CONSTRUCTION MATERIAL WASTE MANAGEMENT PRACTICES IN SELECTED CONSTRUCTION SITES IN ABUJA, NIGERIA

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Abstract

Waste in the construction industry has been the subject of several research projects around the world in recent years. The high volume of waste generated in construction necessitates this study on construction waste minimization practices carried out at selected sites in Abuja, Nigeria. This is with a view to minimizing construction waste through the waste hierarchy principles in addition to other site waste management practices. The research studied the practices used in the management of construction material waste in selected construction sites in Abuja through structured questionnaires administered on construction professionals at the selected sites. The study found that there was no specific legislation on the control of construction waste; and construction professionals felt that completion of projects within a time frame, according to specification and within budget was more important than controlling the quantity of waste produced. While these professionals agreed that there was a need to incorporate site waste management practices, they not only lacked implementation guidelines, but their construction organizations did not have existing policies on site waste management as well. The study therefore recommends that waste management practices should be made an integral part of construction project objectives. The concept of waste hierarchy and efficient utilization of construction materials should be backed by legislation.

Keywords: Construction waste, waste hierarchy, waste management

1. Introduction

Existing research on waste management indicates that waste can be generated at any stage of the construction process from inception, right through the design, construction and operation stages of the built facility (Poon, Yu & Jaillon, 2004; Ekanayake & Ofori, 2004; Wahab & Lawal, 2011). Construction has a major and direct influence on many other industries both through the purchase of inputs and the provision of finished products to other industries, and raw materials account for the largest input into construction activities in the range of 50-60% of the total cost of a project (Formoso, Isatto & Hirota, 2000).

Construction waste is a growing problem in many countries since construction and building activities contribute to approximately 30 percent of overall landfill volumes (Poon, 2007). In Nigeria, for example, not all the materials procured are utilized efficiently; rather, there has been increasing over-consumption of materials during construction. The goal of waste management is to reduce waste sent to landfills by 43%, material consumption by 40%, energy usage by 40% and savings in waste handling charges by 50% (Waste Resource

Action Program (WRAP), 2011). A paradigm shift from the conventional attitude to waste management to a new thinking in waste management may contribute significantly to waste elimination and efficient utilization of scarce non-renewable material resources.

This paradigm shift is required to mitigate the rising threat to the sustenance of naturally occurring material resources used for constructional purposes, for measures to address the issue have not been sufficiently engaged in most of the housing construction sites (Akinkurolere, 2013). Shortage of good natural aggregates in many urban areas is increasing greatly and calls for concern. Any attempt to contribute to material resource conservation and preservation will significantly contribute to the sustainability of construction industry. In addition, the distance between construction materials deposits and new construction sites in urban areas have grown wider and cost of transportation have gone higher. This has increased the cost of building construction materials, giving rise to an urgent need to incorporate waste management practices in construction site (Akinkurolere & Franklin, 2005).

2. Literature Review

The construction industry contributes to the socio-economic development of any country and also exploits natural resources in the creation of construction products thereby causing carbon footprints and environmental degradation through resource depletion, energy consumption, air pollution and generation of waste in the acquisition of raw materials (Watuka & Aligula, 2003). Tam, Tam, Zeng and Ng (2007) posit that there are two reasons for applying waste hierarchy principles in waste management: the economic advantages and environmental advantages. The economic advantages include reduced project costs, better resource efficiency, reduction in materials going to landfills and competitive advantage during the tendering process while the environmental advantages include reduction in depletion of non-renewable material resources, reduced chances of desertification and erosion as well as minimization of immediate and future environmental pollution.

2.1 Construction waste

Waste management has been considered to be a major problem in the construction industry and in many large cities in the world (Begum, Siwara, Pereira & Jaafar, 2006), and has been the subject of several research projects in recent years. Some of these have focused on the environmental damage that results from the generation of material waste while others have focussed on the economic aspect of waste in the construction industry. The Environmental Protection Department (EPD) of Hong Kong (2000) defines construction waste as unwanted materials generated during construction, including rejected structures and materials, materials which have been over-ordered or are surplus to requirements, and materials which have been used and discarded. The term specifically refers to non-hazardous by-products resulting from activities during new construction and renovation. It is generated during the construction process because of factors such as site preparation, material use, material damage, material non-use, excess procurement and human error. Waste arises from a number of different activities carried out by the contractor during construction and maintenance and may include: wood from formwork and false work, material and equipment wrappings, unusable or surplus cement/grouting mixes, damaged/surplus/contaminated construction materials.

2.1.1 Material waste

Waste in construction can be classified into three main types: waste of materials, waste of time and waste of machinery (Ekanayake & Ofori, 2000). However, this research focuses on materials waste. Construction material wastes refer to materials from construction sites that are unusable for the purpose of construction and have to be discarded for whatever reason (Osmani, 2008). This definition excludes earth materials, but includes any other which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process (Ekanayake & Ofori, 2000).

2.1.2 Magnitude of waste in construction

Poon et al. (2004) reports a study of the measurement and prevention of construction waste in Hong Kong in which waste from seven materials was monitored in five house building projects. After sorting and weighing all the material wastes, the amount of direct waste by weight ranged between 1 and 10% in weight of the purchased amount of materials. Further, it was found that an average 9% (by weight) of the total purchased construction materials ended up as site waste. A similar study by Begum et al. (2006) in Malaysia showed the following composition and percentage of material wastes: Soil 27%, wood 5%, brick and blocks 1.16%, metal product 1%, roofing material 0.20%, plastic and packaging materials 0.05%, concrete and aggregate 65.80%. Jones and Greenwood (2003) obtained percentage of waste in ten materials as plaster board 36%, packaging 23%, cardboard 20%, insulation 10%, timber 4%, chipboard 2%, plastic 1%,electric cable 1%, and rubber 1% (Osmani, 2008).

Another study carried out by Kulatunga, Amaratunga, Haigh and Rameezden (2006) in Sri Lanka identified the main materials wastages as sand (25%), lime (20%), cement (14%), bricks (14%), ceramic tiles (10%), timber (10%), rubble (7%), steel (7%), cement blocks (6%), paint (5%) and asbestos sheets (3%).

Formoso et al. (2002) was one of the first studies on material waste in Brazil, involving a single case study based on data from an 18-storey residential building project that was chosen because all the records of materials supply and use were well kept by the construction company. Both direct and indirect wastes of 10 building materials were estimated. The waste percentages included both direct and indirect waste. The total waste was 18% of the weight of all materials purchased, representing an additional cost of 6%. One of the main contributions of this study was that it pointed out the importance of indirect waste in relation to direct waste. For instance, the amount of indirect waste of mortar was as much as 85% of the designed volume of plaster. This represents not only a waste of materials, but also a significant unnecessary additional load on the building structure.

2.1.3 Sources of materials waste

Construction waste stems from construction, refurbishment, and repairing work. Many wasteful activities can take place during both design and construction processes, consuming both time and effort without adding value to the client. Generation of the stream of waste is influenced by various factors such as natural waste. Natural waste is the wastage that costs more than what is saved if tried to prevent. There is a certain limit up to which waste of materials can be prevented. Beyond that limit, any action taken to prevent waste will not be viable, as the cost of saving will surpass the value of materials saved. Thus, natural waste is allowed in the tenders. The amount of natural waste is subjective to the cost effectiveness of the approaches used to manage it. The approaches vary from one scenario to another and so do the natural waste. For instance, the cost of preventing wastage in a project with a good material controlling policy will be less than that of a project which lacks such a policy. Thus, the acceptable level of natural waste in the former situation will be less than the later (Kulatunga et al., 2006; Formoso et al., 2002).

A major factor contributing to waste generation is direct waste. This type of waste can occur at any stage of the construction process before the delivery of material to the site and after incorporating the materials at the building (Kulatunga et al., 2006; Formoso et al., 2002; Shen et al., 2004). Categories of direct waste are summarised in Table 1.

Table 1: Categories of Direct Waste

Category	Reason	Example
Delivery waste	During the transportation of materials to the site, unloading and placing in addition to the initial storage	Bricks, glassing
Cutting and conventional waste	Cutting materials into various sizes and uneconomical shapes	Formwork, tiles
Fixing waste	Dropped, spoiled or discarded materials during fixing	Bricks, roof tiles
Application and residue waste	Hardening of the excess materials in containers and cans	Paint, mortar, plaster
Waste caused by other trades	Damage occurs by succeeding trades	Painted surfaces
Criminal waste	Theft and vandalism	Tiles, cement bags
Management waste	Lack of supervision or incorrect decisions of the management	Throwing away excess material

Source: Kulatunga et al., 2006

Indirect waste occurs when materials are not physically lost but misused on site, causing a monetary loss. An example of indirect waste due is making concrete slabs thicker or larger than specified by the structural design (Kulatunga et al., 2006; Formoso et al., 2002). In the study by Formoso et al., the amount of wasted mortar was as much as 85% of the designed volume of plaster. However, the mortar was not left unused or thrown away, but plastered on the building, representing a waste of materials, a waste of labour, and a waste of money.

Table2: Categories of Indirect Waste

Category	Reason	Example
Substitution waste	Substitution of materials in work, which will incur losses to either contractor or client	Use of facing bricks for common Bricks
Production waste	Contractor does not receive any payments for the works he has carried out	
Negligence waste	Site errors because of the condemned work or use of additional material	Over-excavation of foundation resulting in the use of additional concrete
Operational waste	Unavailability of proper quantities in the contract documents /the materials that are left on sites	Formwork

Source: Kulatunga et al., 2006

The wasted mortar also puts a significant unnecessary additional load on the building structure. Categories of indirect waste are presented in Table 2. These types of waste arise principally from the substitution of materials; from over allocation, where materials are applied in superior quantity of those indicated or not clearly defined in contract documents; from errors; and from waste negligence, where materials are used in addition to the amount required by the contract due to the construction contractor's own negligence (Shen et al., 2004).

2.2 Waste Management Practices through the 3-Rs Concept

When managing construction waste, it is important that practices reflect the waste hierarchy with waste prevention and minimization being the top priority followed by reuse and recycling. The primary aim is to prevent waste generation in the first place which minimizes the resources required to complete the job. Preventing waste is financially advantageous because it reduces the amount of materials being purchased and removes the need to transport waste off site. Waste prevention should be considered throughout all stages of the project especially during the design stage (Vaidya, 2009). This stage of the project offers the biggest opportunity to reduce waste by prioritizing waste prevention from the beginning of the project. During the construction phase, waste prevention can be carried out by ensuring that large volumes of materials are not delivered to site and through the use of a just-in-time delivery system. On the site waste can be minimized by careful storage, handling and the setting up of a central cutting station for some trades.

Trigunarsyah, Sofyan & Hendi (2006) identifies the three R's in construction waste management as follows: reuse, involving salvaging construction waste for other uses, recycling, involving transforming waste into new products and reincorporating them into the construction process) and reduction, which involves preventing or minimizing the generation of waste in the first place.

(a) Reduce

The first and most important step in cutting the amount of waste is reducing the quantity that is actually produced in the first place. There are a number of ways in which waste can 'designed out' just by reviewing how works are designed and installed. By planning work properly at the outset of a project, the amount of materials that end up as waste at the end of it can be greatly reduced (NSCC, 2008).

(b) Reuse

In today's industry, it is simply no longer justifiable to throw away perfectly good materials. As part of managing waste, builders should consider how to make use of common surplus materials arising from projects such as bricks and timber off-cuts either on the same site or at other sites. Where this is not possible, they should liaise with their suppliers about returning the materials to them. There are also websites where leftover building materials can be advertised, so that even if a particular contractor cannot reuse them, they may be able to find someone else that can. Reusing materials is not only good for the environment; it can also lead to cost savings by reducing the amount of new materials that are required (WRAP, 2011).

(c) Recycle

Recycling involves turning leftover/used materials into new products with the potential to turn 100% of non-hazardous construction waste into new products or energy. Recycling is crucial in diverting tonnes of valuable material from landfills. The key to successful recycling is to make it as easy as possible for everyone to segregate their waste. As a minimum, this requires assigning containers for different waste materials with clear signage explaining what can and cannot be disposed of in each one. Having provided the facilities, all site workers then need to be equipped and motivated to make the system work. Where segregating waste on site for recycling is not viable, a local waste transfer station should be contacted to collect and sort the mixed-waste (WRAP, 2011).

3. Methodology

The sample for the study was selected by purposive random techniques. First, interviews were conducted with some professionals to identify their level of awareness/knowledge, experience, interest and expertise in site waste management practices. Then, a structured questionnaire was administered in selected Federal Capital Development Authority and Abuja Property Development Company residential housing sites to built-up environment professionals namely; architects, builders, civil engineers, and quantity surveyors. The population for the study was drawn from the list of registered professionals working with Federal Capital Development Authority and Abuja Property Development Company. A total number of One Hundred and Ninety Four (194) professionals constituted the population for the study out of which approximately One Hundred Respondents were selected through stratified random sampling methods at 5% level of significance. The questionnaire was designed to include questions on the respondents' and organizations' profiles; the respondents' knowledge of waste management, existing legislation on waste management practices and company policies on waste management. These were 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. Mean and relative index ranking were used to analyse the data. The mean score for each of the factors contributing to site waste management practice was calculated and was used to determine the relative ranking in ascending order of agreement. A total of 100 questionnaires were distributed and 77 were duly filled and returned, representing 77% response rate.

4. Findings and Discussion

The results of the survey show how professionals rank of waste management practices by importance. As Table 3 shows, "material waste policy framework should be included at conceptual stage" ranks first, (MS=3.948), "being conscious of material waste is important" (MS=3.883) ranks second, "site waste management practices is important" (MS =3.870) ranks third. "The use of waste hierarchy concept and modular units can reduce cost and time" (MS =3857) ranks fourth, and "the use of material waste practices can improve project outcome" (MS=3844) ranks fifth. These results suggest that the professionals are willing to implement site waste management practice on site but lack the required framework and technology for its effective implementation.

These results suggest that there is a need to establish a policy on site waste management in order to tackle construction waste at the inception stage of a project. Also the attitude of construction professionals affects the practice of site waste management. The practice of site waste management is also important for a sustainable industry as can be seen from the third ranking factor. The use of prefabricated and modular units for improving project outcome and the environmental impact of site waste management practices are the least ranking factors which influence site waste management. This implies that there is a lack of motivation to use waste management practices to optimize the usage of material resources.

Table 3: Professionals' assessment of waste management practices

S/N		SA	A	N	D	SD	SWV	Mean	Rank
1	Site waste management practices is important	29	19	21	6	2	298	3.870	3
2	Material waste policy framework should be included at conceptual stage	30	25	12	8	2	304	3.948	1
3	Being conscious of material waste is important	28	24	15	8	2	299	3.883	2
4	environmental impact of material wastage is important	27	24	16	7	3	296	3.844	5
5	The use of waste hierarchy concept and modular units can reduce cost and time	24	27	17	8	2	297	3.857	4
6	The use of material waste practices can improve project outcome	27	24	16	7	3	296	3.844	5

Table 4 presents the survey of what should drive site waste management practices. "Government legislation framework is required for the implementation of site waste management practices" (MS=3948) ranks first; "making waste management a focus in addition to time, cost and quality" (MS =3857) ranks second; "include waste management plan at tendering and planning stage" (MS=3884) ranks third; while" include modern methods of construction, 3R's and lean concept at design stage" (MS=3844) ranks fourth.

Table 4: Drivers of Site Waste Management Practices

S/N		SA	A	N	D	SD	SWV	Mean	Rank
1	Government legislative framework is required for the implementation of Site Waste Management Practices	29	25	10	8	5	296	3.948	1
2	Making waste management a focus in addition to time, cost, quality	4	10	23	22	28	201	3.857	2
3	Include waste management plan at tendering and planning stage	25	21	17	10	4	284	3.883	3
4	Include modern methods of construction, 3R's and lean concept at design stage	4	7	15	21	30	165	3.844	4

The results show that there is a need for government to develop a legislative framework for the adoption of site waste management practices. Making site waste management a focus in addition to time, cost and quality should be encouraged for successful minimisation of waste on construction sites.

Table 5: Benefits of Site Waste Management Practices

S/N		SA	A	N	D	SD	SWV	Mean	Rank
1	Reduce final cost on project	25	21	17	10	4	284	3.688	2
2	Reduce material shortage on site	4	10	23	22	28	201	2.610	3
3	Reduce delay on project completion	4	7	15	21	30	161	2.142	4
4	Reduce material consumption	29	25	10	8	5	283	3.844	1

From Table 5 below, built environment professionals seem to be well aware of the benefits of site. In their ranking, reduction of material consumption (MS=3.844) ranks first; reduction of final cost on project (MS =3688) ranks second; reducing material shortage on site (MS=2.610) ranks third; while reducing delays on project completion (MS=2.142) ranks fourth.

The findings on the effects of site waste management practices on project outcomes reveal that site waste management practices have the tendency to reduce material consumption and reduce final cost of project. This study reveals that site waste management practice has great potential to contribute to optimal utilization of materials in construction projects.

5.0 Conclusion and Recommendations

In conclusion, the study shows that targets on construction waste management practices should be outlined in relation to company/government policy. This is because although the knowledge of professionals on site waste management practices seems adequate, there is still a lack of sufficient implementation on construction projects which could be as a result of non-availability of guidelines. On waste hierarchy concepts: reuse, reduce and recycling of material are poorly practiced at present. All of these practices need to be improved in line with the information contained in this study.

The following recommendations are made based on the research findings:

i. Government should introduce specific legislation governing the implementation of construction material waste management practices and follow up with strict monitoring to ensure compliance.

ii. Incentive schemes should be set up by government in the form of tax rebates for companies who adopt modern methods of construction which is targeted at reducing over consumption of materials.

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