Evaluation of Building Material Wastage level in the Nigeria Construction Industry

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Abstract:
The study focused on evaluation of factors contributing to material wastages, materials prone to excessive wastage, percentage wastage, wastage index & wastage level, ways of minimizing material wastages and evaluation of volume of wastages generated from building projects. Four construction materials were taken into consideration, namely; concrete, block, timber and reinforcement. Structured questionnaire was used in the quantitative data gathering and analysed. Results shows that construction related factors are the most frequently occurring, and the most significant contributors to overall wastage of material on site. Blocks and Timber (formwork) have the highest wastage index signifying the wastage level of these two materials, compare to concrete and reinforcement. Effective material planning and control policy were perceived to be the most significant strategy for minimizing material wastage. The result also shows that as the volume of material-wastes generated from building construction project increases, so the total cost of building increases and variations in the increase of material-waste generated from building projects accounts for 97.3% in the shortage of materials apportioned for each item in the bill of quantities (BOQ).

Keywords:
Construction, Materials, Wastes, Nigeria

Introduction

Material wastages on building construction project are a global problem, which represents loss of profits. According to Ekanaya (2000), "waste" is a familiar term in the industry world-wide, it is difficult to compare construction waste figures from different construction sites due to a number of reasons, which includes the use of varying definitions; and the use of different estimation approaches. Material wastage is defined by Chartered Institute of Building (1979) as "the difference between the value of those material delivered and accepted on the site and those properly used as specified and as accurately measure in the work, after deducting the cost of substitute materials and those transferred elsewhere". Waste is also perceived as construction material that is additional to the actual quantity required in the work as indicated in the contract document, but nevertheless required or used in performing the work.

It is incontrovertible that material is the most central construction input around which resolves the efficiency or inefficiency of labour, plant and equipment. Several authors asserted that as at late 1974 the quantities of bricks wasted on housing projects were

enough to build 15,000 houses. Motete, Mbachu, and Nkado (2003) confirmed that bricks and concrete have the highest wastage indices signifying that wastage levels of these two materials and their contribution to construction cost overruns are the most critical compared with other building materials in a project where they are used. The sights of broken blocks and wasted heaps of concrete littering all over most construction sites in Nigeria could attest to this finding.

However, material wastage has serious cost implications for stakeholders in the building procurement process; for the contractor, it reduces significantly the expected profit from a project; and for the developer, it escalates the development costs and undermines value. To the consumers and the society at large, it results in high purchase price and rental charges. Hence, the need to analyse the effects of material wastage with a view to minimizing material wastages on building construction projects exists.

Literature Review

Nwachukwu (2004) sees material management as the single manager organization concept embracing the planning, organizing, motivating and controlling of all those activities and personnel principally concerned with the flow of material into an organization. According to Rogoff and Williams (1994), 29% of solid-wastes in the United States of America (USA) are construction wastes. These investigations demonstrated that construction business is a large contributor to waste generation. The benefits of managing construction wastes are multiple. It benefits both the environment and the construction firms in terms of cost reduction. Tam, Shen and Tam (2007) also opined that reducing building material wastages can achieve higher construction productivity, save time and achieve safety improvement.

The literature reported that some materials are more prone to waste than others: concrete, masonry and pipes have the highest average wastage level of all the materials studied. The same study estimate that wastage could be as much as 100% more than usually allowed for in estimating. Johnston (1997) asserted that more than 6 million tons of sand is wasted during contract and that 7 million square meters concrete blocks either disappeared or unaccounted for during valuations; and losses of timber amounted to more than 11 million squares meters. The potential effect of material wastage on contract sum is frightening, but positive action needs to be taken to remedy the situation in Nigeria.

Material Waste Management in the Construction Industry

Waste in the construction industry has been the subject of several research projects around the world in recent years. Some of them have focused on the environmental damage those results from the generation of material waste (Formoso *et al*., 1999). The Hong Kong Polytechnic and the Hong Kong Construction Association (1993) conducted a research on construction waste aimed to reduce the generation of waste at source, and to proposed alternative methods for treatment of construction waste in order to reduce the demand for final disposal areas. Bossink and Brouwers (1996) conducted a research project in The Netherlands, concerned with the measurement and prevention of construction waste regarding sustainability requirements.

Causes of Construction Site Waste Generation

Many factors contribute to construction waste generation. Waste may occur due to one or a combination of many causes. Crittenden and Kolaczkowski (1995) suggest human and mechanical factor. Additional sources of construction waste include: design; procurement; handling of materials; operation; and so on. Motete *et al*. (2003) identifies various factors contributing to material wastage, namely, client, design, management and construction related, material storage and supply and phenomenal occurrences. The factors identified after review of literature were placed under four major sources as: design; operational; material handling and procurement, mainly for the practical purpose of the survey. .

Research Methodology

The target respondents for the study were consultants (Quantity Surveyors, Engineers) and contractor, operating in major cities in Nigeria, whom the researcher believed had first-hand information of things happening on building construction sites. Descriptive statistics tools were employed in analysing the data that are presented. Ranking was used to analyse some of the data through the use of factor analysis, significant index and ranking of best value contributing factor (BVCF), while mean was used to assess the factors contributing to material wastages and suggested strategies for minimizing material wastages.

The scales for the questionnaires were used to calculate the mean score for each factor, which was later used to determine the relative ranking of different factors by assigning ranks to the means scores with low mean scores assigned low ranks and high scores allocated high ranks. This is given in equation below. The relative significance index of the five CSFs (critical success factors) and those of the SSFs (sub-success factors) under each CSF were calculated separately. The 0–5 scale used in the questionnaire survey was converted to a 0–100 scale, with 0 representing the lowest and 100 the highest.

Significance index

$$Si = \frac{R_i0 \text{ X } 0 + R_{i1} \text{ X } 20 + R_{i2} \text{ X } 40 + R_{i3} \text{ X } 60 + R_{i4} \text{ X } 80 + R_{i5} \text{ X} 100}{R_{i0}+R_{i1}+R_{i2}+R_{i3}+R_{i4}+R_{i5}}$$

$$= \frac{20R_{i1} + 40R_{i2} + 60R_{i3} + 80R_{i4} + 100R_{i5}}{R_{i0} + R_{i1} + R_{i2} + R_{i3} + R_{i4} + R_{i5}}$$

$$\text{Relative indexes} = \frac{\text{Mean of Reponses}}{\sum \text{Mean of Reponses}}$$

The concept of material wastage index was developed in this study as an indicator of the wastage rate of a given material and the contribution of the material wastage to construction cost. The index was computed using the formulae adopted from Motete *et al*. (2003); Crittenden and Kolaczkowski (1995); Tam *et al*. (2007) in the equation below:

(V) = Truck volume (m3)
(N) = Total no of truck loads for waste disposal
(W) = Total wastage generated by the project (m3) = (V) x (N)
(C) = Waste index = W/GFA (m3/m2)

The index was computed as follows in equation 3 below:

$$\text{Wastage level (\%)} = \frac{Mp - Mu}{Mp} \times 100\%$$

Where Mp is the purchased material, Mu is the used material (m^2 in concrete, Tonne for reinforcement, m^2 for timber formwork and m^2 for block work).

Findings and Discussion

The results showed that (Table 1a and 1b) out of the six broad categories of factors, under client related contributed significantly, these are; expectation of two high standards and undue interference with the execution of the project. Inclusive or incorrect standard specification and detailing errors pertain to design.

Construction related factors include: idle (waiting periods), abnormal wear of equipment, misinterpretation of drawings, pilfering and vandalism and excess material input, especially due to over-excavation. And in terms of management: delay in planned activities, mode of material delivery, site accidents and acts of God.

The results also show that majority of the respondents perceived effective material planning and control as the most effective strategy for minimizing material wastages. This concurs with the findings of Motete *et al*. (2003) who also laments on the "serious lack of awareness and care amongst management and supervisory employees regarding the utilization of materials and equipment.

From the results in Figure 1 & 2, it can be deduced that blocks and timber formwork have the highest wastage indices, signifying that the wastage levels of these two materials and their contributions to construction cost overrun are the most critical, compared to concrete and reinforcement. The sights of broken blocks and wasted heaps of timber all over construction sites could attest to this finding. Not only do they have serious cost implications, the health and safety (H&S) risks posed by their littering are quite alarming.

Results of analysis on material wastage index and cost of building project display strong statistical relationships. In experiment 1, as the changes in volume of material wastage generated from construction projects increases, so the total cost of building projects increases and the result is statistically significant (R2=80.2%). And in experiment 2, variations in the increase of material wastages generated from construction projects were responsible for 97.3% in the shortage of materials apportioned for each item in the BOQ**.**

Table 1a: Responses from Factors contributing to Material Wastage on Significance Indexes of Sub-factors

Success sub-factors	VH	H	AVG	L	VL	Significance indexes	Relative indexes	Rank
	5	4	3	2	1			
Client related								
Undue pressure to deliver, resulting in crash programme	7	7	9	2	1	46.9231	0.2283	3
Expectations of too high standards	2	7	7	6	2	59.1667	0.2879	1
Late changes/alterations	9	6	5	4	1	45.6	0.2219	4
Undue interference with the execution of the project	0	15	5	5	1	53.8462	0.262	2
∑ **Mean**						**205.5359**		
Design Related								
Architect's variation instruction	4	10	7	4	0	48.8	0.3115	3
Detailing errors	4	6	12	4	0	52.3077	0.3339	2
Inclusive or incorrect standard specifications	0	15	4	7	1	55.5556	0.3546	1
∑ **Mean**						**156.6632**		
Construction Related								
Poor supervision	9	11	2	2	4	46.4286	0.11	7
Pilfering and vandalism	4	6	8	3	5	59.2308	0.1404	4
Faulty workmanship and abortive work	7	10	5	3	2	47.4074	0.1123	6
Excess material input especially due to over-excavation	4	6	8	8	1	57.037	0.1352	5
Misinterpretation of drawings	3	4	8	7	4	63.8462	0.1513	3
Abnormal wear of	0	4	8	9	5	71.5385	0.1695	2
Idle (waiting periods)	0	3	7	4	9	76.5217	0.1813	1
∑**Mean**						**422.0101**		

Table 1b: Responses from Factors contributing to Material Wastage on Significance Indexes of Sub-factors

Management Related								
Poor planning and organization	7	10	6	4	0	45.1852	0.2223	3
Poor material management practices	10	9	4	1	3	43.7037	0.215	4
Over-estimating the quantity required	2	12	5	4	2	53.6	0.2637	2
Delays in plan activities	0	6	15	5	1	60.7407	0.2989	1
∑ **Mean**						**203.2296**		
Supply and Storage Related								
Poor storage	9	6	6	3	2	46.9231	0.2041	4
Improper material handling	5	10	6	5	0	48.4615	0.2108	3
Mode of delivery (e.g. loose as against packaged forms)	2	7	6	4	5	62.5	0.2719	2
Manufacturing defects	0	4	8	7	6	72	0.3132	1
∑ **Mean**						**229.8846**		
Phenomenal Occurrences								
Negligence / carelessness	1	12	7	6	1	55.5556	0.2859	3
Damage by inclement conditions	2	4	8	8	4	66.1538	0.3405	2
Site accidents and acts of God	2	2	7	9	7	72.5926	0.3736	1
∑ **Mean**						**194.302**		

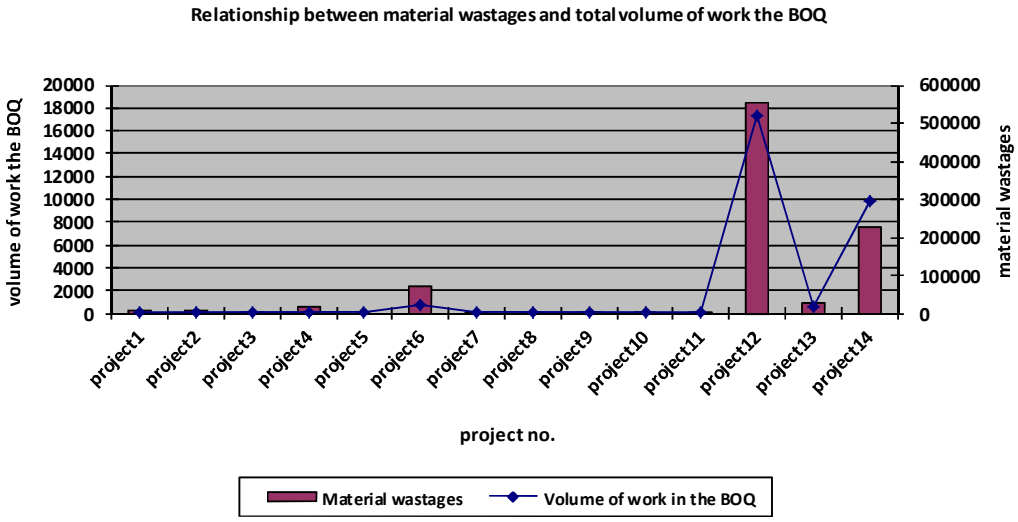

Figure 1: Material wastages on building projects and total volume of work in the B.O.Q

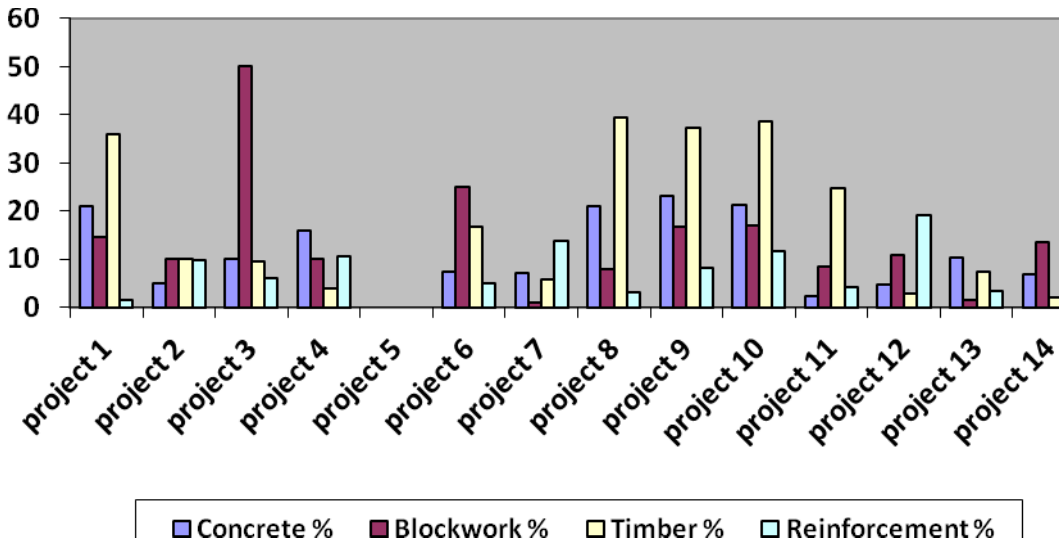

Figure 2: Examination of materials prone to excessive wastages and their relative contribution to cost overrun

Conclusions and Further Research

Because efficient use of materials reduces the quantities of waste generated, the need to manage the materials through disposal or recycling in construction industry cannot be over emphasised. The factors underlying material wastages on building sites could be

broadly categorized into design, management and construction related as well as storage and supply and phenomenal occurrences. Construction related factors are the most frequently occurring and contribute most significantly to overall material wastage levels. The leading factors in all groups are poor supervision (construction related), poor planning and organization (management related) and improper storage (storage and supply). The materials of greatest concern in terms of high wastage rates and contribution to construction cost overruns are blocks and timber formwork.

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