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An Investigation into Material Wastage on Building Construction Sites
(Case Study of Selected Building Construction Sites in Osun State)

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Abstract – ***The paper appraises material wastage on selected Building Construction sites in Osun State. The study administered 60 questionnaires and analysis was done using percentage frequency table and relative importance index. Level of material wastage on Building Construction site and the factors influencing wastage on construction site were identified. The result revealed that Hollow Sandcrete block is the most wasted material on site followed by timber and then concrete. The study identified factors that contribute to wastage on site as Operational attribute (Poor workmanship), Design and Documentation attribute (lack of detailed information in the drawing), Site management and practices (Change of Instruction on site) and Environmental attributes (Poor access road and severe weather condition). The paper concluded that material wastage could lead to a great loss both on the side of the contractor as well as the client, if adequate measures are not put* in *place to curb material wastage on Construction site*.

Keywords: attributes, materials, wastage, construction site, concrete, sandcrete blocks

1.0 Introduction

According to Osmani and Glass (2008), the construction industry plays a leading role in improving the quality of the built environment, but its activities also impact on the wider environment in a number of ways, including waste production. The construction industry is associated with high energy consumption, resource depletion, large amount of waste generation, and is one of the biggest environmental polluters. The construction industry also consumes large quantities of raw materials (Sasidharani and Jayanthi, 2015). Construction material contributes significantly to the cost of construction project; therefore, material wastage has adverse impact on construction cost, contractor's profit margin, construction duration and can be a possible source of dispute among parties to a project (Enshassi, Mohammed and Abushaban, 2009).

Construction material constitutes a major cost component in any construction project. The cost of materials may be 50% to 70% of the total construction cost depending on type of projects til and Pataskar, 2013; Aribisala, 1990). Unfortunately, this large portion of materials is not wholly utilized by the industry. Evidence shows that approximately 40% of the waste generated globally originates from the construction and demolition of buildings (Holm, 1998) and this forms a major portion of the solid waste discarded in land-fills around the world. Almond (2001) in his research publication declared that wastes from construction industry account for 44% of total waste generated in developed countries while it is about 30% in developing nations. Materials are very vital on building sites, but not all the materials delivered to site are used for the purposes for which they have been ordered for and the subsequent disappearance of these materials constitutes part of waste. Waste according to Polat and Ballard (2005), is defined as "any substance or object that was discarded, intended to be discarded, or are required to be discarded which is subjected to a number of regulatory requirements.

It is important to manage all materials from the design stage to the construction stage of the project as poor handling of construction materials affects the overall performance of construction projects in terms of time, budget (cost), quality and productivity (Bamidele and Festus, 2016). Furthermore, Inyang-Udoh (2002) observes that non-compliance with construction programme in material stock control practice is another contributory factor which tends gradually to decrease productivity and profitability of projects and often leads to extension of time.

According to EPD (2003), over 80% of construction and demolition materials are inert substances, which include rubble, earth and concrete suitable for land reclamation and site formation; and which when sorted properly, can be recycled. The remaining non-inert substances of construction and demolition materials include bamboo (used for scaffolding), timber, vegetation, packaging waste and other organic materials, which are not suitable for land reclamation or recycling and are disposed at landfills. Ekanayake and Ofori (2000) categorized construction waste into three major categories as material, labour and machinery waste. However, material wastage is of more concern because most of the raw materials from which construction inputs are derived come from non-renewable resources. The objectives of this study are to identify the level of material wastage on selected construction sites and to examine the factors influencing the wastage on construction site.

1.1. Building Material waste/Construction waste

Building material wastage is defined as the difference between the value or quantity of those delivered materials accepted on site, and those properly used as specified and accurately measured in the work (Shen *et al*., 2002).According to Sasidharani and Jayanthi,(2015), construction waste is defined as waste which arises from construction, renovation and demolition activities including land excavation or formation, civil and building construction, site clearance, demolition activities, road work, and building renovation.

1.2. Causes of construction 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. In this regard, Oladiran (2008) reveals causes of materials waste in Nigerian projects to include 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. Table 1 below reveals some of the causes of construction waste.

Table 1. Causes of Construction waste

Design	Operational	Material storage and handling	Procurement
(i) Lack of attention paid to dimensional coordination of products	(i) Errors by trades men or operatives	(i) Damages during transportation	(i) Ordering errors (e.g., ordering significantly more or less)
(ii) Changes made to the design while construction is in progress	(ii) Accidents due to negligence	(ii) Inappropriate storage leading to damage or deterioration	(ii) Lack of possibilities to order small quantities
(iii)Designers inexperience in method	(iii) Damage to work done caused by consequent trades	(iii) Materials supplied in loose form	(iii) Purchased products that do not comply with specification
	(iv) Use of incorrect	(iv) Use of whatever	

and sequence of construction (iv) Lack of attention paid to standard sizes available on the market (v) Designers unfamiliarity with alternative products	material, thus requiring replacement (v) Required quantity unclear due to improper planning (v) Equipment malfunctioning	material close to working place (v) Unfriendly attitudes of project team and operatives	

Source: Al- Hajj et. al., (2011) as cited in Musa, et. al., 2015

1.3. Waste minimization

Enshassi (1996) and partly corroborated by Agapiou *et. al.* (1998) recommend the following, as measures for controlling materials and to minimize wastages:

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

1.4. Site waste management Programmes(SWMPS)

According to McDonald (1998), construction projects must have a Site Waste Management Plan. A project must not begin unless there is a SWMP in place. Each project should have one SWMP, and since the SWMP is considered a living document- it should be updated through the course of the project). A SWMP is an important instrument for a construction company and their clients. It assists in improving their environmental performance, complying with legislation and reducing rising costs of waste disposal. The benefits that a SWMP can bring to a project include:

1.5. Good practice

i. Better control of the risks relating to the materials and waste on the site
ii. An instrument that will aid dealing with any enquiry that the regulatory authorities may have regarding waste produced on the site
iii. A mechanism which demonstrates that waste is being managed efficiently
iv. Compliance with specific waste related stipulations within the contract
v. Financial savings through effective use of materials and the minimization of waste produced
vi. Compliance with legislation.

According to Shem et al (2002), the establishment of good waste management practice will result in financial savings and will ultimately reduce the impacts upon the environment produced by construction and demolition works. Examples of good practice are given below:

i. Appoint a nominated waste manager for the site
ii. Segregate the different types of waste arising from the work, which will make it easier to supply an accurate description of the waste for waste transfer purposes
iii. Where practicable, compounds for storing materials and waste skips should be located away from environmentally sensitive areas on site, such as drains, water bodies and site boundaries close to housing/offices
iv. Label all waste skips to ensure that all personnel are aware of the type of waste to be deposited in each skip. Consider using colour-coded skips
v. When ordering, avoid over-ordering and order the lengths required
vi. The provision of storage facilities will avoid materials exceeding their shelf lives and damage or contamination from inadequate storage
vii. On delivery, avoid damage during unloading and do not accept incorrect deliveries, specification or quantity
viii. Due care should be taken during the handling of materials to prevent damage

2.0 Research Methodology

The research was conducted by the use of a structured questionnaire and a field survey to determine the variation level of materials wastage on site, and to examine the factors influencing the wastage on Building construction sites. A total of 60 questionnaires were purposively administered to 3 selected project sites in Osun State (Osun State University, Government Secretariat Abere and Redeemer's University Ede).

The questionnaire administered was divided into three sections. Section A sought to know the general particulars of the respondents, section B was focused on information related to wastage variation of Building materials, while section C include list of factors that causes Wastage of material on site(e.g. Operational attribute, Design and documentation attribute, site management and practices and Environmental attribute). The structured questionnaire was analyzed using percentage frequency table and Ranking method

3.0 Results and Discussion

For the purpose of this study, a total number of sixty (60) questionnaires were administered and a total of fifty two (52) questionnaires were retrieved which is 87%, which was considered suitable for the purpose of this research study. The respective information obtained was analyzed as shown in Table 2

Table 2 shows that 17 persons are Builders, which is 32.6% in the percentage rating of the respondents, while 8 are: Architects rating 15.38% of the respondents, 5 Quantity Surveyors, making a total of 9.62% of the respondents percentage rating, 12 Contractors are involved, making 23.08%, and 1 Client was also involved, making 1.92% while 9 respondents falls under Others which gives 17.31% of the percentage rating. From the table above, the highest of respondents are Builders followed by the Contractor.

Table 2. Professional designation of the respondents

PROFESSION	FREQUENCY	PERCENTAGE(%)
Builders	17	32.69
Architects	8	15.38
Quantity Surveyor	5	9.62
Contractors	12	23.08
Clients	1	1.92
Others	9	17.31
Total	52	100

Table 3 shows the identification of materials and their respective variation. Hollow sandcrete block is the most wasted material on site, followed by Timber, then Concrete and Mortar in descending order. Pipe is the least ranked, followed by Asbestos, Paint and then Water. The most wasted material is similar to the work of Aderibigbe et al., (2017) where it was observed that Sandcrete Blocks ranked first in ranking levels of waste of various materials due to their susceptibility to breakage during handling on construction sites

Table 3. Identification of materials and their respective wastage variation.

S/N	MOST COMMON BUILDING MATERIALS	FREQUENCY	COMMENTS
1.	Hollow Sancerre Blocks	33	Wastage level is a bit high, with respect to the view of the respondent. It is the most wasted material on the construction site.
2.	Timber	27	It is another most common material that gets to waste on the construction site, be it as a result of wrong size cutting or as a result of incorrect timber type bought for a particular work.
3.	Concrete	26	This does waste, but not all the time. The wastage is as a result of wrong measurement or incorrect mixing proportion. Sometimes, it might be as a result of natural disaster.
4.	Mortar	23	Most respondents take mortar and concrete most similar in their wastage variation. But it was said that mortar sometimes wasted as a result of incorrect proportion and inexperience mason.
5.	Sand	22	This can get to waste, only if it was not offloaded in a smooth and erosion free space.
6.	Reinforcement	20	It does waste, but not all the time. The wastage is as a result of wrong measurement and wrong design in the formwork.
7.	Cement	19	This can get to waste if packed not in a cool and dry place, but exposed to rain and/or moisture. It should not be kept untidy
8.	Tiles	17	Tiles do get to waste when the floor size is not properly square.
9.	Glass	17	This gets to waste with respect to handling and

			cutting
10.	Electrical cable	15	According to the view of the respondent, wire cable is another common wasting material on construction site.
11.	Iron roofing sheet	14	It is said by most of the respondent that roofing sheets wastage is very minimal.
12.	Water	11	This do not commonly waste, only in a situation whereby the containing tank is leaking.
13.	Paint	5	The wastage is very minimal.
14.	Asbestos	4	The wastage is very minimal.
15.	Pipe	3	According to the respondents view, it has been observed that pipe do not get to waste on the construction site.

Table 4 shows the ranking of the operational attribute as perceived by Professionals on site. The result demonstrated that Poor workmanship happens to be the first on the ranking table, followed by the malfunctioning of the equipment, followed by conservation of waste from cutting, while the least ranked operational attribute is said to be the lack of workers or trade persons on site. Poor workmanship has direct link to wastage of material on site, it is important that proper supervision should be done on site, and skilled labours should be used on site.

Table 4.Operational attribute of material waste on the construction site

S/N	OPERATIONAL ATTITUDE	5	4	3	2	1	TOTAL	RII	RANKING
1.	Poor workmanship	9	13	17	7	6	52	0.646	1st
2.	Equipment malfunction	8	16	13	8	7	52	0.638	2nd
3.	Conservation of waste from cutting	6	18	11	13	4	52	0.635	3rd
4.	Purchased product do not comply with specification	6	15	18	5	8	52	0.623	4th
5.	Accident due to negligence	5	15	18	8	6	52	0.619	5th
6.	Lack of coordination	4	15	20	8	5	52	0.619	5th
7.	Use of incorrect materials, thus requiring replacement	6	13	19	8	6	52	0.619	5th
8	Rework due to errors by trade persons/labour	6	12	20	8	6	52	0.615	6th
9.	Damage to work done caused by subsequent trade	-	20	14	12	6	52	0.585	7th
10.	Lack of workers or trade persons	3	13	14	17	5	52	0.569	8th

From Table 5, it can be deduced that lack of detailed information needed in carrying out some specific instructions ranked first, followed by lack of attention to dimension coordination, followed by incomplete contract document at the commencement of the project, while the lowest ranked is waiting for design documentation and drawing.

Table 5. Design and documentation attribute

S/N	DESIGN AND DOCUMENTATION ATTRIBUTE	5	4	3	2	1	TOTAL	RII	RANKING
1.	Lack of detailed information in the drawing	9	13	20	4	6	52	0.658	1st
2.	Lack of attention to dimension coordination	9	8	25	6	5	52	0.650	2nd
3.	Incomplete contract document at the commencement of the project	7	13	21	7	4	52	0.646	3rd
4.	Poor interpretation of design document and drawing	11	9	23	1	8	52	0.643	4th
5.	Complexity of detailing in the drawing	7	14	14	9	8	52	0.612	5th
6.	Errors in the contract documentation	5	9	23	9	6	52	0.592	6th
7.	Waiting for design documentation and drawing	2	10	18	16	6	52	0.546	7th

Table 6 shows that changing order/instruction by supervisor was the most ranked factor out of the 10 factors highlighted under the site management and site practices attributes, followed by lack of waste management plan, lack of proper supervision and lack of quality management system aimed at waste management, have the same rank, both ranked 3rd, while lack of technical professional in contractor organization is the least ranked on the table. Changing order by Supervisor ranked first, and it should be avoided on construction site because it can lead to delay of work

Table 6. Site management and practices

S/N	SITE MANAGEMENT AND PRACTICES	5	4	3	2	1	TOTAL	RII	RANKING
1.	Changing order/instruction by supervisor	9	19	24	-	-	52	0.742	1st
2.	Lack of waste management plan	6	14	25	6	1	52	0.685	2nd
3.	Lack of proper supervision	5	14	28	4	1	52	0.669	3rd
4.	Lack of quality management system aimed at waste management	5	16	23	8	-	52	0.669	3rd
5.	Improper planning	6	23	16	3	4	52	0.662	4th
6.	Slow decision making by the site management	4	22	15	8	3	52	0.662	4th
7.	Poor site layout	5	22	14	6	5	52	0.662	4th
8.	Ineffective control of the projects progress by the contractor	-	20	22	10	-	52	0.638	5th
9.	Poor communication, coordination between parties involved	4	17	15	9	7	52	0.662	6th
10.	Lack of technical professional in contractor organization	-	12	14	19	7	52	0.519	7th

Table 7 shows the ranking of the effect of environmental attribute with respect to wastage on site. Poor access road ranked highest as the most affecting factor on the site, followed by severe weather condition, followed by damage by other parties, and lastly, effect of the site condition.

Table 7.Environmental attributes in and around the construction site

S/N	ENVIRONMENTAL ATTRIBUTE	5	4	3	2	1	TOTAL	RII	RANKING
1.	Poor access road	4	15	23	10	-	52	0.642	1st
2.	Severe weather condition	5	11	25	9	-	52	0.623	2nd
3.	Damage by other parties	7	12	16	12	5	52	0.615	3rd
4.	Effect of the site condition	3	12	23	10	4	52	0.600	4th

4.0 Conclusion and Recommendation

From the study it can be concluded that sandcrete block is the most wasted material on Building construction site, followed by timber and then concrete. Poor workmanship ranked first in terms of operational attribute, while lack of detail drawing ranked first in Design and documentation attribute. Changing order/ instruction ranked first in site management practices while poor access road ranks first in environmental attribute. Other factors that resulted in wastage from field study are; poor or inadequate storage facility, excess material on site, poor supervision of the workmen during progress of work and improper material handling on construction site. In view of the above, material wastage could be reduced to the barest minimum provided the following under listed recommendations are followed:

1. The use of site waste management programmes (SWMPS) should be encouraged in all Building construction sites
2. There should be a proper supervision act on the construction site
3. There should be accurate ordering of materials, waste management policy and foremen commitment in all Building construction sites
4. There should be a provision of storage facility on the construction site.
5. There should be proper planning of very construction process
6. Excess supply of materials to the construction site, should be avoided
7. Operatives should be educated on the best way to handle materials so as to reduce material wastage
8. Using the right workmanship for the job should at all-time be encouraged

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