A Relationship between Quality-of-Estimating, Construction Material-Waste Generation and Cost Overruns in Abuja, Nigeria

Ibrahim Saidu and Winston Shakantu
Department of Construction Management,
Nelson Mandela Metropolitan University,
Port Elizabeth, South Africa
E-mail: s214344924@nmmu.ac.za

Abstract:
While wastage of materials has become a serious problem requiring urgent attention, cost overrun is a problem which affects 90% of the completed projects in the world, as wastage of materials leads to increase in the final project cost. The wastage of materials and cost overrun occur at different stages of a project, from the planning, design, estimating to project-completion stage. The purpose of this paper is to examine the material-waste causes and the control measures that have effects on cost overruns at the estimating stage of a project. The methodological approach adopted for the discourse is mixed (quantitative and qualitative) technique. The collected data were analysed using the descriptive (cross-tabulation) method. The paper found "inaccurate quantity take-off"; "insufficient time for estimate"; "lack of details drawings and specifications for estimating"; and "inadequate project risks evaluation" as the top material waste causes that have very-high effect in causing cost overrun at the estimating stage of a project. The paper concludes that material-waste causes and their control measures all have a significant effect in causing/controlling cost overruns at the estimating stage of a project. The management of material waste and cost overrun should be revised based on the findings of this research and included as part of the pre-contract management process of a project.

Keywords:
Construction, Control measures, cost overrun, estimating stage, material waste

1 Introduction

The construction industry contributes to the socio-economic growth of any nation. Hence, it is imperative that construction projects are completed within the scheduled time, cost and anticipated quality. However, they are faced with the severe problems of cost overruns and material waste (Abdul-Rahman, Memon and Abd. Karim 2013). Ameh and Itodo (2013) highlighted that in every 100 houses built there is sufficient waste material to build another 10 houses. Adewumi and Otali (2013) argue that despite the 5% allowance made to take care of material wastage in the course of estimate preparation for a project has been usually inadequate because waste is seen in many ways in a construction project in Nigeria. Babatunde (2012) and Wahab and Lawal (2011) attributed it to little/lack of attention given to waste management practices.

Consequently, material waste is occasioned by several sources and causes at different stages of projects, including planning, estimating, design, and construction stage. Identification of these causes and application of relevant control measures to minimise their occurrence is a

step towards alleviating the consequences (Oladiran, 2009; Nagapan *et al.,* 2012; Mou, 2008).

On the other hand, cost overrun is a common problem in both developed and developing nations which makes it difficult for many projects to be completed within their budget (Memon, Abdul Rahman, Zainun, and Abd Karim, 20130). Being a common problem, cost overrun was found across twenty (20) nations and five (5) continents of the world (Allahaim and Liu, 2012). The argument in the construction industry on how to reduce or totally remove cost overruns from projects has been on-going among the built environment professionals, project owners and the users for the past seventy (70) years (Apolot, Alinaitwe and Tindiwensi, 2010; Allahaim and Liu, 2012), but there is no substantial improvement nor significant solution in mitigating its detrimental effects (Allahaim and Liu, 2012).

Furthermore, on-site wastage of material leads to increase in the final cost of the building project. As materials are wasted, more are procured and thereby; affecting the estimated cost. (Ameh and Itodo, 2013; Teo, Abdelnaser, and Abdul, 2009).This is regardless of the 5% allowance made to materials in the process of bill-of-quantities production in order to take care of waste.

Previous studies from various countries have confirmed based on the estimating point of view that waste represent relatively larger percentage of production cost. For instance, Ameh and Itodo (2013) in Tam, Shen, and Tam (2007) in a UK study reported an additional cost of 15% to construction projects cost overruns as a result of material wastage. A study conducted by the Hong Kong Polytechnic and the Hong Kong Construction Association (1993) put material waste contribution to cost overruns at 11%. Bossink and Bounwers (1996) in a similar study of material wastage in the Netherlands concluded that material wastage account for between 20-30% of project cost overruns.

Management-of-material waste and cost overruns is not new field of knowledge and expertise. Many studies have been carried out in the fields, but still, there is need for a research that provides an objective assessment of the effect of material waste on construction-cost overrun in the Nigerian construction industry. Hence, this paper aims to examine the effects of material waste causes and control measures on cost overrun at the estimating stage of a project.

2 Relationship between 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 and Asmi, 2012). The physical construction waste is a waste from construction, renovation and demolition activities, including civil and building construction, demolition activities, and roadwork (Nagapan, Abdul-Rahman and Asmi, 2012). It is, however, referred by some directly as solid waste: the inert waste which comprises mainly sand, bricks, blocks, steel, concrete debris, tiles, bamboo, plastics, glass, wood, paper, and other organic materials (Nagapan, Abdul Rahman and Asmi (2012). 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 and Asmi, 2012).

On the other hand, the non-physical waste normally occurs during the construction process. By contrast with material waste, non-physical waste relates to time and cost-overrun for a construction project.

In other words, waste in construction is not only focused on the quantity of materials on site, but also overproduction, waiting time, material handling, inventories and unnecessary movement of workers (Ma, 2011; Nagapan, Abdul-Rahman and Asmi, 2012). Consequently, Memon Abdul-Rahman and Memon (2014) added that the non-physical waste includes undesired activities which can cause the physical waste such as rework, unnecessary material movements, and so forth.
Figure 1 which shows the classification of construction waste further depicts that, since construction waste entails both the physical and the non-physical waste, there is a relationship between material waste originating from the physical waste and cost overrun from the non-physical waste since they originate frome the same waste family. This is supported by the summary of the causes of material waste and those of cost overrun in Table 1:

Figure 1: Classification of construction waste (Adapted from Nagapan, Abdul-Rahman and Asmi, 2012: 2-3).

Table 1: Relationship between material-waste causes and cost overruns

Causes of Cost overrun	Cost overrun	Material waste
Design error	✓	✓
Deficiencies in cost estimates	✓	✓
Insufficient time for estimate	✓	✓
Improper planning at on stage	✓	✓
Political complexities	✓	✓
Insurance problems	✓	✓
Changes in material specification	✓	✓
Laws and regulatory framework	✓	✓
Poor design management	✓	✓
Lack of design information	✓	✓
Designing irregular shapes and forms	✓	✓
Lack of communication among parties	✓	✓
Change in the scope work	✓	✓
Delay payment to supplier/subcontractors	✓	✓
Shortage of materials	✓	✓
On-site waste	✓	✓
Project size	✓	✓
Lack of constructability	✓	✓
Unrealistic contract duration	✓	✓
Rework	✓	✓

(Source: Le-Hoai, lee and lee, 2008; Memon, Abdul-Rahman and Abdul-Aziz, 2011; Love, Edward and Irani, 2011; Allahaim and Liu, 2013; Olawole 2010; Kasimu, 2012; Malumfashi and Shuaibu 2012; Nagapan *et al.,* 2012; Osmani, Glass and Price, 2008; Wahab and Lawal; 2011; Ameh and Itodo, 2013; Aietan and Smallwood, 2013; Osmani, 2011)

3 Research Methodology

The research employed the use of mixed method approach (quantitative and qualitative). The study covered building construction projects within Abuja, the Federal Capital Territory of Nigeria. Abuja was selected because; it has the highest population of professionals within the built environment and has many on-going construction projects.

An interview was purposefully conducted with the construction professionals handling a project (private or public projects) with a value of ₦1.6 billion Naira/R100 million Rand and above. The basis or rationale for this selection is that projects of this value and above are likely to produce large quantities of material waste and huge amount cost overruns when compared with the projects of less value. The interview respondents comprised: 15 Project Managers (PM), 9 Quantity Surveyors (QS), 5 Site Engineers (SE) and 1 Senior Technical Officer (STO) of waste management department.

Structured questionnaires on the issues relating to the causes-of-material waste and cost overruns at the estimating stage of a project were filled which addressed the quantitative aspect of this research. The research employed the descriptive, the narrative, and the inferential analyses. The descriptive tool that was used to analyse the data (questionnaires) was the cross tabulation method. The results were presented in Table 1 and 2. The responses from the questionnaires are rated based on the cut-off points highlighted by Morenikeji (2006) in a five Likert scale that, the material-waste causes and control measures that have percentage of "90 to 100" are rated "very high effect"; 70 to 89% are rated "high effect"; 50 to 69% are rated "moderate effect"; 30 to 49% are rated "little effect"; and 29 to 1% are rated "very little effect" on cost overruns. The analysis of variance (one-way ANOVA) was used to compare, if there is DIFFERENCE in the views of the respondents on the results of the effects of material-waste causes on cost overrun.

Furthermore, the recorded, transcribed, and interpreted interview data (narrative) were analysed using the deductive approach which involves constant comparative analysis after the interview data were sorted and coded to generate knowledge about common pattern within the interviewees' evidence on material waste and cost overrun at the estimating stage of a project.

4 The Research Findings

The findings of this research are presented in two major sections namely: Section A and B. Section A: deals with the qualitative aspect of the research which are in narrative form (results from interview), while Section B: deals with the quantitative aspect (results from questionnaire) of the research.

4.1 SECTION A: Interview Results (Qualitative)

4.1.1 Contributions of quality-of-estimating to material waste generation

Poor quality estimation (under/over) for project has a relationship with material-waste generation and cost overruns. Poor quality estimation results in poor unit rates and wrong procurement.
In the case of over estimation, more materials would be procured onsite which would be over and above the required quantity and the remaining materials would result in waste, and thereby contribute to cost overrun.

Also, under estimation would require additional cost of transportation, loading and unloading of materials for supplementary procurement resulting to waste of resources and contributing the cost-overrun. Therefore, an experienced estimator is required to achieve an accurate and precise estimate for a project. These results corroborate the findings of Subramani, Sruthi, and Kavitha (2014); Ameh and Osebe (2006); Jenpanistub (2011); and Aziz (2013) who highlighted poor cost estimation/estimation techniques as a major cause of project-cost overruns.

4.1.2 Contributions of quantity take-off to material-waste generation and cost overrun

Wrong quantity take-off results in over/under estimation which contributes to waste generation and cost overrun. For instance, sharp sand/aggregate has a shrinkage allowance of thirty (30) percent, and the absence of this allowance in taking-off process would result in under estimation for the material. This result corroborates the findings of Lee-Hoai, Lee (2008) who established "inaccurate quantity take-off" as one of the top five (5) most important causes of cost overruns in large projects in Vietnam. The result also supported the argument of Aziz (2013) who examined the causes of cost overrun in Egyptian construction industry.

4.1.3 Insufficient time-for-estimate as a factor that contributes to waste and cost-overrun

Insufficient time for estimate contributes to material waste and cost overruns to a very large extent because pressure on the estimator to produce an estimate earlier than when due, could lead to making incorrect assumptions, and could not afford the estimator the time to engage in other estimating activities. Thus project estimators need sufficient time to conduct market surveys/intelligence, in order to have an idea on the current prices of materials; study the project particulars such as the designs/drawings and specifications; engage in risks evaluation and analyses to determine the project risk factors which will assist in achieving a good estimation for material waste; and ample time for checking and cross checking the prepared estimate in case of errors and omissions. Also, a design may sometimes specify foreign materials that might not be locally obtainable, thus, sufficient time must be allowed to avoid assuming estimation figures.
Consequently, these results support the findings of Kasimu (2012) who identified the problems of insufficient time as one of the major causes of cost-overrun in the Nigerian construction project.

4.2 SECTION B: Questionnaire Results (Quantitative)

4.2.1 The effects of material-waste causes on cost overrun at the estimating stage of a project

The material waste causes that have 'very high effects' on project-cost overrun at the estimating stage as indicated in Table 2 were: (i) inaccurate quantity take-off (100%); (ii) insufficient time for estimate (100%); (iii) lack of detailed (readable & interpretable) drawings and specifications for estimating (93.3%); and (iv) inadequate project risks evaluation, analysis, and estimation (90%). They were deemed to have very high effects on cost overrun because they fall between 90-100%. However, the material waste causes that have very little effects in causing cost-overrun at estimating stage were: (a) improper monitoring and improvement on previous mistakes (23.3%); (b) design requiring frequent change (3.3%); and (c) late engagement of estimators (3.3%). They were deemed to have very little effects on cost overrun because they fall between 29-1%.

These results confirmed the findings of Ameh and Osegbe (2011) who believe that most of the problems relating to cost overrun occur at the planning and estimating stage of a project. Ogunsemi and Jagboro (2006) attributed the problems of cost overrun to erroneous quantity take off at an early stage of a building project.

Table 2: Results of cross tabulation on the effects of material waste causes on cost overrun at the estimating stage of a project

Causes and sources of material waste on cost overrun (Quality of estimating)	**Project Manager (PM)**	**Quantity Surveyors(QS)**	**Site Engineers(SE)**	**Senior Technical Officer**	**Total**	**Ranking**	**Decision**
Over/under estimating	15(100%)	5(55.6%)	3(60%)	1(100%)	24 (80%)	4	High
Inaccurate quantity take-off	15(100%)	9(100%)	5(100%)	1(100%)	30(100%)	1	Very high
Insufficient time for estimate	15(100%)	9(100%)	5(100%)	1(100%)	30(100%)	1	Very high
Different estimation methods	7(46.7%)	3(33.3%)	5(100%)	1(100%)	16(53.3%)	8	Moderate
Inexperienced estimator	9(60%)	6(66.7%)	4(80%)	1(100%)	20(66.7%)	7	Moderate
Lack of detailed drawing and specifications (readable & interpretable)	15 (100%)	7 (77.8%)	5 (100%)	1 (100%)	28 (93.3%)	3	Very high
Inadequate project risks evaluation, analysis, and estimation	14 (80%)	7 (77.8%)	3 (60%)	1 (100%)	25 (90%)	5	Very High
Inadequate knowledge of site conditions	9 (60%)	8 (88.9%)	4 (80%)	1 (100%)	22 (73.3%)	6	High
Lack of estimating information	6(40%)	4(44.4%)	4(80%)	1(100%)	15(50%)	10	Moderate
Poor knowledge of fluctuating market conditions/prices	8 (53.3%)	5 (55.6%)	2 (40%)	1 (100%)	16 (53.3%)	8	Moderate
Improper monitoring and improvement on previous mistakes	4 (26.7%)	1 (11.1%)	2 (40%)	0 (0%)	7 (23.3%)	11	Very little
Frequent design change	0(0%)	1(11.1%)	0(0%)	0(0%)	1(3.3%)	12	Very little
Late engagement of estimators	0 (0%)	1 (11.1%)	0 (0%)	0 (0%)	1 (3.3%)	13	Very little

4.2.2 The effects of material waste control measures on cost overrun (Quality of estimating)

Table 3 shows that the material waste control measures that have very high effects in controlling cost overrun at the estimating stage of a project were: (i) sufficient time for estimate (100%); (ii) accurate quantity take-off (100%); (iii) engaging experienced estimator/s (96.7%); (iv) availability of detailed drawings, dimensions, and specifications (96.7%); and (v) proper project risk estimation (90%).

They were deemed to have very high effects on cost overrun because they fall between 90-100%. These results were supported by Jackson (2003: 4) who identified that drawings must be detailed before achieving a better estimate. It was also supported by Peeters and Madauss (2008: 81) who higlighted that realistic cost estimation is the best way to avaoid cost overrun for project.

Nonetheless, the material waste control measures that have very little effects in controlling cost-overrun at estimating stage were: (a) monitoring and improving on previous estimating mistakes (23.3%) and (b) thorough design check and estimate (13.3%). They were deemed to have very little effects on cost overrun because they fall between 29-1%. These results corroborate the findings of Abdul-Azis, Memon, Abd-Rahman, and Abd-Karim (2013: 2625-2627) who stated that improving on past mistakes would help in reducing project cost overrun.

Table 3: Results of cross tabulation on the effects of control measures for material waste on cost overrun (Quality of estimating)

Control measures for material waste (Quality of Estimating)	Project Manager (PM)	Quantity Surveyors(QS)	Site Engineers(SE)	Senior Technical Officer WMCST	Total	Ranking	Decision
Ensure a good knowledge of material estimation (Unified method of estimating)	5 (33.3%)	4 (44.4%)	2 (40%)	0 (0%)	11 (36.7%)	10	Little
Error free estimation	15(100%)	6(66.7%)	4(80%)	1(100%)	26(86.7%)	4	High
Knowledge of fluctuating market prices of materials	8 (53.3%)	4 (44.4%)	3 (60%)	1 (100%)	16 (53.3%)	6	Moderate
Thorough checking of design and the prepared estimate	2 (13.3%)	1 (11.1%)	1 (20%)	0 (0%)	4 (13.3%)	12	Very little
Experienced estimator	15(100%)	8(88.9%)	5(100%)	1(100%)	29(96.7%)	2	Very high
Detailed drawings, dimensions and specifications	15 (100%)	8 (88.9%)	5 (100%)	1 (100%)	29 (96.7%)	2	Very high
Proper risks estimation	14(93.3%)	8(88.9%)	4(80%)	1(100%)	27(90%)	5	Very high
Knowledge of site conditions	4(26.7%)	5(55.6%)	3(60%)	1(100%)	13(43.3%)	9	Little
Sufficient time for estimate	15(100%)	9(100%)	5(100%)	1(100%)	30(100%)	1	Very high
Availability of estimating information	5 (33.3%)	5 (55.6%)	4 (80%)	1 (100%)	15 (50%)	7	Moderate
Accurate quantity take-off	15(100%)	9(100%)	5(100%)	1(100%)	30(100%)	1	Very high
Monitoring and improving on previous estimating mistakes	4 (26.7%)	1 (11.1%)	2 (40%)	0 (0%)	7 (23.3%)	11	Very little

4.2.3 Comparative views of respondents on the effects of material waste causes and control measures on cost overrun at estimating stage of a project

The result of the ANOVA analysis which compares the respondent views on the effects of material-waste causes and control measures on cost overruns revealed that, the values of f-calculated (0.952 and 0.917) were both less than the value of f-tabulated (1.701) respectively. The probability values (0.399 and 0.412) were both greater than the critical value of 5% (0.05) significance level at 95% confidence level within the mean square group (2.35-2.47 and 2.00-2.18) respectively. The evidences are statistically not significant. The results imply that the respondents were of the same views on the effects of material-waste causes and control measures on cost overrun at the estimating stage of a project.

5 Conclusion and Recommendations

The paper concludes that material-waste causes and their control measures were found to have significant (very-high, high, medium, low, and very-low) effects in causing/controlling cost overruns at the estimating stage of a project. Also, there was no significant difference in the views of the respondents on these issues. Therefore, the respondents have the same view on the results of the effects of material-waste causes and control measures on cost overruns at the estimating stage of a project.

It is important that careful consideration be given to the issues identified in this study, most especially the material waste causes and the control that have very-high and high effects on cost overruns; as these would assist in a achieving an error-free estimation which would lead to reduction in the rate of material waste and cost overrun for a project. It is also recommends that management of material waste and cost overruns for a project should be revised, based on the findings of this research and included, as part of the initial project procurement process. This would enable the design and the estimating teams to investigate or evaluate the extent to which completed buildings meet the required cost overruns and waste-management objectives. Further research should be conducted to investigate the effects of material waste causes on cost overrun at the post-contract stages of a project.

6 References

Abdul-Azis, A.A., Memon, A.H., Abdul-Rahman, I. and Abd. Karim, A.T. (2013). Controlling Cost Overrun Factors in Construction Projects in Malaysia, *Research Journal of Applied Sciences, Engineering and Technology,* 5(8), 2621-2629.

Abdul-Rahman, I., Memon, A.H. and Abd. Karim, A.T. (2013). Significant Factors Causing Cost Overruns in Large Construction Projects in Malaysia, *Journal of Applied Sciences,* 13(2), 286-293.

Adewuyi, T.O. and Otali, M. (2013). Evaluation of Causes of Construction Material Waste: Case of River State, Nigeria, *Ethiopian Journal of Environmental Studies and Management* 6, 746-753.

Aiyetan, O. and Smallwood, J. 2013. "Materials Management and Waste Minimisation on Construction Sites in Lagos State, Nigeria." *Proceedings of the 4th International Conference on Engineering, Project, and Production Management (EPPM, 2013. 1161-1172.*

Allahaim, F.S. and Liu, L. (2012). Cost Overrun Causes the Framework in Infrastructure Projects: Toward a Typology, *37th Australian University Building Educators Association, International Conference* (AUBEA 2012) Sydney, University of NSW (UNSW). 1-15.

Ameh, J.O. and Itodo, E.D. (2013). Professionals' Views of Material Wastage on Construction Sites, *Organization, Technology and Management in Construction. An International Journal,* 5(1), 747-757.

Ameh, O.J. and Osegbe, E.E. (2011). Study of Relationship between Time Overrun and Productivity on Construction Sites, *International Journal of Construction Supply Chain Management, 1*(1), 56-67.

Apolot, R., Alinaitwe, H. and Tindiwensi, D. (2010). An Investigation into the Causes of Delay and Cost Overrun in Uganda's Public Sector Construction Projects: In, *Second International Conference on Advances in Engineering and Technology.* Uganda. 305-311.

Babatunde, S.O. (2012). Quantitative Assessment of Construction Material Wastage in Nigerian Construction Sites, *Journal of Emerging Trends in Economics and Management Sciences,* 3(3), 238-241.

Jenpanitsub, A. (2011). Cost Overruns in Transport Projects - Experiences from Sweden. Msc Dissertation, department of transport Science, KTH Royal Institute of Technology, Stockholm, Sweden, 1-127.

Kasimu, M.A. (2012). Significant Factors that Cause Cost Overrun in Building Projects in Nigeria, *Interdisciplinary Journal of Contemporary Research in Business* 3(11), 775-780.

Le-Hoai, L., Lee,Y.D. and Lee, J.Y. (2008). Delay and Cost Overrun in Vietnam, Large Construction Projects: A comparison with Other Selected Countries, *KSCE Journal of Civil Engineering,* 12(6), 367-377.

Love, P.E.D., Edwards, D. and Irani, Z. (2011). "Moving Beyond Optimism Bias and Strategic Misrepresentation; An Explanation for Social Infrastructure Project Cost Overruns." *IEEE Transaction on Engineering Management.*

Ma, U. (2011). No *Waste: Managing Sustainability in Construction.* Surrey: Gower Publishing Limited. 118-120

Malumfashi, B.I. and Shuaibu, I. (2012). Risk Management and Cost Overrun in Infrastructure Projects in Nigeria, *Journal of Environmental Sciences and Policy Evaluation,* 2(2), 19-31.

Mou, K. (2008). The Role of Government and Construction Waste. MSC Dissertation, The Centre of Urban Planning & Environmental Management, University of Hong Kong, Hong Kong, , 1-179.

Nagapan, S., Abdul Rahman, I., Asmi, A. and Hameed, A. (2012). Identifying the Causes of Construction Waste -Case of Central, *International Journal of Integrated Engineering,* 4(2), 22-28.

Nagapan, S., Abdul-Rahman, I. and Asmi, A. (2012). Factors Contributing to Physical and Non-Physical Waste Generation in Construction Industry, *International Journal of Advances in Applied Sciences (IJAAS),* 1(1), 1-10.

Ogunsemi, D. and Jagboro, G. (2006). Time–Cost Model for Building Projects in Nigeria, *Journal of Construction Management and Economics,* 24(3), 253–258.

Oladiran, O.J. (2009). Causes and Minimization Techniques of Materials Waste in Nigerian Construction Process, *Fifth International Conference on Construction in the 21st Century (CITC-V); Collaboration and Integration in Engineering, Management and Technology,* Istanbul, Turkey. 20-22, May 2009.

Olawale, Y.A. and Sun, M. (2010). Cost and Time Control of Construction Projects: Inhibiting Factors and Mitigating Measures in Practice, *Construction Management and Economics,* 28(5), 509–526.

Osborne, J.W. (2008). *Best Practices in Quantitative Methods.* University of Louisville, K.Y.: SAGE Publications Inc.

Osmani, M. 2011. "Construction waste." Chap. 15 in *Waste: A handbook for management*, by Letcher and Vallero, 1-565. San Diego: Academic Press an imprint of Elsevier. Osmani, M., Glass, J. and Price, A.D.F. (2008). "Architects' perspectives on construction Waste reduction by design." *Waste Management* 28: 1147–1158.

Peeters, W. and Madauss, B. (2008). A Proposed Strategy against Cost Overruns in the Space Sector: The 5C Approach, Space *Policy,* 24, 80–89.

Pheng, L.S., Arain, F.M. and Ting, L.T. (2010). *Comparative Advantage in the Construction Business.* New York: Nova Science Publishing, Inc.