
CONTRIBUTION OF MATERIAL WASTAGE ON CONSTRUCTION SITES TO COST OVERRUN IN MAKURDI, BENUE STATE; AN ON-SITE QUANTIFICATION OF WASTE.

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ABSTRACT

On building projects, material waste can result in cost overruns. Surveys are the primary source of data used in research to demonstrate how much material waste contributes to cost overruns on building sites. However, the precise contribution has not yet been determined. This article's goal is to present the findings of an impartial investigation of how material waste contributes to project cost overruns. The study pays particular attention to selected materials, attempting to compute the quantity wasted and the contribution of the waste to cost overrun. The researchers used five carefully chosen sites in Markurdi, Benue state, and six building materials—sandcrete block, cement, reinforcement bars, roofing sheets, timber, and tiles—that account for the majority of building material expenses. Based on this, it was possible to ascertain the waste of materials and its percentage contribution to cost overrun on the various sites and compute the average wastes of the materials on all sites. Results revealed that roofing sheet has the highest average percentage waste with 6.43% followed by 5.37% for tiles, 4.77% for timber, 4.14% for reinforcement bars, 3.96% for cement and 1.6% for Sandcrete block. Material waste on site was attributed to worker's mistake, Poor material handling, Improper storing of materials and Changes in design. The study recommends that construction professionals should be well-informed about the implications of material waste contributions to project cost overruns.

Key words: Building material wastes, Project site, Cost overrun, construction industry, Nigeria

I. INTRODUCTION

The global community is increasingly concerned about the problem of waste management as the amount of trash on land and in waterways has reached a critical level. The construction and demolition (C&D) waste crisis is a global concern that affects not only the construction management at the on-site level, but also the sustainable development of the construction industry as a whole [1]. The term construction waste is common in the industry and is defined in various ways. However, construction waste can simply be defined as any material left over from the construction process that is not re-used or recycled [2].

Construction and demolition waste is the largest contributor to landfills, accounting for 15-30% of all waste disposed. This figure is expected to rise to 40% when taking into account the amount of construction and demolition waste generated each day by the construction industry[3][4]. A study conducted by[5] with regards to sustainable building materials mentioned that approximately a quarter of global logging operations occur within the construction sector. This industry contributes around 39% of carbon dioxide emissions, 49% of emitted sulfur dioxide, and 25% of emitted nitrous oxide. Additionally, the extraction of raw materials accounts for 40% of these activities, while other emissions make up the remaining 10%, particularly in industrialized nations. Locally and globally, high cost of executing construction projects have resulted from increasing levels of construction waste [6].

The improper use or wastage of construction materials can have a significant financial impact on contractors, as it can affect their profits, construction costs, and duration, leading to tensions among project participants [7]. The cost of construction materials can be a major expense in constructing a civil engineering structure, often reaching up to 65% of the total cost. This figure is highly dependent on the project type, the construction technique and plant used, the efficiency and quality of the construction process [8].

The cost of materials used in construction can range from 50-70% of the total cost, depending on the specific needs of the project. Materials are a major expense in construction, and poor management of these materials can lead to higher costs during construction. Proper management of materials can result in significant savings in project costs, and is essential for the success of any construction project. If one fails to effectively manage their construction project materials, it can have a detrimental effect on the time, cost, and quality of the building project [9].

Project managers and construction staff often struggle to effectively control materials in construction projects, and they may also have difficulty identifying the root causes of material wastage. One reason for this is the absence of appropriate tools to measure the amount of waste generated on construction sites accurately. This lack of measurement tools can make it challenging to track and manage materials effectively, leading to inefficiencies, delays, and increased costs. As a result, it's essential to invest in appropriate measurement tools and technology that can help project managers and construction personnel better manage materials and reduce wastage. This can lead to more efficient and cost-effective construction projects, resulting in improved project outcomes and client satisfaction [9].

Understanding the quantity of material wasted and the causes of this wastage can help to minimize project costs while also conserving the environment. By identifying the sources of waste and implementing strategies to reduce it, stakeholders can reduce the amount of waste generated by construction activities, leading to more efficient and sustainable construction projects. Ultimately, minimizing material wastage can lead to a more environmentally

responsible and cost-effective construction industry. However, there are only a few literatures that address the issue of building material waste particularly in Benue state.

II. AIM AND OBJECTIVES

The aim of this study is to determine the amount of waste, expressed as a percentage, of specific building materials that are commonly found on construction sites in Benue state with a view of providing a guide for estimating allowance for waste. The objectives are as follows:

- i. To compute material quantities supplied, used and wasted on construction sites.
- ii. To determine the causal factors of wastage of materials on construction sites
- iii. To ascertain contribution of waste of building material on cost overrun.

III. LITERATURE REVIEW

3.1 Concept of Material Waste

Researchers hold varying opinions on what materials should be categorized as construction waste. [10] suggest that any material that is produced during construction activities and then left behind, regardless of whether they were processed or stored beforehand, is often referred to as construction waste. According to [6] the term "material" is generally used to refer to various items such as sawn materials, spare parts, and components that are used to produce goods or services. [7]Opined that construction waste refers to any material, other than earth material, that is transported to construction sites or used on-site for purposes such as land filling, incineration, recycling, reusing, or composting, rather than for the intended specific purpose of the project. This can occur due to a change in materials, excess quantities, non-use, non-compliance with specifications, or as a byproduct of the construction process.

[9] mentioned that the concept of construction material wastage can also be expressed as the disparity between the value of materials that are delivered and accepted on-site and those that are actually used in the specified manner, accurately measured in the work, and accounting for any cost savings achieved by substituting materials and transferring them elsewhere. When materials are wasted, it can lead to unnecessary increases in costs and time associated with the project. Construction waste typically refers to materials that are lost or unused during the course of a construction project. These losses may occur in various forms such as excess materials, scraps, or improperly installed components [2]. Based on all the above conceptions, construction waste are materials that are left over and not reusable on the construction project.

3.2 Causes of Wastages on Construction Site

There is a wide range of reasons that result to wastage of materials on site. These causes have been extensively discussed in previous literature and are mentioned in the table below.

Table1. Causes of material waste on construction site

S/N	Cause of Material Waste on Construction Sites	Reference
1	Lack of on-site waste management plan	[11]
2	Frequent changes to design,	[11], [7],
3	Time pressure	[11]
4	Lack of supervision	[11], [7],
5	Improper storing of materials	[11], [7], [12]
6	Lack of possibilities to order small quantities	[11]
7	Lack of skilled workers	[11], [2]
8	Theft and vandalism	[11], [7],
9	Poor contract documents	[11]
10	Workers mistake	[9]
11	Selection of low-quality products	[9], [2], [12]
12	Loss of onsite material control	[9][13]
13	Material price changes in procurement	[12]
14	Poor material handling	[12], [2], [13]
15	Inappropriate work methods	[2],
16	Overestimation	[13]
17	Overmeasurement	[13]

3.3 Impact of Material Waste on Cost of Project

The issue of cost overrun has been a persistent problem in the construction industry for many years. This refers to situations where the expenses needed for the completion of a project exceed the originally agreed-upon budget between the sponsor and contractor. Such cost overruns can be seen as a squandering of valuable resources [10]. Building materials play a crucial role in construction projects, and it's essential to factor in reasonable allowances for their wastage during the estimation process. Failure to do so can lead to financial losses for the client and undue profits for the contractor. Therefore, it's important to ensure that adequate provisions are made to account for potential material waste during the project planning and budgeting stages [13].

There is a widely held belief that building material wastage on construction sites is a significant contributor to cost overruns. Therefore, any efforts to improve the management of building materials on construction sites can have a positive impact on the performance of the construction industry, potentially leading to cost-saving benefits. By reducing wastage, contractors can save money on materials, and clients can benefit from cost savings in their projects, ultimately leading to a more efficient and profitable construction industry [14].

According to [15], the contribution of construction waste to the total project cost overrun is 30% of the total cost of materials. Approximately 10–15% of purchased materials for the construction of a project are recorded as a waste. In this regard, construction waste has been argued to be one of the main causes of economic reduction and business failure in the construction sectors.[16]gathered that construction wastes have a negative impact on project costs and time. For instance, material waste accounts for an additional 15% to construction project cost in UK, 20–30% in Netherland and 11% in Hong Kong. In UAE, 75% of waste comes from construction Waste. Also, results in a study by [17]indicated that the variation in

material waste leading to exceeding project costs ranges from 1.96% to 8.01%, with an average contribution of 4.0% to project-cost overruns.

The economic losses resulting from construction material wastage can pose a significant threat to the overall economic growth of a nation. This is because construction projects are major contributors to a country's economy, and any wastage of resources can lead to financial losses, reduced productivity, and inefficiency. Furthermore, such wastage can lead to delays in project completion, which can have a negative impact on the economy as a whole. Therefore, it's essential to take measures to reduce material wastage and improve the overall efficiency of construction projects to support the economic growth of a nation.

IV. METHODOLOGY

This study employed a quantitative approach according to [10] and [13] grounded in the positivist research paradigm. The quantitative nature of the research is evident as it involved numeric measurements of on-site material waste volume and project cost overruns. In this part, the research utilized field observation and direct measurements to collect the necessary data from five ongoing projects in Benue State, Nigeria, over a span of four months. The selection of projects was carried out through purposive sampling, mainly influenced by the willingness of clients and project consultants to provide the researchers with access to their records of material purchases. Makurdi, as the capital of Benue, is considered the construction hub of the State, currently experiencing growth in building infrastructure. The choice of building materials for the survey was primarily based on their common usage in construction projects in the study area. The materials included in the survey are Sandcrete blocks, Cement, Reinforcement bars, Roofing sheets, Timber, and Ceramic tiles.

Furthermore, a questionnaire survey was conducted with contractors, quantity surveyors, purchasing officers, storekeepers, tradesmen, and artisans at selected project sites. This approach aimed to identify the reasons behind building material waste.

The study also employed sample mean, percentage frequency, mode and tables to analyze and present data respectively

Sample mean is expressed as follows:

$$\bar{X} = \frac{\sum X}{N} \dots \dots \dots (1)$$

Where: $\sum X$ is sum of all data values

N is total number of data items in sample

$$\text{Contribution} = \frac{\text{Quantity of material wasted}}{\text{Quantity of material used}} \times \text{Cost overrun} \dots \dots \dots (2)$$

$$\text{Percentage contribution} = \frac{\text{Contribution of waste to cost overrun}}{\text{Cost overrun}} \times 100 \dots \dots \dots (3)$$

Formular 2 and 3 are sourced from [17]

V. DATA PRESENTATION AND ANALYSIS

The subsequent information represents the data collected from the examined project sites.

Project A

Table 2.Quantity of Materials Supplied, Used, Wasted, Cause of Waste, proposed Cost overrun and % Contribution of Material Waste to cost overrun

Item	Total Qty supplied	Total Qty used	Qty wasted	Cause of waste	Proposed cost	Cost overrun	Contribution of Material Waste to cost overrun	% contribution
Sandcrete block(no)	7,258	7,149	29	Changes in design,	2,903,200	23,150	93.91	0.41
Cement (bags)	3,864	3,846	19	Time factor, over mixture, changes in design, theft	9,475,000	95,000	469.32	0.49
Reinforcement bars (no)	8,360	8,344	16	Theft, changes in design	667,200	78,000	149.57	0.19
Roofing sheet(no)	149	140	9	Workers mistake	923,900	55,600	3,574.29	6.43
Timber (no)	3,841	3,666	175	Improper storing of materials	576,150	26,250	1,253.07	4.77

Project B

Table 3.Quantity of Materials Supplied, Used, Wasted, Cause of Waste, proposed Cost overrun and % Contribution of Material Waste to cost overrun

Item	Total Qty supplied	Total Qty used	Qty wasted	Cause of waste	Proposed cost(₦)	Cost overrun(₦)	Contribution of Material Waste to cost overrun (₦)	% Contribution
Sandcrete block(no)	4,800	4,728	72	Poor quality of blocks, Poor material handling	1,680,000	25,200	383.76	1.52
Cement (bags)	184	181	3	Time Pressure	920,000	45,000	745.86	1.66
Reinforcement bars (no)	139	135	4	Workers mistake	667,200	24,000	711.11	2.96

Project C

Table 4. Quantity of Materials Supplied, Used, Wasted, Cause of Waste, proposed Cost overrun and % Contribution of Material Waste to cost overrun

Item	Total Qty supplied	Total Qty used	Qty wasted	Cause of waste	Proposed cost(₦)	Cost overrun(₦)	Contribution of Material Waste to cost overrun (₦)	% Contribution
Sandcrete block(no)	674	668	14	Poor material handling	214,400	4,500	94.31	2.10
Cement (bags)	10	9	1	Improper storing of materials	32,000	4,000	444.44	11.11

Project D

Table 5. Quantity of Materials Supplied, Used, Wasted, Cause of Waste, proposed Cost overrun and % Contribution of Material Waste to cost overrun

Item	Total Qty supplied	Total Qty used	Qty wasted	Cause of waste	Proposed cost(₦)	Cost overrun(₦)	Contribution of Material Waste to cost overrun (₦)	% Contribution
Tiles(cartons)	442	419	23	Poor material handling, Lack of supervision, Workers mistake, Inappropriate work methods.	2,121,600	43,200	2,319.81	5.37

Project E

Table 6. Quantity of Materials Supplied, Used, Wasted, Cause of Waste, proposed Cost overrun and % Contribution of Material Waste to cost overrun

Item	Total Qty supplied	Total Qty used	Qty wasted	Cause of waste	Proposed cost(₦)	Cost overrun(₦)	Contribution of Material Waste to cost overrun (₦)	% Contribution
Sandcrete block(no)	3,100	3,028	72	Poor quality of blocks, Poor material handling	775,000	21,600	513.61	2.38
Cement (bags)	120	117	3	Loss of onsite material control, Improper storing of materials	60,000	15,000	384.62	2.56
Reinforcement bars (no)	34	33	1	Over estimation	163,200	4,800	145.45	3.03

Table 7. Mean of % contribution of material waste to cost overrun

Material	Mean %contribution
Sandcrete	1.60
Cement	3.96
Reinforcement bars	4.14
roofing sheet	6.43
Timber	4.77
Tiles	5.37

Table 8. Causes of Material waste on Project A - Project E

Cause of waste	Frequency
Poor material handling	4
Improper storing of materials	3
Changes in design	3
Workers mistake	3
Theft,	2
Selection of low-quality products	2
Time Pressure	2
Over mixture	1
Lack of supervision	1
Inappropriate work methods	1
Loss of onsite material control	1
Over estimation	1

Table 7. Ranking of Causes of Material Waste on Surveyed Projects.

Causal Factor	Mean	Ranking
Lack of on-site waste management plan	4.03	1
Poor material handling	4.03	1
Improper storing of materials	3.84	2
Lack of possibilities to order small quantities	3.81	3
Inappropriate work methods	3.72	4
Overmeasurement	3.63	5
Overestimation	3.56	6
Worker's mistake	3.44	7
Loss of onsite material control	3.34	8
Material price changes in procurement	3.31	9
Lack of supervision	3.22	10
Frequent changes to design,	3.12	11

Lack of skilled workers	3.12	11
Selection of low-quality products	3.00	12
Time pressure	2.44	13
Poor contract documents	2.44	13
Theft and vandalism	2.41	14

VI. DISCUSSION OF RESULTS

Data collected on Quantity of Materials Supplied, Used, Wasted, Cause of Waste, Proposed Cost and cost overrun at the chosen Project sites are displayed in the Tables 2,3,4,5 and 6. The tables also present the contribution of Material Waste to cost overrun and its expression in percentage. Tables 2-6 show varying data collected on Sandcrete block, Cement, Reinforcement bars, Roofing sheet, Timber and Tiles on the five (5) sites surveyed. While variation in materials document on the different sites is owing to such factors as speed of project activities, time of permission to access the site and access to data on proposed cost and cost overrun. The tables 2-6 confirm contribution of material waste to cost overrun. Table 7 further summarizes the % contribution per material as 1.6% for Sandcrete blocks, 3.96% for cement, 4.14% for reinforcement bars, 6.43% for roofing sheet, 4.77% for timber and 5.37% for tiles. This results, which ranges from 1.6% -6.43% slightly corresponds with the 1.96% to 8.01% observed by [17] with an average contribution of 4.37% to project-cost overruns, supports the data provided by [17] regarding the percentage contribution of material waste to exceeding project costs. It can be observed that roofing sheet has the highest % contribution to cost overrun which is 6.43%. Data collected attribute the cause of waste of Roofing sheet to Workers mistake.

Furthermore, consideration on the causes of waste of materials presents Poor material handling, Improper storing of materials, Changes in design and Workers mistake as the most frequent occurring causal factor for waste of materials. This is similar to data collected from questionnaire on causes of material waste whereby Lack of on-site waste management plan, Poor material handling and Improper storing of materials

VII. CONCLUSION

The study proves that material waste on construction site has significant contribution to cost overrun. The study concludes that the percentage contribution of material waste to cost overrun ranges from 1.6% -6.43%. Also, analysis of data collected shows that percentage contribution varies from one material to the other as well as from one site to the other. Roofing sheets are captured as the material with the highest waste and contribution to cost overrun with a percentage contribution of 6.43% attributed to worker's mistake. Other causes of material waste are Poor material handling, Improper storing of materials and Changes in design.

VIII. RECOMMENDATIONS

According to the study, in order for construction professionals to assess how much these effects could be minimized, they should be well-informed about the implications of material waste contributions to project cost overruns early on in the process. More so, given that Lack of on-site waste management plan, Poor material handling, Improper storing of materials and worker's mistake are the most significant causes of material waste, attention should be intensified in these aspects in order to minimize material waste.

CONFLICT OF INTEREST:

No conflict of interest

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