The contributions of construction material waste to project cost overruns in Abuja, Nigeria

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Abstract

Material wastage on construction sites can contribute to cost overruns. Research to provide evidence of the extent of material wastages' contribution to cost overruns on construction sites is based mostly on surveys. Thus, the actual contribution is not yet ascertained. The purpose of this article is to report the results of an objectively investigated study on the contributions of material waste to project-cost overrun. The methodological approach adopted for the study is the quantitative technique that is rooted in the positivist paradigm. The investigation included ongoing building construction projects within Abuja, Nigeria, from which a sample of 31 public and private projects was purposefully selected (project value of ₦1.6 billion Naira and above). The data for this research were sourced from the field investigation (measurement of the volume of material waste) and data from the archival records (drawings, bills of quantities, project-progress reports, and specifications) on material waste and cost overruns. The collected data were analysed using the Pearson moment correlation and the descriptive method. The research results revealed a statistically significant relationship between material waste and cost overrun. This implies that any increase in the volume of material waste would lead to a corresponding increase in the amount of cost overrun. The results showed that the significant percentage contribution of material waste to project-cost overrun ranges from 1.96% to 8.01%, with an average contribution of 4.0% to project-cost overruns. It is recommended that construction professionals be well informed of the consequences of material waste contributions to project-cost overrun at an early stage, in order to enable the professionals to evaluate the extent to which these consequences could be minimised.

Keywords: Cost overrun, construction waste, construction industry, material waste, Nigeria

Abstrak

Materiaalvermorsing op konstruksieterreine kan bydra tot die oorskryding van boukostes. Navorsingsresultate oor die omvang van materiaalvermorsing ten opsigte van koste-drempeloorskryding op konstruksieterreine is gebaseer meestal op opnames. Die werklike omvang is dus nog nie vasgestel nie. Die doel van hierdie artikel is om die resultate van 'n objektiewe ondersoek wat gedoen is oor wat die bydraes van afvalmateriaal van 'n projek is op die projekkoste-drempeloorskryding weer te gee. Die metodologiese benadering vir die studie was die kwantitatiewe tegniek wat gewortel is in die positivistiese paradigma. Die ondersoek het deurlopende bou-projekte binne Abuja, Nigerië, ingesluit waaruit 'n steekproef van 31 openbare en private projekte doelbewus gekies is met 'n projekwaarde van 1600000000 ₦ Naira en hoër. Die data vir hierdie navorsing is verkry van die veldondersoek (meting van die volume afvalmateriaal) en data uit die argiefrekords (tekeninge, bou-bestekke, projek-vorderingsverslae en spesifikasies) op afvalmateriaal en koste-drempeloorskryding. Die data-analise is gedoen met behulp van die Pearson oomblik korrelasie en die beskrywende metode. Die navorsingsresultate het 'n beduidende statistiese verband tussen afvalmateriaal en koste-drempeloorskryding getoon. Dit impliseer dat 'n toename in die volume afvalmateriaal sou lei tot 'n ooreenstemmende toename in die koste-oorskrydingsbedrag. Die navorsing toon dat die beduidende persentasie bydrae van afvalmateriaal tot projekkoste-oorskryding wissel van 1.96% tot 8.01%, met 'n gemiddelde bydrae van 4.0% tot die projekkoste-oorskryding. Dit word aanbeveel dat professionele konstruksiewerkers goed ingelig moet word oor die gevolge van afvalmateriaal se bydraes tot projekkoste-oorskryding in 'n vroeë stadium van die projek. Sodoende kan professionele konstruksiewerkers die mate waartoe die gevolge van oorskryding geminimaliseer kan word, evalueer.

1. Introduction

The construction industry contributes to the socio-economic growth of any nation by improving the quality of life and providing the infrastructure, such as roads, hospitals, schools, and other basic facilities. Hence, it is imperative that construction projects are completed within the scheduled period of time, within the budgeted cost, and meet the anticipated quality. However, being a complex industry, it is faced with the severe problems of cost overruns, time overruns, and construction waste (Abdul-Rahman, Memon & Abd-Karim, 2013: 268; Dania, Kehinde & Bala, 2007: 122; Tam, 2008: 1073). The majority of this waste has not been well managed, thus causing substantial health and environmental problems (Imam, Mohammed, Wilson & Cheesman, 2008: 469), and affecting the performance of many projects in Nigeria (Adewuyi & Otali, 2013: 746; Ameh & Itodo, 2013: 748; Oladiran, 2009: 1).

Studies from different parts of the world have shown that material waste from the construction industry represents a relatively large percentage of the production costs. Consequently, the poor management of materials and waste leads to an increase in the total cost of building projects (Ameh & Itodo, 2013: 745).

Material wastage has become a serious problem, and requires urgent attention in the Nigerian construction industry. This constraint negatively affects the delivery of many projects (Adewuyi & Otali, 2013: 746). Ping, Omran & Pakir (2009: 258) observed that extra construction materials are usually purchased, due to the material wastage during the construction process. Adewuyi & Otali (2013: 746) argue that the quantity of material waste generated on some construction sites exceeds, to some extent, the 5% allowance made to take care of material wastage in the course of preparing an estimate for a project. Accordingly, Ameh & Itodo (2013: 748) noted that, for every 100 houses built, there is sufficient waste material to build another 10 houses in Nigeria.

Osmani (2011: 209) established that 10% of the materials delivered to sites in the United Kingdom (UK) construction industry end up as waste that may not be accounted for.

Consequently, cost overrun is a common issue in both the developed and the developing nations, which makes it difficult for many projects to be completed within budget. The majority of the developing countries experience overruns exceeding 100% of the initial budget (Memon, Abdul-Rahman, Zainun & Abd-Karim, 2013: 180). Allahaim & Liu (2012: 2) reported that cost overruns were found across twenty (20) nations and five (5) continents. Cost overrun affects 90% of completed projects (Abdul-Rahman, Memon & Abd-Karim, 2013: 268).

The argument in the construction industry on how to reduce or totally remove cost overrun from a project has been ongoing among the built environment professionals, project owners, and the users for the past seventy years (Apolot, Alinaitwe & Tindiwensi, 2011: 305; Allahaim & Liu, 2012: 1). However, there is neither a substantial improvement, nor any significant solution to mitigate its detrimental effects (Allahaim & Liu, 2012: 1).

To link cost overrun to material waste, cost overrun should be introduced/clarified. Studies from different countries have revealed that cost overruns represent a large percentage of the production costs of construction projects. For instance, 33.3% of the construction project owners in the UK are faced with the problem of cost overruns (Abdul-Rahman, Memon & Abd-Karim, 2013: 268; Olawale & Sun, 2010: 511). The Big Dig Central Artery/Tunnel project in Boston could not be completed within its budgeted cost; it had an overrun of 500%. The Wembley stadium in the UK had a 50% cost overrun, and the Scottish parliament project, which had a time overrun of more than three years also experienced a cost overrun of 900% (Love, Edwards & Irani, 2011: 7).

Moreover, Ameh & Itodo (2013: 748) reported that, in the UK, material waste accounts for an additional 15% to construction project cost overruns and for approximately 11% of construction cost overruns in Hong Kong. Similarly, a study done in The Netherlands revealed a cost overrun of between 20% and 30% as a result of construction-material wastage. The methodologies adopted to achieve these relationships are based on surveys.

Therefore, research evidence has shown that previous studies from different parts of Nigeria have centred on waste-management practices and sought the perceptions of construction professionals on the contributions of material waste to cost overruns which are based on surveys and considered a subjective assessment. Nonetheless, these studies have failed to objectively (quantitatively and empirically) address the contributions of material waste to project cost overruns, because of wrong perceptions and calls for actual data such as on-site observation and records.

Ameh & Itodo (2013: 745) recommended a further study on the actual and objective measurement of materials wastage and associated cost overruns in the Nigerian construction industry. This recommendation led to the development of the problem posed in this study. The percentage of additional cost contributed by material wastage to construction-cost overruns in the Nigerian construction industry is hardly understood. On this basis, this article reports the findings of an investigation into the actual contributions of construction material waste to project cost overruns in Abuja, Nigeria.

2. Literature review

2.1 The concept of waste in the construction industry

Construction waste is a global challenge facing both construction practitioners and researchers. It can have a significant impact on time, cost, quality and sustainability, as well as on the success of projects (Nagapan, Abdul-Rahman, Asmi, Memon & Latif, 2012: 22). It is the difference between purchase and actual use (Al-Hajj & Hamani, 2011: 2). Nagapan *et al.* (2012: 22) contend that waste is any surplus or unwanted material persistently causing environmental issues and global warming. Consequently, waste has been described as any constituent generated, as a result of construction work, and abandoned, irrespective of whether it has been processed, or stocked up before being abandoned (Yuan, Lu & Hao, 2013: 484; Hassan, Ahzahar, Fauzi & Eman, 2012: 176). Therefore, Ma (2011: 137) concludes that waste is anti-sustainability that paves the way towards sustainability.

Many scholars view construction waste as any human activity that consumes resources, but creates no value, such as mistakes that require rectification, waiting time/waste of time, cost, unwanted production/overproduction, management of work programmes, and poor constructions (Ma, 2011: 127-134; Nagapan *et al.*, 2012: 22; Nagapan, Abdul-Rahman & Asmi, 2012: 2253; Chikezirim & Mwanaumo, 2013: 500).

2.2 The concept of cost overrun in the construction industry

Cost overrun has plagued construction for decades (Edward, 2009: 3). It is referred to as "cost increase" or "budget overrun", and it involves unanticipated costs incurred in excess of the budgeted amounts (Shanmugapriya & Subramanian, 2013: 735). It is defined as a percentage difference between the final completion cost and the contract-bid cost (Shanmugapriy & Subramanian, 2013: 735; Shrestha, Burns & Shields, 2013: 2). Cost overrun has also been referred to as the percentage of actual or final costs above the estimated or tender cost of a project (Ubani, Okorocha & Emeribe, 2011: 74; Jenpanistub, 2011: 19). Nega (2008: 48) defines cost overrun as an occurrence, in which the delivery of contracted goods/services is claimed to require more financial resources than originally agreed upon between a project sponsor and a contractor.

2.3 Material waste and construction cost overrun

Construction waste is generally classified into two main classes, namely the physical waste and the non-physical waste (Nagapan, Abdul-Rahman & Asmi, 2012: 2-3).

Physical construction waste is the waste from construction, renovation activities, including civil and building construction, demolition activities, and roadworks. However, it is also referred to directly as solid waste: the inert waste that comprises mainly sand, bricks, blocks, steel, concrete debris, tiles, bamboo, plastics, glass, wood, paper, and other organic materials (Nagapan, Abdul-Rahman & Asmi, 2012: 2-3). This type of waste consists of a complete loss of materials, due to the fact that they are irreparably damaged or simply lost. The wastage is usually removed from the site to landfills (Nagapan, Abdul-Rahman & Asmi, 2012: 2-3).

Non-physical waste normally occurs during the construction process. While waste from materials is a physical waste, cost overrun and time overrun are non-physical waste. Therefore, cost overrun is a waste of resources. Ma (2011: 118) defines waste as being associated not only with wastage of materials, but also with other activities such as repair, waiting time, and delays.

Since construction waste entails both physical and non-physical waste, there is a relationship between material waste originating from physical waste and cost overruns originating from non-physical waste.

3. Research methodology

This research used the quantitative method that is rooted in the positivist research paradigm. It is quantitative, because the data were generated from the numeric measurement of the volume of on-site material waste and the amount of project cost overruns.

The study covers 'ongoing' building construction projects in Abuja, the Federal Capital Territory of Nigeria, from which a sample of 31 projects was selected. The sample comprises both public and private projects, with a value of 1.6 billion Naira/R100 million and above, using purposive sampling techniques. The rationale for the selection is that building construction projects of this value and above are likely to generate large quantities of material waste and huge amounts of cost overruns, when compared with projects of less value. In addition, it is possible to have more experts (experienced professionals) than in smaller-sized/lower-valued projects.

Abuja was selected as a geographical case study area, because it is one of the metropolitan cities in Nigeria with the highest population of professionals within the built environment and has many ongoing construction projects.

This study focused mainly on the primary data, which included the field investigation and data from the archival records (drawings, bills of quantities, project progress reports, and specifications) on material waste and cost overruns in the Nigerian construction industry. These data were generated from 'ongoing' and non-completed projects.

3.1 Archival records

The volume of materials used for each building project was generated from the measured quantities of each material from the priced/unpriced bills of quantities (BOQ) prepared for the project. The measurement unit of each material, as contained in the BOQ (linear, square and cubic metre, number, kilogram, tonne, and so on), was converted to a common standard unit (volume/cubic metre). The converted volumes were summed up to achieve the total volume of materials for a building.

Where access to BOQ is denied, the building volume was generated by taking direct measurements of the quantities from drawings, and by making the necessary adjustment (for openings, plastering, finishes, and so on), in accordance with the rules of the Standard Method of Measurement (SMM) for building works, in order to determine the net building volume.

The data on Estimated Cost (*EC*), Estimated Time (*ET*), Cost Now (*CN*), and Time Now (*TN*), the Percentage of the Work Completed (% of *WC*), the Estimated Cost of the Work Completed (*ECWC*), and the Actual Cost of Work Completed (*ACWC*) for different projects were all collected from the records of projects compiled by the quantity surveyor for individual projects.

The collected values of "*ACWC*" were deducted/subtracted from the values of "*ECWC*" to determine the project's cost overruns.

3.2 Field investigations

Data on the volume of on-site material waste was generated by physical on-site measurements with the aid of measuring instruments such as tape and measurement rule. Where the generated on-site material waste had already been disposed of and removed from the site, a request was made to allow the researcher to access the total volume (material waste) disposed of/removed from the project's on-site records.

The collected data (waste volume) was used to determine the contributions of material waste to the generated amount of cost overruns.

3.3 Data analyses

Both descriptive and inferential analyses of the data were employed in this study. The descriptive tool included percentage distributions and the result is presented in Table 2.

The Pearson moment-correlation (Inferential) analysis available from the Statistical Package for Social Sciences (SPSS) was performed to determine the contribution of material waste to the project's cost overrun. The volume of material waste was represented by the independent variable (x), and the amount of cost overrun was represented by the dependent variable (Y), as material waste can cause cost overruns.

The Pearson moment-correlation is represented mathematically as:

$$r = \frac{n(\sum xy)-(\sum x)(\sum y)}{\sqrt{[n\sum x2-(\sum x)2][n\sum y2-(\sum y)2]}};$$

Where *r* = Pearson moment-correlation coefficient; *x* = Values in the first data set; *y* = Values in the second data set, and *n* = Total number of values.

The approximate conversion rates used as at the period of data collection were:

Nigerian Naira to US dollar === ₦200=1USD;

Nigerian Naira to South African Rand === ₦16=R1.

The average project completion for the entire building-construction projects visited was 52.4%, as the constructions were ongoing at the time of data collection. This kind of research is easier with ongoing projects, because material waste is mostly removed from a project site as soon as the project is completed, making it difficult to measure the acutal material waste.

4. Results and discussion

4.1 The contributions of material waste to project-cost overruns

Table 1 shows the result of the correlation analysis between a 52.4% average volume of on-site material waste recorded on-site (independent variable "x") and the calculated amount of cost overrun (dependent variable "*y*").

It was observed from the analysis that the probability value (0.0027) was less than the 0.05 (5%) significance level, and the hypothesis was tested at the 95% confidence level. The R-square value (52.82%) shows a strong relationship between the variables.

Therefore, it is inferred that the relationship was statistically significant.

The result implies that any increase in material waste on the construction site would result in a corresponding increase in the amount of cost overrun for a project.

Table 1: Results of the Pearson moment-correlation analysis between the volume of material wasted (52.4% average project completion) and the cost overruns

S/n	Variables		Type of analysis	Observation			
	X	**Y**		**R square**	**Probability value**	**Strength of relationship**	**Remarks**
7	Volume of material wasted	Cost overrun	Pearson Moment correlation	52.82%	0.0027	Strong	Statistically significant

Consequently, since it has been statistically established that material waste contributes significantly to project-cost overruns, Table 2 further explains the percentage contribution of material waste to project-cost overruns in a descriptive format.

The project values ranged from a minimum of ₦1.635 billion to a maximum of ₦63 billion, and the percentage of work completed also ranged from a minimum of 4% to a maximum of 100%.

Table 2 indicates that contributions of material waste ranged from a minimum of ₦31,220,528.06 (1.96%) to a maximum of ₦39,933,360.29 (8.01%), with an average contribution of approximately 4% to the project-cost overrun.

Furthermore, this percentage (4%) differs from the 5% normally allowed for materials, in order to take care of waste in the process of compiling a bill of quantities.

This result corroborates the findings of the studies conducted in the UK, Hong Kong, The Netherlands, and Nigeria, namely that wastage of construction materials contributes to additional project costs by reasonable percentages (Ameh & Itodo, 2013: 748). The result also supports the findings of Ping, Omran & Pakir (2009: 262).

The result implies that the average contribution of material waste to project-cost overruns is 4%. This result (4% contribution) does not support the following findings:

Memon (2013: 10) concluded that construction waste accounts for approximately 30%-35% of a project's construction cost; construction materials waste on site account for approximately 9% by weight of the procured materials. The reason for the variation between the findings of this research and those of Memon (2013: 10) is that the findings reported by Memon (2013: 10) are, to a large extent, based on surveys and perceptions may be wrong. Another factor may be differences in geographical locations and methods of construction.

In addition, the study negates the findings reported by Ameh & Itodo (2013: 748) that, in the UK, material waste accounts for an additional cost of 15% to construction project-cost overruns; accounts for approximately 11% to construction cost overruns in Hong Kong, and accounts for 20%-30% in The Netherlands. This is probably because the methodology adopted for most of these studies was a survey research design, which relies on the professionals' perceptions of material wastage and cost overrun during construction operation, which is considered a subjective assessment. For instance, the respondents are required to tick a questionnaire with the following options: from 10%-15%, 15%-20%, 20%-30%, and so forth, from which conclusions were drawn.

Furthermore, the contributions of material waste to cost overrun (cf. Table 2) were determined by dividing the "material waste volume" by the "volume of material used for the project" multiplied by the amount of cost overrun. It is given as:

$$\textbf{\textit{Contribution}} = \frac{\textit{Volume of material waste recorded}}{\textit{Volume of material used for project}} \times \textit{cost overrun}$$

$$\textbf{\textit{Percentage contribution}} = \frac{\textit{contribution of waste to cost overrun}}{\textit{cost overrun}} \times 100$$

Source: Researcher's own construct, 2015

Table 2: Average contributions of material waste to project-cost overruns

S/n	Estimated cost of projects (EC) (₦)	% of work completed	Volume of materials used for building (m^3)	Volume of material waste recorded on each project	Cost overrun (₦)	Contribution of material waste to cost overrun in (₦)	% contribution of material waste to cost overrun
1	3,200,000,000.00	17%	1,517.25	65.24	256,000,000.00	11,007,704.73	4.30%
2	14,000,000,000.00	47%	16,686.60	634.09	1,960,000,000.00	74,479,906.03	3.80%
3	1,650,000,000.00	59%	3,024.84	124.02	181,500,000.00	7,441,593.61	4.10%
4	6,000,000,000.00	35%	3,759.38	155.49	300,000,000.00	12,408,163.05	4.14%
5	5,880,000,000.00	43%	3,092.29	196.23	1,081,000,000.00	68,597,909.64	6.35%
6	1,800,000,000.00	63%	12,022.09	963.40	498,321,000.00	39,933,360.29	8.01%
7	15,900,782,413.00	30%	22,510.10	891.85	908,078,720.00	35,978,072.35	3.96%
8	7,300,000,000.00	30%	4,395.42	128.04	1,095,000,000.00	31,897,702.61	2.91%
9	1,800,000,000.00	68%	3,785.40	232.14	457,100,000.00	28,031,699.16	6.13%
10	6,000,000,000.00	23%	3,222.36	136.34	420,000,000.00	17,770,453.95	4.23%
11	1,650,000,000.00	65%	11,180.74	572.45	378,800,000.00	19,394,428.28	5.12%
12	1,900,000,000.00	25%	3,488.40	108.14	125,000,000.00	3,874,985.67	3.10%
13	2,580,333,000.00	15%	2,194.95	57.72	193,524,975.00	5,089,073.35	2.63%
14	40,000,000,000.00	5%	33,679.62	707.27	4,321,562,000.00	90,752,542.81	2.10%
15	20,940,557,219.00	17%	2,944.52	57.71	1,592,955,087.00	31,220,528.06	1.96%
16	3,450,000,000.00	23%	1,145.96	36.01	500,012,000.00	15,712,094.77	3.14%
17	1,666,345,702.00	31%	6,445.36	223.01	317,164,997.00	10,973,935.67	3.46%
18	2,300,000,000.00	25%	4,301.80	141.96	230,000,000.00	7,590,032.08	3.30%
19	2,300,000,000.00	90%	17,117.24	701.81	115,000,000.00	4,715,021.23	4.10%
20	15,031,447,866.00	11%	7,412.42	158.85	282,172,900.00	6,047,035.27	2.14%
21	1,880,000,000.00	48%	9,266.67	398.47	631,600,000.00	27,159,017.42	4.30%
22	1,686,920,734.00	100%	9,522.10	400.88	1,413,079,266.00	59,490,576.25	4.21%
23	1,635,000,000.00	56%	4,049.59	247.03	320,630,936.00	19,558,883.77	6.10%
24	1,800,000,000.00	68%	7,446.82	156.38	140,562,110.00	2,951,743.53	2.10%
25	1,686,951,106.00	100%	5,322.35	NR	1,013,048,894.00	NR	NR
26	1,700,000,000.00	60%	9,248.40	322.74	340,000,000.00	11,864,927.99	3.49%
27	2,860,000,000.00	88%	14,720.64	529.94	646,031,000.00	23,256,982.59	3.60%
28	7,621,687,168.00	100%	15,585.50	568.87	7,562,312,832.00	276,024,054.50	3.65%
29	2,635,001,302.00	95%	18,200.68	893.65	482,081,763.00	23,670,124.83	4.91%
30	1,931,621,700.00	98%	16,130.75	645.23	268,323,734.00	10,732,948.69	4.00%
31	63,000,000,000.00	90%	190,723.05	4,005.18	5,333,222,000.00	111,997,548.70	2.10%
Average percentage contribution of material waste to cost overruns=4.00%							

Table 2 shows that about 15 out of the 31 projects were 50% completed and that only 7 were 90-100% completed. These findings are reliable, because the average completion is above 50%. As stated earlier, this kind of research is easier with ongoing projects. The author could not wait until a project was completed, as this would constrain the on-site measurement of material waste.

5. Conclusion and recommendation

The empirical findings from the study established that a relationship exists between material waste and cost overruns. This implies that an increase in material wastage on site leads to a corresponding increase in cost overruns, regardless of the percentage allowed for material waste in the process of the bill preparation.

It is also concluded from the empirical analysis that the significant percentage contribution of material waste to project cost overrun ranges from 1.96% to 8.01%, with an average contribution of 4.00% to project-cost overruns.

Therefore, the average percentage contribution of material waste to cost overrun for a project is 4.00%, which is different from the percentage allowed for material waste in the process of preparation of a bill of quantities.

The study recommends that construction professionals should be well informed of the consequences of material waste contributions to project cost overrun at the early stage of a project, in order to enable the professionals to evaluate the extent to which these consequences could be minimised.

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