.0-7.5%.

Table 4: Extent of water wastage

Range of wastage	Frequency	Percent (%)

0-2.5%	8	11.1
2.6-5.0%	8	11.1
5.0-7.5%	8	11.1
7.6-10%	28	38.9
above 10%	15	20.8
Total	67	93.1
System	5	6.9

Table 4 indicates the extent of water wastage on construction sites. The highest percentage (38.9%) of respondents maintains the percentage waste ranges between 7.6-10.0%.

Table 5: Extent of roof tile wastage

Range of wastage	**Frequency**	**Percent (%)**
0-2.5%	14	19.4
2.6-5.0%	29	40.3
5.0-7.5%	19	26.4
7.6-10%	5	6.9
Total	67	93.1
System	5	6.9
Total	72	100

Table 5 indicates the extent of roof tile wastage on construction sites. The highest percentage (40.3%) of respondents maintains the percentage wastage ranges between 5.0-7.5%.

Table 6: Extent of cement mortar wastage

Range of wastage	**Frequency**	**Percent (%)**
2.6-5.0%	18	25
5.0-7.5%	34	47.2
7.6-10%	6	8.3
above 10%	6	8.3
Total	64	88.9
System	8	11.1
Total	72	100

Table 6 indicates the extent of cement mortar wastage on construction sites. The highest percentage (47.2%) of respondents maintains the percentage wastage ranges between 5.0-7.5%.

Table 7: Extent of floor tile wastage

Range of wastage	Frequency	Percent (%)
0-2.5%	5	6.9
2.6-5.0%	8	11.1
5.0-7.5%	21	29.2
7.6-10%	13	18.1
above 10%	20	27.8
Total	67	93.1
System	5	6.9

Table 7 indicates the extent of floor tile wastage on construction sites. The highest percentage (29.2%) of respondents maintains the percentage wastage ranges between 5-7.5%, , and 27.8% > 10%.

Table 8: Extent of paint wastage

Range of wastage	Frequency	Percent (%)
0-2.5%	3	4.2
2.6-5.0%	19	26.4
5.0-7.5%	6	8.3
7.6-10%	21	29.2
above 10%	18	25
Total	67	93.1
System	5	6.9

Table 8 indicates the extent of paint wastage on site. 29.2% maintain that paint wastage on site ranges between 7.6-10%, 26.4% between 2.6-5%, and 25% > 10%.

Table 9: Extent of brick and block wastage

Range of wastage	Frequency	Percent (%)
2.6-5.0%	8	11.1
5.0-7.5%	25	34.7
7.6-10%	26	36.1
above 10%	8	11.1

Total	67	93.1
System	5	6.9
Total	72	100

Table 9 indicates the extent of brick and block wastage on construction sites. The highest percentage (36.1%) of respondents maintain that brick and block wastage ranges between 7.6-10%, followed by 34.7% 5-7.5%.

Table 10: Extent of reinforcement wastage

Range of wastage	Frequency	Percent (%)
0-2.5%	12	16.7
2.6-5.0%	16	22.2
5.0-7.5%	31	43.1
7.6-10%	8	11.1
Total	67	93.1
System	5	6.9
Total	72	100

Table 10 indicates the extent of reinforcement wastage on construction sites. The highest percentage (43.1%) of respondents maintains that the percentage wastage ranges between 5-7.5%.

Table 11: Extent of formwork wastage

Range of wastage	Frequency	Percent (%)
0-2.5%	3	4.2
2.6-5.0%	24	33.3
5.0-7.5%	28	38.9
7.6-10%	9	12.5
Total	64	88.9
System	8	11.1
Total	72	100

Table 11 indicates the extent of formwork wastage on construction sites. The highest percentage (38.9%) of respondents maintains that wastage ranges between 5-7.5%, and 33.3% between 2.6-5.0%. Therefore, effectively 72.2% maintain that it ranges between 2.6-7.5%.

Table 12: Extent of roofing sheet wastage

Range of wastage	Frequency	Percent (%)
0-2.5%	8	11.1
2.6-5.0%	25	34.7
5.0-7.5%	29	40.3
7.6-10%	5	6.9
Total	67	93.1
System	5	6.9
Total	72	100

Table 12 indicates roofing sheet wastage on construction sites. The highest percentage (40.3%) of respondents maintains that wastage ranges between 5.0-7.5%, 34.7% between 2.6-5.0%. Therefore, effectively 75% maintain that it ranges between 2.6-7.5%.

From Tables 3-13, it can be observed that four construction materials, namely concrete, water, paint, and bricks and blocks have the same percentage waste and account for the highest percentage waste bracket (7.6-10%). This is attributable to many reasons such as handling, cutting, and application, which could be as a result of inadequate experience on the part of the workers.

Table 13 indicates the respondents' perceptions with respect to the factors causing material wastage on construction projects in terms of a mean score (MS) ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (Minor) and 5 (Major). It is notable that 16 / 26 (61.5%) of the MSs are > 3.00 which indicates that the factor is more a major than a minor cause of material waste. The main source of construction waste is rework / improvement (MS = 3.90). Rework / improvement as a result of poor workmanship or lack of adherence to specification, constitute a major source of material waste on site. Next is conversion waste, materials handling and storage, damage to work done by other trades, transportation, last minute client's requirement, familiarity with construction technology, and weather elements (MS = 3.70). Conversion waste results mainly from concrete, as the waste arises from materials handling and storage based on damages either during off-loading and placing in to position and taking for use. Damage to work leads to rework, hence wastage of initial work done in the form of materials, time, and cost. Next to rework / improvement factor cause of waste is stockpile waste, design, and movement are sources where wastage of materials frequently occurs. Stockpile waste can result from the load of materials exceeding the capacity of the material below, which leads to damages. Design waste results from the need to use a certain size of material or component relative to the design, while waste resulting from movement results from spillage of materials.

Table 13: Factors causing material wastage

Factor	MS	Rank
Rework / Improvement	3.90	1

Conversion waste	3.70	2
Materials handling and storage	3.70	2
Damage to work done by other trades	3.70	2
Transportation	3.70	2
Last minute client requirements	3.70	2
Familiarity with the construction technology	3.70	2
Weather	3.70	2
Equipment	3.70	2
Stockpile waste	3.50	10
Design	3.50	10
Movement	3.50	10
Cutting waste	3.30	13
Construction method	3.30	13
Site space	3.30	13
Processing	3.00	16
Transit waste	2.70	17
Residual waste	2.70	17
Ordering and non-delivery	2.70	17
Inventory	2.70	17
Unforeseen ground conditions	2.70	17
Substitution	2.50	22
Waiting time	2.50	22
Application waste	2.50	22
Buying materials	2.30	25
Production of defective product	2.30	26

Table 14: Impact of construction material wastage on contractors

Material	**Percentage frequency (%)**	**Position**
Poor workmanship as a result of shortage of materials	65.0	1
Insolvency as a result of loss	65.0	1
Increase in construction cost	57.0	3
Reduced competiveness	54.0	4
Increase in construction duration	51.0	5

Leads to poor workmanship	45.0	6
Brings the contractor into disrepute	45.0	7
Decrease in turnover	36.0	8

Table 14 indicates the impact of construction material wastage on the contractor. ’Poor workmanship as a result of shortage of materials’ (65%) and ‘insolvency as a result of loss’ (65%) predominate. These are followed by ‘increase in construction cost’ (57%), ‘reduced competitiveness’ (54%), and ‘increase in construction duration’ (51%).

Table 15: Impact of measures to controls material wastage

Measure	MS	Rank
Taking inventory of materials on site before use	3.80	1
Determine daily allocation of materials to different operations on site	3.60	2
Weekly materials return to be submitted by the head of operation on site	3.50	3
Employ competent and trustworthy hands	3.50	3

Table 15 presents the respondents’ perceptions with respect to the impact of measures to control material wastage on construction projects in terms of a MS ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (Minor) and 5 (Major). Taking inventory of materials on site before use (MS = 3.80) is the most effective measure to control material wastage on construction sites, as it serves as a guide relative to detecting the source of wastage against the actual materials for production. Next is determining daily allocation of materials to different operations on site (MS = 3.60). The instance that the amount of materials used exceeds the daily materials required for production, it is an indicator of excessive wastage. Two control measures have the same MS, they are weekly materials return to be submitted by the head of operation on site, and employ competent and trustworthy hands. It is notable that all the measures have MSs > 3.00, which suggests that all the measures have a major as opposed to a minor impact in terms of controlling materials wastage.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Rework / improvement contribute the most to material wastage. Other causes such as materials handling and storage, damage to work by other trades, transportation, last minute client requirements, weather, equipment and familiarity with construction technology, also contribute substantially to material wastage. Other causes that contribute to materials wastage include poor handling of materials, delivery of storage facilities, poor storage facilities, and lack of competent workers. Therefore, it can be concluded that site management should focus on planning and controlling of all resources, but also organising and leading.

The impact of material wastage on contractors is significant and cannot be ignored: poor workmanship; insolvency; increase in construction cost; increase in construction duration, and reduced competitiveness. Control measures can be implemented to minimize material wastage, which include taking inventory of materials on site before use, determination of daily allocation of materials to different operations on site, and employing competent and trustworthy hands.

4.2 Recommendations

In view of the conclusions, the following recommendations were made:

- Contractors should focus on quality in their construction activities in order to mitigate rework / improvement which is the major cause of material wastage.
- Contractors should also adopt appropriate materials handling and storage methods to mitigate material wastage.
- Contractors should plan and organise site layouts to avoid experiencing difficulty in movement of materials on site that causes wastage.
- Clients should be briefed and are enjoined to provide the requisite information to mitigate last minute changes so that contractors can manage their materials effectively.
- Contractors should make use of various measures of control that can minimize wastage.

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