Waste Generation and its Implication to Construction Project Delivery in the Upper West Region of Ghana

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Abstract
This paper discusses waste generation and its implication to construction project delivery in the upper West region of Ghana. Construction industry is a vital connection to the infrastructure growth in Ghana. On the other hand, it also losses a lot of money to materials waste which is inimical to project delivery. The study aimed at finding out how much construction waste is costing construction project delivery and attempted to make suggestions to the industry on how waste can be minimized in order to maximize profits.The study employed both qualitative and quantitative method of sampling which allowed appropriate and accurate data organization, analysis and interpretation. The research revealed that a number of construction companies in the study area do not adhere to international best practices and standards of waste management on construction sites, such as waste minimization strategies. Maintenance of human resources was also found to be non- existent in these construction firms. There is the need for effective supervision and enforcement of by-laws regulating waste management on construction sites.
Keywords: Constructions sites, waste generation, project delivery, Upper West Region, Waste

1. Introduction

The construction industry plays a vital role in meeting the needs of society and enhancing quality of life (Shen and Tam, 2002). It is a key sector in the Ghanaian economy and it is therefore of primary importance that these industries are managed in a way to minimized construction materials waste during the construction process. Since construction has a major and direct influence on many other industries by means of both purchasing the inputs from industries and providing products to almost all other industries, eliminating or reducing waste could yield great cost savings to society (Polat and Ballard, 2004).

Effective minimization of waste contributes to profit maximization which is the reason for the existence of most companies, as defined by (Crittenden and Kolaczkowski, 1992) is "any technique, process or activity which avoids, eliminates or reduces waste at its source or allows reuse of the waste".

The construction industry has been encouraged to re-use built assets, minimize waste, and minimize energy in construction, (Ofori et al., 2000).

In a study on methods for waste control in the building industry in Brazil, Formoso et al. (1999) classified waste into unavoidable waste (or natural waste), in which the investment necessary for its reduction is higher than the economic benefit, and avoidable waste in which the cost of waste is higher than the cost to prevent it. The percentage of unavoidable waste depends on the technological development level of the company (Polat and Ballard, 2004; Formoso et al., 1999; Womack and Jones, 1996).

Waste can be categorized according to its source - the stage in which the root causes of waste occurs. Bossink and Brouwers (1996) in a study on waste rates in the Dutch construction industry identified the main sources of waste in construction as design, procurement, material handling, operation and residual. Sources of waste are also identified from the processing preceding construction such as materials manufacturing, design, material supply, and planning, as well as from the construction stage (Formoso et al., 1999).

In a study on construction material waste source evaluation in Singapore, Ekanayake and Ofori (2000) divided construction waste into three major categories: material, labour and machinery waste. The current study, however, focuses on material wastage since most of the raw materials for construction inputs are from non-renewable resources and once wasted, becomes very difficult to replace them (Ekanayake and Ofori, 2000).

As construction is a locomotive sector of the national economy, waste in the construction industry affects the overall national economy. It is important therefore to explore measures aimed at minimizing material waste and assess the level of practice of such measures in the construction industry since cost reduction arising from minimization of materials waste is of direct benefit to all stakeholders.

Despite the serious threat waste poses to the profit margin of most firms in the Upper West region, no serious attention is paid to identifying factors that contribute to the increase of waste in the construction industry. For that matter, the construction of roads, houses, bridges or anything for individuals or the government in the Region is capital intensive and a significant component of this cost build-up most often include waste. Unfortunately, there seemed to be a failure on the part of contractors in the region to initiate measures to reduce the cost of waste. This failure may be due to lack of education on construction waste management or the limited technology available to them in this part of the country. The lack of construction management and the associated high cost of construction often imposes a burden on clients in the form of exorbitant charges. Consequently, prospective clients worsen the situation by engaging non-professionals.

As a result of the virtual absence of waste management strategies, many construction companies in the Upper West Region incur high production cost and debts reducing the competitive edge of these companies which ultimately causes their collapse.

The economic advantage of any building or construction company depends solely upon how effectively the company plans or organizes the job at hand, from the beginning to the completion of the project. For that matter poor planning, poor site organization and poor supervision would result in waste of resources including materials which is an extra cost to the contractor. In view of this, it is therefore imperative to identify how, where and when waste in construction projects is generated and explore measures to minimize construction waste.

The main objective of the study is to examine construction waste generation and its implication on construction project delivery in the Upper West Region of Ghana.

2.Review of Related Literature

The literature review involves researching what others have written in the subject area of waste generation and its implication to construction project delivery. Polat and Ballard (2004) defined waste simply as "that which can be eliminated without reducing customer value". Waste in construction is also defined as "the difference between the value of those materials delivered and accepted on site and those used properly as specified and accurately measured in the work, after deducting cost saving of substituted materials and those transferred elsewhere" (Polat and Ballard, 2004; Pheng and Tan, 1998).

According to Chen et al (2002) construction waste can be closely defined as debris of construction and demolition. Specifically, construction waste refers to solid waste containing no liquids and hazardous substances, largely inert waste, resulting from the process of construction of structures, including building of all types as well as roads and bridges.

The Environmental Protection Authority of South Africa (2009) defines construction waste as solid inert component of the waste stream arising from the construction, demolition or refurbishment of buildings or infrastructure but does not contain Municipal Solid Waste, Commercial and Industrial Waste (General), Listed Waste, Hazardous Waste or Radioactive Waste. Construction and demolition waste includes bricks, concrete, tiles and ceramics, steel and inert soils.

Foreign material includes green waste, plastics, electrical wiring, timber, paper, insulation, tins, packaging and other waste associated with construction or demolition of a building or other infrastructure. Foreign material must not be Municipal Solid Waste, Liquid, Listed, Hazardous or Radioactive Waste.

2.1Classification of Construction Waste

Waste in construction can culminate as a result of different causes and situations. Construction waste falls into different categories, which are elaborated on below:

2.1.1Waste According to the Type of Resources Consumed

According to Castelo Branco (2007:13), construction waste can be categorised into physical and financial waste. This classification includes the following:

Physical waste of materials: Additional amount of materials relative to those specified in the project.

Physical waste of man-hours: Man hours increased by delay in the arrival of materials and overproduction.

Physical waste of equipment: Equipment hours increased in function of the problem quoted for the man power.

Financial waste as a result of physical waste: Determine the costs associated with physical waste.

Financial waste in result of material purchase: Relative additional cost for the use of a material with superior value to the specified one.

2.1.2Waste According to its Nature

Skoyles and Skoyles (1987:18-24), categorise waste into four principal types, namely "natural direct", "indirect" and "consequential waste". Waste is, to a certain extent, inevitable on building sites and this is generally recognised by everybody in the construction industry. Skoyles and Skoyles (1987:19), refer to this acceptable level of waste as "natural waste".

"Indirect waste" is distinguished from "direct waste" in that the materials are not usually lost physically, but the payment for part or whole of the value is lost. This is the waste, which can be prevented, and involves the actual loss. Table one (1) summarises the various forms in which direct and indirect waste can occur.

Table 1: Types of Waste

Principal types	Forms of principal types
Indirect waste	• Substitution, where materials are used for purposes other than those specified. • Production waste, where ma.terials are used in excess of those indicated or not clearly defined in contract documents, e.g. additional concrete in trenches, which are extracted wider than designed because no appropriately sized digger bucket was available. • Operational waste, where materials are used for temporary site work for which no quantity or other allowances have been made in the contract documentation, e.g. tower crane bases, site paths, temporary protection. • Negligent waste, where materials are used in addition to the amount required by the physical waste, financial waste, man-hour equipment and material purchase due to physical waste. Waste according to the type of resource consumed contract, owing to the construction contractor's own negligence.
Direct waste	• Deliveries waste comprises all losses in transit to the site, unloading and placing into the initial storage. • Site storage and internal site transit waste comprise losses due to bad stacking and initial storage, including movement and unloading around the site, to stack at the workplace or placing into position. • Conversion waste comprises losses due to cutting uneconomical shapes, e.g. timber, sheeted goods. • Fixing waste comprises materials dropped, spoiled or discarded during the fixing operation. • Cutting waste includes losses caused by cutting materials to size or irregular shapes. • Application waste includes materials such as mortar for brickwork and paint spilled or dropped during application, similarly, materials left in containers or cans which are not Sealed and mixed. Materials like mortar for plaster left to harden at the end of the day. • Waste due to the uneconomical use of the plant. This covers plant running when not in use, or not employed to its optimal use. • Management waste includes losses arising from an incorrect decision and not related to anything other than poor organization or lack of supervision. • Waste caused by other trades. This includes losses arising from events such as "borrowing" by trades for purposes other than work, and not returning the plant or material or damage by succeeding trades. • Criminal waste covers pilfering, theft from the site and vandalism. • Waste due to incorrect type or quality of materials. This includes waste stemming from materials wrongly specified and waste due to errors, particularly in the bills of quantities and specification. • Waste that is usually caused by apprentices, unskilled tradesmen, and tradesmen on new operations.

Source: Skoyles and Skoyles (1987:19)

2.3Sources of Construction Waste

Waste can be categorized according to its source- the stage in which the root causes of waste occurs. Bossink and Brouwers (1996) identified the main sources of waste in construction as design, procurement, material handling, operation and residual. Sources of waste are also identified from the processing preceding construction such as materials manufacturing, design, material supply, and planning, as well as from the construction stage (Formoso et al., 1999). According to Ofori and Ekanayake (2000), construction waste can be divided into three major categories: material, labour and machinery waste. The current study, however, focuses on material wastage since most of the raw materials from which construction inputs are derived come from non-renewable resources and once wasted, becomes very difficult to replace them (Ofori and Ekanayake, 2000). Garas et al. (2001) categorized material wastes by activity, to include over-ordering, overproduction, wrong handling, wrong storage, manufacturing defects and theft or vandalism. Poon et al. (2004) also define waste minimization as "any technique, process or activity which avoids, eliminates or reduces waste at its source. In the opinion of Begum et al. (2006), source reduction is any activity that reduces or eliminates the generation of waste at source, usually within a process or re-use of what would otherwise be a waste material. Different measures for minimizing materials waste have been discussed (Begum et al., 2006; Faniran and Caban, 1998).

2.4Measuring and Ranking of Construction Waste
According to Urio and Brent (2006), Table two summarises the ranking value of the causes of construction waste by project managers, contractors, site representatives and waste management supervisors.

Table 2: Ranking of the Causes of Construction Waste

Causes of Construction Waste	Overall Ranking
Lack of onsite waste management plan (WMP)	1
Waste from application process; e.g. during plastering	2
Over –mixing of material due to the lack of knowledge of the requirement	3
Errors by tradesperson and labourer	4
Cutting of uneconomical shape/length	5
Damages by subsequent trades	6
Changes in design	7
Use of incorrect material	8
Damage during transportation on site	9
Inclement of weather	10
Other errors	11
Contract document incomplete at time of construction commencement	12
Error in contract document	13
Over ordering	14
Inappropriate storage	15
Damage during transportation to site	16
Accidents	17
Supplier error	18
Criminal waste due to damage or theft	19
Equipment malfunction	20

Source: Urio & Brent, 2006

2.5The True Cost of Waste
The true cost of waste consists of direct and indirect costs. The direct costs consist of landfill tax and the fee charged by the waste management company for transporting the waste offsite and rental cost of skip.
Indirect costs consist of:
(i) Purchase price of the material that ended up as waste.
(ii) Cost of transportation from suppliers to the site of material that ends up as waste.
(iii) Missed opportunity of not reclaiming reusable material.
(iv) Lost time in terms of labour and management time.
(iv) Loss of ability to win contracts based on bad waste history; it is a requirement from organisations with a strong environmental policy, such as local authorities to engage contractors with a good waste history.

2.6Financial Benefits of Waste Minimization
According to (DETR 2000 cited in Andrew et al. 2004) "25% of waste produced on construction sites could be minimized easily, which could increase profits by up to 2%". Very often construction projects are competitively priced, allowing for very little profit margins. With the introduction of environmentally friendly approaches to minimize waste it will mean that these extra profits will be very noticeable in the contractor's balance sheet.

3.Research Methodology
The study employed both qualitative and quantitative method of sampling which allowed appropriate and accurate data organization, analysis and interpretation.

Quantitative research is concerned with measuring of quantity or amount and involving statistical manipulation, or hypothesis testing. It deals with numbers and their manipulation in order to gain insight in that which is being studied. Kothari (2004) defines quantitative research as that which involves generation of data in quantitative form, which is then subjected to rigorous quantitative analysis in a formal and rigid way.

The decision to combine both qualitative and quantitative methods enabled the researchers to crosscheck the data gathered by different methods, thereby, making the results of the study valid and credible. As observed by Bryman (2004) “combining different methodologies in a single study enhances the researcher’s claim for the validity of his or her conclusions if they can be shown to provide mutual confirmation”.

A preliminary quantitative study was carried out to investigate the perception of industry’s players regarding construction waste issues. From the identified factors, a structured questionnaire was developed and distributed in the Upper West Region of Ghana. In order to obtain a representative sample for the study, purposive sampling techniques was used to select the firms and the respondents for the study. This technique was used to select contractors, consultants and clients from various construction firms as respondents.

The researchers also made use of probability sampling techniques. A simple random sampling without replacement techniques was used in which every unit in the population has a chance of being selected in the sample, and this probability can be accurately determined

For the purpose of the fieldwork, a total of thirty (30) contractors and their workers, were chosen from various companies within the Upper West region of Ghana.

Data was analyzed with Statistical Package for Social Sciences (SPSS) and Microsoft Excel. Tables, charts and percentages of the data gathered among others were used in the case of the quantitative technique, while descriptions were also used in the case of the qualitative analysis. The questionnaires item that has the highest responses was considered the general view of the respondents. Results of the findings were based on the statistical outcome of the responses given through the interview and administration of the questionnaires by the researchers.

The purpose of respondent’s demography is to review the capabilities of the respondents in understanding the issues of construction waste.

4.Discussions and Interpretation of Results

Descriptive Statistics about the Study Respondents

Out of the 30 contractors sampled, 28 (93.3%) were males while 2(6.70%) were females. Majority of respondents were in the age bracket of 30 – 39 years range (14 contractors representing 46.7%). The results show that a greater number of contractors in the Upper West Region of Ghana have had some form of education though they may not be construction related (40.0% have had tertiary education). Detailed demographic information about respondents are presented in Table 3.

Table 3. Descriptive statistics of study participants

	Sample size	Percentage
Gender		
Male	28	93.3
Female	2	6.70
Total	30	100
Age (years)		
18 – 29	8	26.7
30 – 39	14	46.7
40 – 49	5	16.7
50 above	3	10.0
Level of Education		
Primary	9	30.0
Secondary/technical/Vocational	8	26.7
Tertiary	12	40.0
Non formal education	1	3.3

The number of years Contractors' have experienced in the Construction Industry

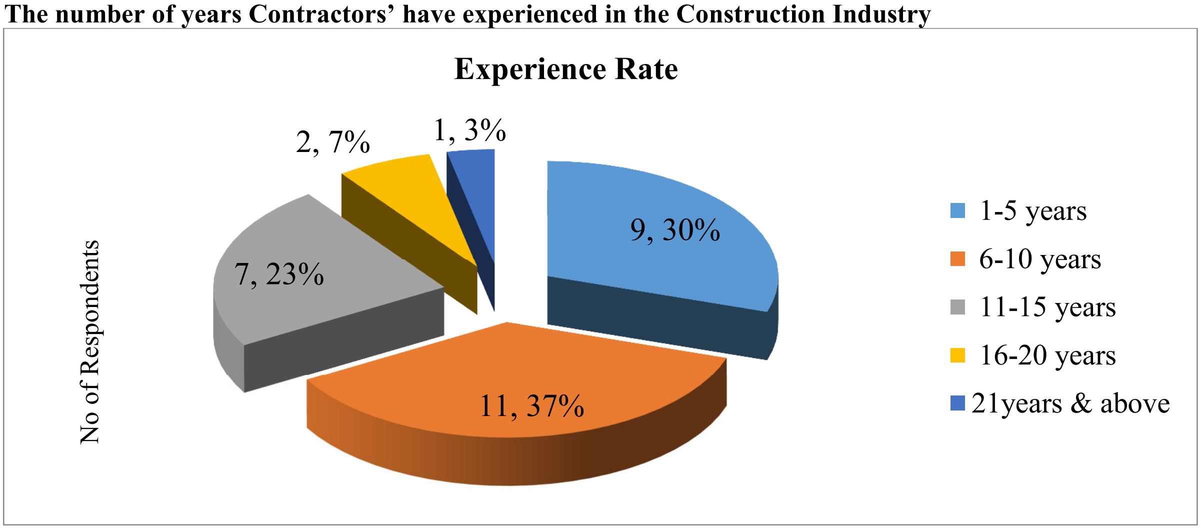

Figure 1. Experience Rate

Most contractors in the study area are less than 15years of work experience and therefore are likely to ignore methods and procedures of minimizing waste at the construction site.

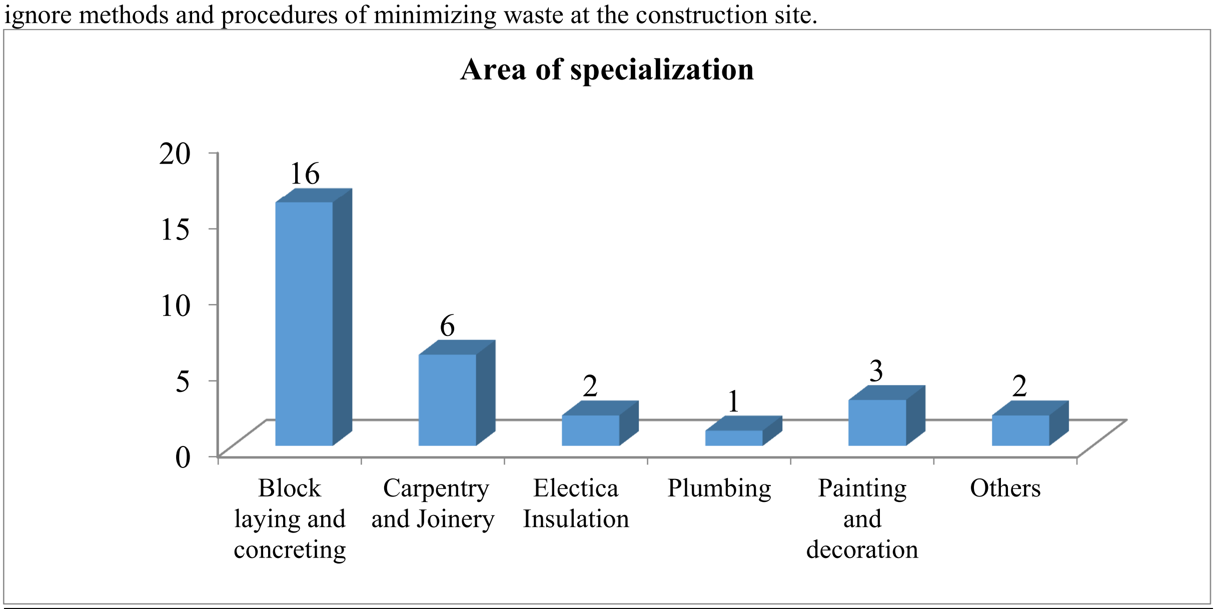

Figure 2. Area of Specialization

Figure 2. above indicates that 16 respondents representing 53.33% were specialized in block laying and concreting, 6 respondents representing 20.0% were into carpentry and Joinery, 3 respondents representing 10% were specialized in painting and decoration whilst 2 respondents representing 6.67% were specialized in electrical insulation as well as plumbing.

Table 4. Taking jobs in other areas of specialization other than contractor's area of competence.

Answer	Number of responses	Percentages %
Yes	26	86.67
No	4	13.33

About 87% of respondents in the study area take jobs or projects which are not their area of specialization. Undoubtedly it would be very difficult to control waste which invariably increases cost of construction.

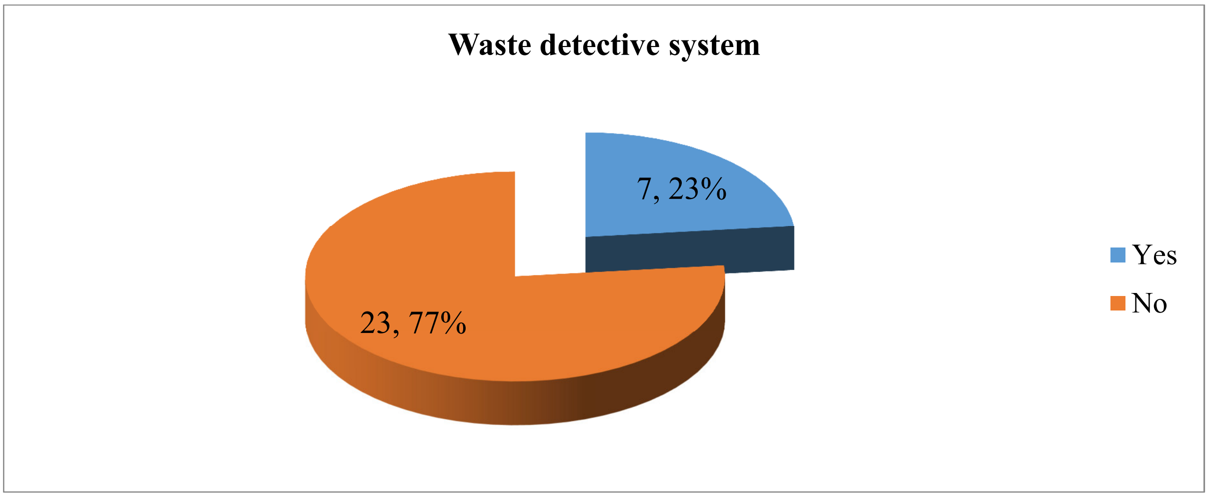

Figure 3. Waste Detective System

The result from figure 3 above indicates that 23 contractors representing 77% out of the 30 contractors noted that they have no mechanism in place to determine the rate waste. These companies can identify waste but cannot measure the rate due to lack of mechanisms. The lack of mechanism they talked about was as a result of the companies' lack of interest or ignorance of the existence of the waste mechanisms or waste detective systems.

The absence of a clear waste rate and the lack of detection systems indicated the problems of the accuracy of most project costs. It is an accepted practice that certain percentage of the cost is allocated to waste but since there is no system of measuring waste the proposed allocations could either be less than the actual waste produced or could be more than the waste produced.

The remaining 7 contractors representing 23% agreed they had it but the researchers found it very difficult to ascertain this fact because there was no prove of the existence of these waste detective system.

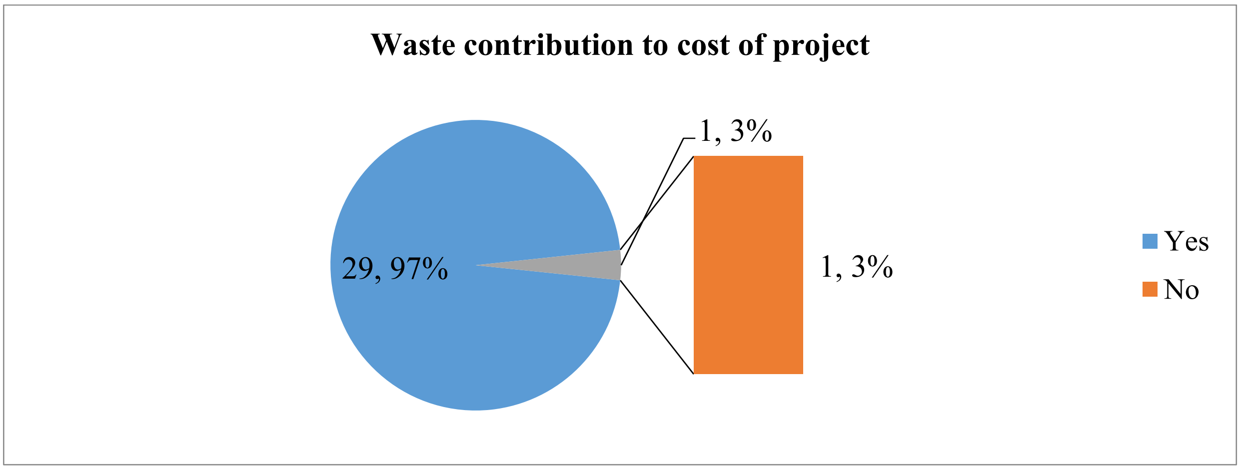

Figure 4. Waste Contribution to Cost of Project

The above figure 4 demonstrated that 29 out of the 30 respondents representing 97% agreed that construction waste contribute in reality to the cost of construction projects.

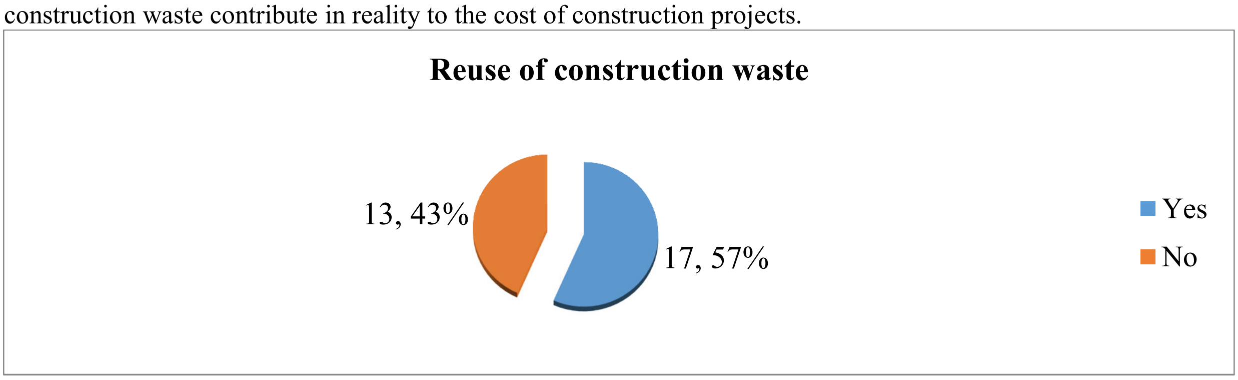

Figure 5. Reuse of Construction Waste

From figure 5 above, a greater portion of 57% of the contractors believed the waste generated on site can be reuse while a small number 43% disagreed. Those that disagreed stated that, it depends on the nature of the waste generated. They noted that most of these wastes are mixed or sometimes caked as well as cut into pieces and for that matter cannot be reused. Those that agreed explained that the reuse may be difficult but possible.

Analysis of factors that generate waste in the construction industry which ends up affecting the delivery of construction projects.

Table 5. Test for appropriateness of factor analysis

KMO and Bartlett's Test[a]

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.631
Bartlett's Test of Sphericity	Approx. Chi-Square	255.581
	df	153
	Sig.	.000

a. Based on correlations

Observing from table 4.10 appropraite for factoring hence the KMO value of 0.631 which implies that the test is “medioere” suggesting that factor analysis is appropriate and the correlation matrix is also appropriate for factoring hence the grouping with the population (variable) are real.

Again, the Bartlet’s test of sphericity is also highly significant with P-value of 0.00 and a chi-square value of 255.58 this though relatively large enough to warrant factor analysis. The three value altogether suggest that factor analysis is appropriate.

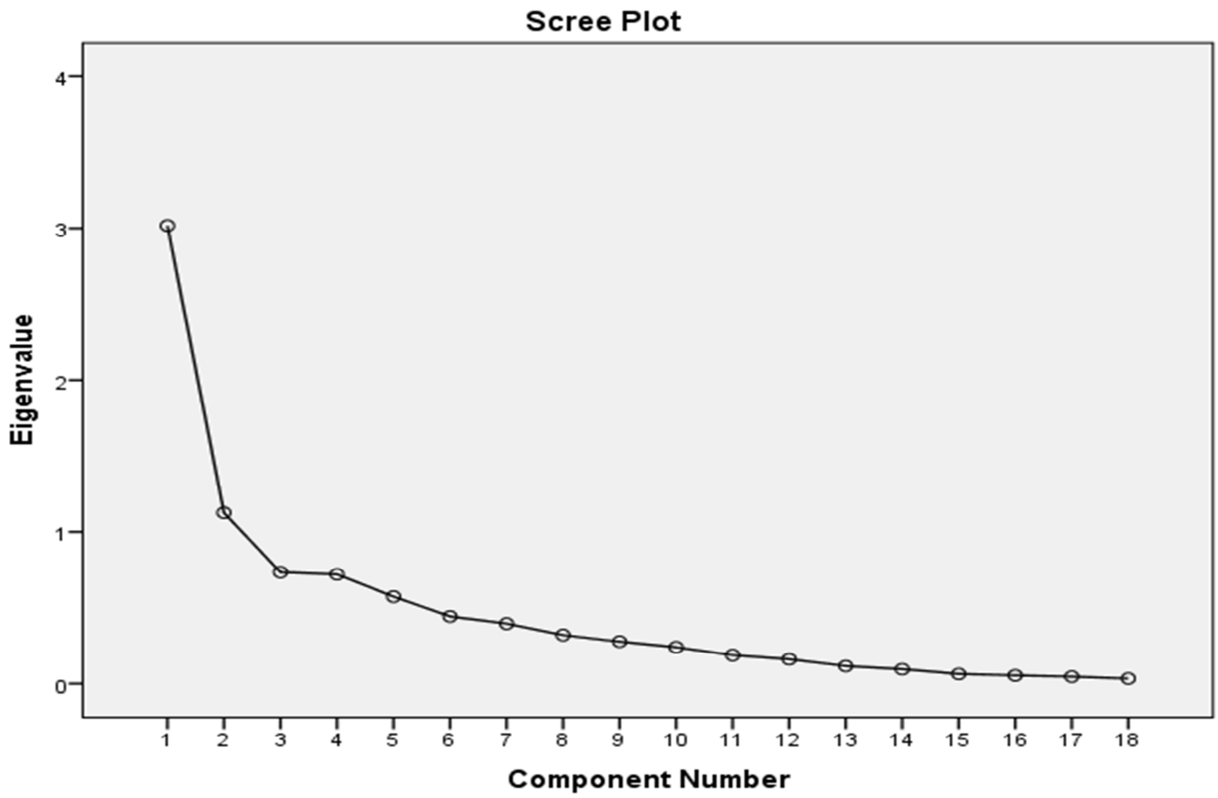

Figure 6. The scree plot showing component turning points

The scree plot shows component turning point (elbow) turning on components four ending on component five suggesting that five extracted but a close observation shows that factors after component two falls below eigenvalue greater than one hence component one and two significantly greater than one and to be considered.

Table 6. Arguments on factors that Generate Waste in the Construction Industry

		Unecono	Poor sup	the use c	Poor stor	Lack of m	Poor wor	Variation	Improper	Poor layo	Lack of cc	Wrong sp	Lack of in	Use of pc	Lack of se	Delay in	Manufac	Over ord	Negligence
Correlatio	Uneconomical use of the plant on si	1																	
	Poor supervision	0.263	1																
	the use of apprentices or unskilled	0.188	-0.22	1															
	Poor storage of materials on site	-0.063	0.167	0.096	1														
	Lack of motivation/incentives	0.352	0.379	-0.233	0.132	1													
	Poor workmanship	0.257	0.1	-0.048	-0.087	0.141	1												
	Variation in contracts	0.051	0.027	-0.078	0.179	0.179	0.423	1											
	Improper planning	0.12	0.074	0.211	-0.051	0.145	0.288	0.197	1										
	Poor layout of site	0.413	0.23	-0.055	-0.04	0.438	0.35	0.276	0.397	1									
	Lack of coordination	0.591	0.177	0.042	-0.123	0.474	0.5	0.287	0.203	0.557	1								
	Wrong specifications	0.311	0.18	0.221	0.103	0.116	0.602	0.513	0.113	0.261	0.331	1							
	Lack of inventory control	0.503	0.196	0	0.085	0.484	0.426	0.553	0.188	0.489	0.527	0.589	1						
	Use of poor quality materials	0.119	0.347	-0.199	-0.06	0.244	0.542	0.269	0.431	0.519	0.24	0.393	0.177	1					
	Lack of security	0.33	0.199	-0.244	0.143	0.404	0.296	0.485	-0.169	0.272	0.314	0.459	0.507	0.128	1				
	Delay in placing order for materials	0.062	-0.29	-0.208	-0.252	-0.051	0.314	0.255	0.069	0.217	0.056	0.242	0.185	0	0.428	1			
	Manufacturing defects	0.271	0.208	0.037	0.059	0.3	0.508	0.447	0.065	0.304	0.485	0.788	0.53	0.305	0.619	0.343	1		
	Over ordering of materials	-0.017	0.099	-0.177	-0.095	0.268	0.354	0.547	0.18	0.141	0.177	0.469	0.504	0.045	0.497	0.559	0.583	1	
	Negligence	0.066	0.308	0	0.268	0.135	0.2	0.352	0.074	0.115	0.089	0.18	0.098	0.139	0.455	0.072	0.208	0.247	1

Using factor analysis, the unrotated component matrix above helps us to assign label or best describe the factor grouping. Taken a cut off value of 0.5, it can be seen that the first factor loads highly on five indicator variables such as; manufacturing defects, use of wrong specification, lack of security, over ordering of materials and variation in contract. In approximation lack of inventory control (0.494) is considered making it six indicator variable. In all other component, none of the factors have significant loading suggesting that the first factor grouping is describing a dominant trend in waste generation in the contraction industry of the study area.

Table 4.11 give us correlation matrix, using preferable cut off form 0.5. It is therefore obvious that there exist a high correlation among the following factor grouping. Group f_1 manufacturing defects, use of wrong specification, lack of security, over ordering of materials, lack inventory control, poor workmanship and variation in contracts. Group f_2 lack coordination, uneconomical use of plants on site, poor layout of site, lack of inventory control, poor workmanship. Group (f_3) delay in placing order for materials, over ordering. Group f_4 use of poor quality material, poor workmanship poor layout of site.

Some factors have repeated themselves in factor grouping 2 and 4. Taking them out f_1 recorded seven (7) factors, f_2 recorded three (7) factors while f_3 and f_4 recorded a factor each. These gives a total of twelve (12) distinct factors which are highly correlated among themselves. The correlation between "delay in placing order of materials" and "use of poor quality materials" which are the standing factors in group f_3 and f_4 respectively is zero (0). This implies that respondents in general terms have a neutral view of rating the two either high or low. It also suggest that factors in factor grouping f_3 and $f_4$could not have any significant effect supporting the suggestion from the " eigenvalue" greater than one rule analysis which out factor grouping one and two only being feasible.

The research found out twelve (12) outstanding factors contributing in various ways to generating construction waste.

Manufacturing defects usually occur when a product deviates from its intended design, irrespective of how much care the manufacturer took to design the product, select materials, and oversee its production. Implementing quality assurance controls there is the likelihood to limit the number of defective products that are shipped to the consumer (contractor). Defects in manufactured construction products may involve low-quality materials and poor workmanship while assembling components to make the finished product. Often, the manufacturing defect could be eliminated if a more careful worker or better-quality materials were used to create the product.

In order to minimize construction waste, we recommend that factors such as manufacturing defects, use of wrong specification, lack of security, over ordering of materials and variation in contracts among other should be highly considered.

Conclusions

From the contractor's point of view, the study has shown that 60% of contractors in the Upper West region have below tertiary level of education and most of them had less than 15years of working experience. Most contractors lack technical managerial skills hence making them ignore methods and procedures of control and minimizing waste at construction sites which eventually increases construction cost.

Block laying and concreting is the dominating field of specialization of contractors in the region with plumbing and electrical insulations contractors being scares (minority). This causes about 87% of contractors taking contract works out of their area of specialization where they have limited or no knowledge on types or kinds of waste generated at those fields of work. Contractors also have less or no knowledge about mechanisms to put in place to determine the rate of waste generated at these fields of work hence end up increasing cost in construction project delivery.

Although 97% of contractors agreed that construction waste contribute in reality to increase in projects cost delivery only 23% of them claim having mechanisms in place to determine rate of construction waste. Per discussions, it was realized that even those contractors who claim having these mechanisms do not actually implement them effectively to check and reduce the rate of waste at site. Some even have no skills themselves as at how to implement these mechanisms hence living it to apprentice to handle.

The non-existence of waste measurement is an indication of lack of knowledge about the volume of waste generated. This certainly affect cost of delivery because arbitrary measurement of waste generated has been used to compute the cost of the project. Contractors as a result stands at risk of losing even part of their profit in cases where the waste generated is more than what was factored in the project cost.

Waste minimization plan is to encourage operatives to be conscious of the threat of waste to the industry and rise to the challenge by being responsible. The lack of plan to minimize waste emphasizes the lack of interest in reducing the cost of project delivery. The reasons why stakeholders i.e. contractors and consultants fail to develop waste minimization plan is because it is not a major requirement for securing a contracts in the study area. As a result little or no attention is given to the development and implementation of waste minimization plan.

The survey results show that generally construction waste generation contribute significantly in practice to project delivery. The construction Professionals' understanding of construction waste management was found to be deficient. In order to minimize construction waste, we recommend that factors such as manufacturing defects, use of wrong specification, lack of security, over ordering of materials and variation in contracts among other should be highly considered.

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