The Perspective of Tradesmen on Material Wastage in the Construction Industry

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***Abstract*— Construction material wastage has been identified as a major threat to the environment, cost of delivery, and project duration. This paper sought to identify the significant level of the major sources and factors influencing material wastage from the perspective of tradesmen and to assess the quantities of the various categories of waste on building construction sites in the Upper West Region of Ghana. The study was carried out employing both open and closed-ended questionnaire survey. A total of 150 respondents representing different trades were involved in the study. The findings revealed that frequent design changes and poor design, excessive quantities of materials than required, poor material handling and storage on-site, poor strategy for waste minimization, and poor site management and conditions were the highest-ranking factors that influence construction material waste generation. It was further revealed that wood, sandcrete block, concrete, and metal were the most wasteful construction materials. The study recommended the investment of considerable efforts to ensure due diligence to improve all contractual documents. Contractors should endeavour to employ qualified on-site technical supervising and administrative staff to implement and safeguard effective site management practices to ensure material waste minimizing.**

Keywords—Construction waste; Minimisation; Environment; Tradesmen; Upper West Region; Ghana

I. INTRODUCTION

The construction industry is critical to the socio-economic development of every nation [1]. However, the industry is regarded as a major contributor to the destruction of the environment. The huge depletion of natural resources for construction materials, the waste associated with construction activities, and demolition of structures are inimical to the environment. [2]. For this reason, Poon as cited by Ghoddousi et al. [3] argued that the construction industry seems to have a poor environmental reputation due to the excessive consumption of natural resources and a considerable amount of waste associated with constructional activities. In their study, Agyekum et al. [4] noted that several global statistical and environmental reports have considered the construction industry to be one of the major producers of solid waste.

The waste generated from constructional activities or processes is referred to as construction waste [3], [5]. Construction waste is therefore a byproduct of activities such as construction, demolition, renovation, or repair of infrastructure. As posited by Ekanayake and Ofori in [6], [7], construction waste may also be considered as any material expect for earth material, needed to be transported elsewhere from a construction site or used within a construction site for landfilling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to materials damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process. Globally, studies have shown that construction waste represents a relatively high percentage of production costs. Udawatta et al. [8], argues that besides its direct impact on the environment, construction waste also affects efficiency and cost of delivery.

Adewuyi et al. [9], posited that the cost of materials significantly influenced the overall cost of a construction project. Impliedly, material wastage has a considerable adverse effect on profit margin and project duration, besides it is a potential source of dispute among parties to a project. They also argued that unwarranted wastage of construction materials, non-existence of appropriate waste management mechanisms, and low level of awareness of the importance of construction waste minimisation are setbacks to waste minimisation efforts. They further noted that although it is almost impossible to eliminate wastage, there must be deliberate efforts by industry players especially those of the developing nations to institute workable measures to limit wastage.

Previous studies on construction waste such as [4], [6], [10], [11] identified and suggested solutions for construction material wastage, minimisation, and management. Nonetheless, these and other studies largely focused and sought the views of only construction professionals such as consultants, project managers, engineers, and architects on the subject matter. Tradesmen, being major stakeholders who are physically and directly involved in the actual execution of the construction works have largely been excluded from such

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studies. Adewuyi and Otali [12], described tradesmen as a category of construction workers who are directly involved in putting the construction materials together to attain the desired outcomes or deliverables. [9], noted that the awareness of the tradesmen about construction waste minimization can contribute to improved performance of construction activities and reduction of waste during construction. Therefore, the need to evaluate the subject matter from their perspective is very important.

The occurrences in the Ghanaian construction industry is identical to the global trend. According to Ayarkwa et al. [13], materials purchased for construction projects generated varied waste rates of between 5% and 27% in the Ghanaian construction industry. Lingard et al. as cited in [8], have, however, argued that implementing effective waste management plans could reduce the cost of construction thereby increasing profit margins, improving quality, and ensuring sustainability.

The general building and civil engineering contractors in Ghana are respectively classified as D1, D2, D3, D4 and K1, K2, K3, K4 depending on their annual turnover, equipment holding, and personnel [1], [14], [15]. For contractors who execute both general building and civil engineering works, they are classified as D1/K1, D2/K2, D3/K3, and D4/K4 [16]. The D1K1 category of contractors are regarded as large firms, those in the D2K2 category are considered medium, and the D3K3 and D4K4 are referred to as small firms [1]. Tegan et al. [17] submitted that the small firms (D3K3 and D4K4) constituted about 90% of the registered general building and civil contractors in the Ghanian construction industry. These firms are usually perceived to perform poorly on quality. In a study by Akomah and Jackson [18], they reported that the attitude of employees affected the rate of materials wastage which subsequently affected performance and quality. Adu and Ekung [19], also noted that the knowledge and understanding of the main causes and effects of increased production cost coupled with the quality of training given to key technicians or tradesmen influenced a material waste generation. Luangcharoenrat et al. [20], also advanced that the reduction in construction material waste conserves natural resource reserve by reducing the rate of depletion of virgin materials for the production of construction materials, besides it also reduces the expenses associated with construction waste disposal. Judging by the aforementioned, reduction in the levels of construction material waste will lower construction costs, increases the profit margins, and safeguard the environment. Therefore, it would be of great importance to identify, assess, and be adequately informed about construction material wastage to develop tools for construction waste minimization and cost reduction. In this perspective, this paper seeks to identify the significant level of the major sources and factors influencing material wastage from the perspective of the tradesmen and to assess the quantities of the various categories of waste on building construction sites in the Upper West Region of Ghana.

II. METHOD AND MATERIALS

To achieve the objectives of this study, a structured questionnaire survey using both closed and open-ended questions was administered to source for the primary data. A total of a hundred and fifty (150) questionnaires were randomly but purposively administered to artisans engaged by six (6) different small scale contractors (D3/K3 and D4/K4) with nearing completion (90 – 97% per project schedule) building construction projects in the Upper West Region of Ghana. Permission was sort before administering the questionnaires to the tradesmen who were working at the times of the site visits. The tradesmen were clustered into five major skilled trades namely: Cluster 1 – Carpenters; Cluster 2 - Steel benders; Cluster 3 – Masons; Cluster 4 - Services Operators (Plumbers & Electricians); Cluster 5- Finishers (Tillers, Painters, etc)

The study was divided into two sections. For the first section, a total of five (5) samples were selected from each of the skilled trade groups from each construction site. Thus 30 samples for a particularly skilled trade group and a total of 150 samples for all trade groups. Based on 20 factors responsible for construction material wastage and 10 major sources of construction waste adopted and modified from a study by Eze et al. [21], the questionnaire was divided into three (3) parts. The first part sought to gather information on the years of experience of respondents in the construction industry. The second part focused on factors responsible for construction material wastage. [20], in their study submitted that the factors responsible for construction material wastage can be clustered into four main categories namely: design and documentation, material and procurement, construction method, and planning, and human resources. A total of 20 factors were considered for this study based on the categorization by [20]. The third part focused on the sources of waste on the construction site. The respondents were required to score parts two and three on a Likert scale range of 1 to 5 to determine which factor and construction material contributed highly to the generation of waste on-site. The study enjoyed a hundred percent return rate as questionnaires were administered and collected the same day when completed.

The analysis of the questionnaire was divided into demographic and Relative Importance Index (RII) analysis. The statistical methods used in analyzing the second and third parts of the data gathered from the respondents were Relative Importance Index (RII). The RII analysis according to Rooshdi et al. [22], allows the researcher to rank the factors in terms of their degree of significance from the perspective of the respondents, moreover, it is an appropriate tool used to prioritize indicators rated on Likert type scale.

$$RII = [\sum W/(A \times N)] \quad (0<RII<1) \tag{1}$$

$$\text{Mean Item Score (MIS)} = [(\sum W)/N] \tag{2}$$

Where: W - scale for rating a factor (ranges from 1 to 5) = $(5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1)$

A – is the highest weight in the scale = 5

N - total number of respondents = 150

The second section of the study dealt with the quantification of waste generated at all six sites. To quantify construction material waste generated at the sites, material reconciliation was carried out. According to Rameezdeen et al. [23], this is attainable by comparing the difference between the store records and the actual requirement of the material with respect to the Bill of Quantities (BoQ) work items. They further argued that the norms of the Schedule of Rates (SR) for

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building works have to be taken as the basis for analyzing the work items of the Bill of Quantities because most contractors use SR for building works as the basis for estimating and material requisition. of work. Wastage was estimated as a proportionate to the actual work since wastage allowances are usually expressed in proportion to the actual quantity.

Material Waste Quantity = Store records - Actual material requirement (3)

Material Wastage (%) = {[Store records - Actual material requirement] / (Actual material requirement)} ×100 (4)

III. RESULTS AND DISCUSSION

A. *Profile of respondents*

The study found that all the respondents were 100% (n = 150), male. This probably suggests male dominance amongst skilled trade groups in the construction industry in Wa. Generally, this finding is in line with a study by Hedidor and Bondinuba [24], which indicated that males dominated the construction industry. Both findings corroborate Ayarkwa et al. [25], assertion that the female dominance (male to female ratio - 48.7%:51.3%) in population as indicated by Ghana's 2010 population and housing census does not, however, reflect in their representation in most industries, especially the construction industry. Danso [26], suggested that the low dominance of females in the construction industry could be attributed to the intensive physical or manual strength that is required to execute most of the constructional activities.

The age distribution of the respondents ranged between 20 to 53 years, with the majority (42.7%) of the respondents between 30 to 39 years of age and 34.0% within the 40 to 49 age brackets. Also, 14.7% fell within the 20 to 29 age bracket with 8.6% within the 50 to 59 age group. In summary, the mean age of 38.2 years with a standard deviation of 8.4 was observed among the tradesmen. The study further revealed that the skilled tradesmen in the study area were within the economically active working-age group. Ghana Statistical Service [27], defines an economically active population as persons aged 15 years and older, of either sex who furnishes the supply of labour to produce economic goods and services.

The experience of the respondents is critical to the reliability of the outcome of this study. Rice [28], submitted that experience promotes effectiveness since experience gained over time enhances the knowledge, skills, and productivity of workers. Table 1 depicts that 12.03% of the respondent had up to a maximum of 5 years working experience, 33.3% of the respondents had 6 -10 years of experience as tradesmen, the majority (39.3%) of the respondents had 11 – 15 years of working experience and 15.3% of the respondents have between working for 16 to 20 years as tradesmen. In summary, 88% of the respondents had worked for over 5 years therefore, they can be presumed to be well experienced, capable, and competent enough to execute good judgment to reflect the prevailing situations on the subject matter in the construction industry.

Table 1: Years of experience of tradesmen

Trade group	Years of xperience			
	1 - 5 years	6 – 10 years	11 - 15 years	16 – 20 years
Carpenters	4	12	13	5
Steel benders	1	11	11	5
Masons	5	10	14	4
Services Operators	4	8	11	5
Finishers	4	9	10	4
Total	18	50	59	23
Percentage	12.0%	33.3%	39.3%	15.3%

B. *Causes of wastage of material*

The respondents of this study rated and ranked twenty factors that influenced waste generation on construction sites according to their RII as presented by Table 2. "Frequent design changes and poor design" with an MIS of 3.373 and a corresponding RII of 0.675 was ranked as the most significant factor that caused waste on sites. This finding corroborates [6], [21], who identified and ranked frequent design changes as the most significant factor in construction waste generation. According to [6], changes made to drawings of an ongoing construction lead to partial demolition thus resulting in material wastage or abandoning of already procured construction materials that are not suitable for the new design. "Excessive quantities of materials than required" (MIS of 3.187 and RII of 0.637) was ranked as the second most significant factors that caused waste on sites. According to Cheng and Mydin [29], the generation of waste resulting from excess material on-site can be attributed to the lack of effective and coordinated site management, supply chain, and appropriate recycling suppliers.

Poor material layout planning, inappropriate storage facilities for the on-site materials, lack of knowledge on how to move, handle and store materials coupled with general principles of safety [30], usually accounted for "poor material handling and storage on-site" (MIS of 3.147 and RII of 0.629), which was ranked as the third most significant cause of material waste on sites by the tradesmen. "Poor strategy for waste minimization" (MIS of 3.107 and RII of 0.62) was ranked as the fourth-highest among material waste generation factors. The construction worker's willingness to change their behavior and attitudes is crucial to a successful material waste minimization [20]. Daoud et al. [31], argued that an effective procurement process is akin to an efficient waste minimization strategy. Yuan [32], also submitted that investing in systems that seek to enhance the knowledge and skills of workers with regards to waste management effectively reduces material wastage on construction sites. The respondents further ranked "poor site management and conditions" (MIS of 3.087 and RII of 0.617) as the fifth most significant factor that triggered material wastage on construction sites. This finding corroborates [6], [33], who found that poor site management and conditions contributed to material wastage on the construction site.

Also, the respondents ranked "lack of incentives for tradesmen" (MIS of 2.847 and RII of 0.569); "long project duration" (MIS of 2.807 and RII of 0.561); "time pressure"

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(MIS of 2.773 and RII of 0.555); "the frequent breakdown of equipment" (MIS of 2.747 and RII of 0.549); "inadequacy of experienced skilled workers" (MIS of 2.580 and RII of 0.516) as the least five factors that contributed to material waste generation on site.

Table 2: Factors influencing construction waste generation.

S/N	Factors influencing construction waste generation	Responses (Likert Scale)					MIS	RII	Rank
		1	2	3	4	5			
1	Design (Frequent design changes and poor design)	20	23	32	31	44	3.373	0.675	1
2	Excessive quantities of materials than required	23	29	28	37	33	3.187	0.637	2
3	Poor material handling and storageon site	23	33	30	27	37	3.147	0.629	3
4	Poor strategy for waste minimization	21	35	31	33	30	3.107	0.621	4
5	Poor site conditions	24	32	30	35	29	3.087	0.617	5
6	Damage during transportation	31	25	28	37	29	3.053	0.611	6
7	Complicated design	29	31	27	30	33	3.047	0.609	7
8	Poor interaction between various professionals	30	27	33	29	31	3.027	0.605	8
9	Use of incorrect materials that require replacement	27	31	34	29	29	3.013	0.603	9
10	Inappropriate placement of the material	37	27	25	25	36	2.973	0.595	10
11	Poor quality of materials	33	28	26	37	26	2.967	0.593	11
12	Accidents due to negligence	30	33	27	33	27	2.960	0.592	12
13	Inclement weather	27	37	31	31	24	2.920	0.584	13
14	Theft and vandalism	38	26	27	30	29	2.907	0.581	14
15	Rework due to workers mistakes or experience	38	23	33	28	28	2.900	0.580	15
16	Site Management	33	30	37	27	23	2.847	0.569	16
17	Long project duration	40	25	33	28	24	2.807	0.561	17
18	Time Pressure	37	30	34	28	21	2.773	0.555	18
19	Frequent breakdown of equipment	43	27	30	25	25	2.747	0.549	19
20	Shortage and lack of experience of skilled workers	47	35	23	24	21	2.580	0.516	20

C. Sources of material waste

The study revealed that the highest construction material waste stream in the study area was "wood" (MIS of 3.187 and RII of 0.637). The study considered waste resulting from formwork, roof truss, framing, plywood, and other timber products as wood. Mbereyaho et al. [34], argued that timber products are widely utilised material in the construction industry owing to its relatively large resource availability, cheap cost, and versatility. Site observations corroborated a survey report by Shen et al. [35], where unavoidable destruction as a result of usage and cutting were identified as the main causes of wood waste. "Sandcrete block" (MIS of 3.107 and RII of 0.621) was also identified as part of the main waste streams of construction material waste. It followed wood as the second most wasteful construction material. According to Anosike and Oyebade [36], sandcrete block is an important material in building construction since it is the most widely used walling unit. Observations at the various sites affirmed [35], the assertion that cutting, breakages during transportation and handling on-site, and unused blocks were the main causes of block waste.

"Concrete" (MIS of 3.053 and RII of 0.611) was also identified as part of the main components of construction material waste. Concrete is the most widely used material on construction projects for substructure and superstructure components of buildings [35]. It was observed that concrete wastage was generated from excess quantity resulting from changes and mistakes in quantifying the required amount of concrete due to ineffective planning and communication. "Metal" (MIS of 3.027 and RII of 0.605) in the view of the respondents was the fourth most wasteful construction material on site. This study considered metal to be wastes generated from reinforcement bars, steel and aluminum pipes, panels and frames, and other metallic substances. These four waste streams are the top four most significant sources identified in the study area. Table 3 presents the other sources of construction material waste with their respective MIS and RII. The findings of this study as reported are consistent with [4], [9], [21], [37] who all reported formwork (wood), blockwork (sandcrete block), and concrete to be part of the most wasteful materials on construction sites.

Table 3: Source of construction material waste.

S/N	Sources of construction Waste	Response (Likert Scale)					MIS	RII	Rank
		1	2	3	4	5			
1	Timber	23	29	28	37	33	3.187	0.637	1
2	Mortar	21	35	31	33	30	3.107	0.621	2
3	Sandcrete blocks	31	25	28	37	29	3.053	0.611	3
4	Concrete	30	27	33	29	31	3.027	0.605	4
5	Reinforcement	37	27	25	25	36	2.973	0.595	5
6	Coarse aggregate	30	33	27	33	27	2.960	0.592	6
7	Paint	38	26	27	30	29	2.907	0.581	7
8	Fine aggregate	33	30	37	27	23	2.847	0.569	8
9	Tiles	37	30	34	28	21	2.773	0.555	9
10	Pipes	47	35	23	24	21	2.580	0.516	10

D. Percentage of Wastage.

The quantitative assessment of wastage obtained from all six sites is presented in Table 4. "Wood" had the highest material wastage percentage mean of 9.50 followed by "sandcrete block" (8.50), "concrete" (8.17), and "metal" (7.67) as fourth. On the other hand, "tiles" and "PVC pipe" had the least mean material wastage of 4.67 and 4.33 respectively.

Table 4: Percentage of wastage.

S/N	Material	Material Wastage (%)						Mean
		Site A	Site B	Site C	Site D	Site E	Site F	
1	Timber	12	7	8	13	10	7	9.50
2	Sandcrete blocks	10	7	6	9	9	10	8.50
3	Concrete	5	12	8	7	8	9	8.17
4	Metal	9	4	5	7	9	12	7.67
5	Mortar	2	10	11	9	3	9	7.33
6	Coarse aggregate	3	5	6	12	7	10	7.17
7	Paint	8	6	12	4	3	2	5.83
8	Fine aggregate	5	8	3	6	2	5	4.83
9	Tiles	9	3	2	4	3	7	4.67
10	PVC pipes	5	3	7	3	4	4	4.33

IV. CONCLUSION

The study identified twenty factors that were clustered into four categories: design and documentation, material and procurement, construction method and planning, and human resources as contributory factors to material wastage. Wood, sandcrete block, concrete, and metal were the four most wasteful materials on construction sites in the study area. The tradesmen opined that frequent design changes and poor design, excessive quantities of materials than required, poor material handling, and storage on-site, poor strategy for waste minimization influenced high rates of material wastage. The quantification of waste material on the various sites aligned with the opinions of the tradesmen who indicated that wood, sandcrete block, concrete, and metal were the most waste construction materials.

Given the conclusions, this study recommends the investment of considerable efforts to ensure due diligence to improve all contractual documents. Contractors should endeavour to employ qualified on-site technical supervising and administrative staff to implement and safeguard effective site management practices to ensure material waste minimizing.

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