ASOCSA2016 - 037

Effects of Design-Management Related Material Waste Causes on Project-Cost Overrun in Abuja, Nigeria

Ibrahim SAIDU[1], Winston MW SHAKANTU[2]
s214344924@nmmu.ac.za, Winston.shakantu@nmmu.ac.za
[1]Department of Construction Management, the Nelson Mandela Metropolitan University, Eastern Cape, Port Elizabeth, South Africa (+27810916224)
[2]Department of Construction Management, the Nelson Mandela Metropolitan University, Eastern Cape, Port Elizabeth, South Africa; (+7785147492, +27415041400).

ABSTRACT

Background

Material wastage and cost overruns are common problems affecting construction projects in the Nigerian construction industry. These problems occur at different stages of a project, from planning, design, estimating, and construction to project completion.

Purpose of the paper

This paper examines the effects of material-waste causes and their control measures on cost overruns at the design-management stage of a project.

Research methodology and implications

The quantitative approach that is rooted in the positivist research paradigm was adopted. Interview was conducted with thirty (30) construction professionals from which a structured questionnaire (tick-box) was ticked/marked by the researcher. The information generated from the tick-box questionnaire was the only data utilised in this research. The professionals were purposeful selected based on project value of 8million USD and above. The collected data were analysed using the descriptive method (cross-tabulation). ANOVA was used to compare the views of different professionals on the effects of waste causes on cost overrun at the design-management stage of a project.

Findings based on the empirical research

The paper found that material-waste causes and their control measures have significant effects (very-high, high, medium, low, and very-low) in causing or minimising cost overruns at the design-management stage of a project. There was no significant difference in the views of the professionals on the effects of material waste on cost overrun at the design management stage of a project.

Practical implications and outcomes

Management of material waste and cost overrun should be revised based on the findings of this research as a reference document and included as part of the design-management process for a project.

Key words: Control measures, Cost overruns, Design management, and Material waste.

1. INTRODUCTION

Cost overrun and material waste are common problems in both developed and developing nations which makes it difficult for many projects to be completed within their budget (Saidu and Shakantu, 2015). Ameh and Itodo (2013) highlighted that in every 100 houses built there is sufficient waste material to build another 10 houses. Also, 10% of materials delivered to site in the UK end up as a waste that may not be accounted for (Osmani, 2011).

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 years (Apolot *et al.*, 2010; Allahaim and Liu, 2012), but there is no substantial improvement nor significant solution in mitigating its detrimental effects (Allahaim and Liu, 2012).

Material waste and cost overrun are occasioned by several causes at different stages of projects, including planning, estimating, design and design management, and construction stage. Identification of these causes and the application of relevant control measures to minimise their occurrence is a step towards alleviating the consequences (Mou, 2008; Oladiran, 2009; Nagapan *et al.,* 2012; Saidu and Shakantu, 2015). While Ameh and Itodo (2013) believed that building material wastage on construction sites accounts for cost overruns; they also highlighted that most managers of construction projects pay little attention to the effects of material waste generated on cost overrun in Nigeria.

Many studies have been carried out in this field, for instance, Ameh and Itodo (2013), Tam, Shen, and Tam (2007), and Saidu and Shakantu

(2015), but still, there is need for a research that provides an objective assessment of the effects of design management related material-waste causes and their control measures on project cost overrun. Hence, this research aims to examine the effects of design management related material-waste causes and their control measures on project cost overrun in Abuja, Nigeria.

2 LITERATURE REVIEW

2.1 Relationship between material waste and cost overrun

Construction waste was generally classified into physical waste and the non-physical waste (Nagapan *et al.,* 2012; Saidu and Shakantu, 2015). While the physical construction waste originates from the construction activities, renovation, demolition, and so forth; the non-physical construction waste comprises of time overrun and cost overrun (Ma, 2011; Nagapan *et al.,* 2012). Saidu and Shakantu (2015) established 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 emanating from the non-physical waste, since they originate from the same construction-waste family. Consequently, Memon *et al.* (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. This shows that cost overruns, time overruns and construction-material waste are generally categorised as construction waste. This is further supported by Ma (2011), who defines waste as anything that does not add value. Time overruns, cost overruns, and material waste do not add value to any project.

Saidu and Shakantu (2015) identified some causes of material waste that are related to the causes of cost overrun as shown in Table 2.1

Table 2.1 Causes of material waste related to those of cost overruns

S/n	Causes of Cost overrun	Cost overrun	Material waste
1	Design error	✓	✓
2	Deficiencies in cost estimates	✓	✓
3	Insufficient time for estimate	✓	✓
4	Improper planning at on stage	✓	✓
5	Political complexities	✓	✓
6	Insurance problems	✓	✓
7	Changes in material specification	✓	✓
8	Laws and regulatory framework	✓	✓
9	Poor design management	✓	✓
10	Lack of design information	✓	✓
11	Designing irregular shapes and forms	✓	✓

12	Lack of communication among parties	✓	✓
13	Change in the scope work	✓	✓
14	Delay payment to supplier/subcontractors	✓	✓
15	Shortage of materials	✓	✓
16	On-site waste	✓	✓
17	Project size	✓	✓
18	Lack of constructability	✓	✓
19	Unrealistic contract duration	✓	✓
20	Rework	✓	✓

3. RESEARCH METHODOLOGY

The research employed the use of quantitative method that is rooted in the positivist research paradigm. The study covered building construction projects within Abuja, the Federal Capital Territory of Nigeria. Abuja was selected because, it is one of metropolitan cities that has the highest population of professionals within the built environment and has many on-going construction projects.

Interview was purposefully conducted with the construction professionals handling a project (private or public projects) with a value of 1.6 billion Naira / 8 million USD 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 respondents comprised: 15 Project Managers (PMs), 9 Quantity Surveyors (QSs), 5 Site Engineers (SEs) and 1 Senior Technical Officer (STO) of a waste management department.

A tick-box structured questionnaires on the issues relating to the material waste causes and cost overruns at the design-management stage of a project were ticked/marked by the interviewer in the course of the interview and these addressed the quantitative nature of this research. The research employed the descriptive and inferential analyses. The descriptive tool that was used to analyse the data (questionnaires / tick-box) was the cross tabulation method. The results were presented in Tables 4.1 and 4.2. The responses from the tick-box 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”; 50to 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.

4. RESULTS AND DISCUSSION

This section presents and discusses the results of this study.

4.1 Effects of material-waste causes on cost overruns at design management stage of a project

The results in table 4.1 indicate that the percentages of 100, 93.3, 93.3, 90, 90, and 90 relative to "error in design and detailing, ranked 1st"; ''frequent design changes and material specification, ranked 2nd''; "lack of design information, ranked 2nd"; "design complexity / complication, ranked 4th"; ''poor management of design process, ranked 4th''; and "inexperienced designer or design team, ranked 4th"; respectively, by the respondents were the causes of material waste deemed to have had 'very high effects' on project cost overruns at the design management stage of a project; because they fall between 90 and 100 percent. While the percentages of 86.7, 86.7, and 80 relatives to "difficulty in interpreting material specifications, ranked 7th"; "readability, constructability and maintainability problems of design, ranked 7th"; and "the lack of standardisation in design/sizes and units, ranked 9th"; respectively, were deemed to have 'high effects' on cost overruns; because they fall between 70 and 89 percent.

These results imply that design and detailing errors are mostly caused by inexperienced designers and poor management of design process. These could lead to a wrong estimation; because, the estimates are generated and solely depend on the design, and thereby having a serious impact on the project cost. These are in line with the findings of Ameh and Osegbe (2011); Love *et al.* (2011); Memon *et al.* (2011); Baloyi and Bekker (2011); Allahaim and Liu (2012); and Shamugapriya and Subramanian (2013) on the practical causes of cost overruns and material waste.

Percentages of 66.7, 63.3, 56.7, and 56.7 in respect of "poor harmonization of clients' brief, ranked 10th"; "designing uneconomical shapes and outlines, ranked 11th"; "poor communication flow among design team, ranked 12th"; and "the lack of buildability analysis, ranked 12th"; respectively, were the material waste causes deemed to have 'moderate effects' on project-cost overruns; because they fall between 50 and 69 percent.

Other material waste causes of percentages between 1 and 29 percent were deemed to have 'very little effects' on cost overruns at the design stage of a project. They included: "poor knowledge of the changing design requirements, ranked 19th"; "designing dead spaces, ranked 20th"; and "aesthetic considerations, ranked 22nd". This is probably because; the respondents believed that dead spaces and aesthetic issues must have been included in the design, which the estimator must have considered in

the estimating process. Therefore, have little effect in causing cost overruns.

Table 4.1 Results of cross-tabulation for the effects of material-waste causes of on cost overruns at design management

S/n	Causes of material waste that have effect on cost overrun at design management stage	PMs	QSs	SEs	STO	Total	Ranking	Decision
1	Frequent design changes & material specification	15	9	4	0	28 (93.3%)	2	Very High
2	Error in design and detailing	15	9	5	1	30 (100%)	1	Very high
3	Lack of design information	13	9	5	1	28 (93.3%)	2	Very high
4	Design complexity / complication	13	9	5	0	27 (90%)	4	Very high
5	Poor communication flow among design team	8	6	3	0	17 (56.7%)	12	Moderate
6	Designing dead spaces	2	1	0	0	3 (10%)	20	Very little
7	Poor knowledge of the changing design requirements	0	2	2	0	4 (13.3%)	19	Very little effect
8	Poor management of design process	13	9	5	0	27 (90%)	4	Very High
9	Inexperience designer / design team	14	8	4	1	27 (90%)	4	Very high
10	Interaction between various specialists	6	3	1	0	10 (33.3%)	14	Little effect
11	Designing uneconomical shapes and outlines	12	6	0	1	19 (63.3%)	11	Moderate
12	Lack of standardization in design/ sizes and units	12	8	5	1	26 (86.7%)	7	High effect
13	Lack of buildability analysis	7	6	3	1	17 (56.7%)	12	Moderate
14	Difficulty in interpreting material specifications	14	6	5	1	26 (86.7%)	7	High
15	Readability, constructability & maintainability	13	6	4	1	24 (80%)	9	High
16	Insufficient time for design	3	2	4	0	9 (30%)	16	Little effect
17	Poor harmonization of client's brief	9	7	3	1	20 (66.7%)	10	Moderate
18	Over or under designing	4	3	1	0	8 (26.7%)	17	Very little
19	Poor structural	2	3	0		5	18	Very little

	arrangement of a design					(16.7%)		
20	Aesthetic considerations	0	2	0	0	2 (6.7%)	22	Very little
21	Poor planning of design process		2	0	0	3 (10%)	20	Very little
22	Poor design functionality	0	2	0	0	2 (6.7%)	22	Very little
23	Designing unavailable technology	6	2	2	0	10 (33.3%)	14	Little effect
24	Lack of geo-physical survey	0	1	0	0	1 (3.3%)	24	Very little

4.2 Effects of material-waste control measures on cost overruns at design management stage of a project

It is apparent from Table 4.2 that the percentages of 100, 100, 93.3, 93.3, and 93.3 relative to "explicit detailing in design, ranked 1st"; "interpretable designs and specifications, ranked 1st"; "engaging an experienced designer, ranked 3rd"; "error-free design, ranked 3rd"; and "proper design information and consultation, ranked 3rd"; respectively, by the respondents were considered to be the material waste-control measures that have 'very high effects' in controlling project-cost overruns at the design management of the pre-contract stage of a project; because they fall between 90 and 100 percent. Furthermore, percentages of 86.7, 86.7, and 76.8 relative to "proper management of design process, ranked 6th"; reduced design complexity, ranked 6th"; and "readability, constructability and maintainability in design, ranked 8th"; respectively, by the respondents were considered to be`the material waste-control measure that have high effect on cost overruns; because they fall between 70 and 80 percent.

These results are also in line with the findings of Abdul-Azis *et al.* (2013) on the control measures for project-cost overruns. Also, the results confirm the findings of Osmani *et al.* (2008) on the management measures for material waste at the design stage of a project.

Also, "standardization in design, ranked 9th"; and "designing economic shapes and outlines, ranked 10th"; respectively, were rated as having 'moderate effect' in controlling cost overruns by the respondents; because they fall between 50 and 69 percent.

"The use of prefabricated units and standardised material sizes, ranked 14th"; "design for materials optimisation, ranked 17th"; "design for offsite construction, ranked 17th"; "the early engagement of a designer, ranked 21st"; and "improving on previous design mistakes, ranked 21st"; respectively, were considered by the respondents to have 'little effect' in controlling the project-cost overruns at the design management stage for a project. These results support the findings of Abdul-Azis *et al.* (2013) on the control measure for project-cost overruns.

Table 4.2 Cross-tabulation for the effects of material-waste control measures on cost overruns at management design stage of a project

S/n	Control measures for material waste that have effects on cost overrun at design stage	PMs	QSs	SEs	STO	Total	Ranking	Decision
1	Design for materials optimization	2	1	0	0	3 (10%)	17	Very little
2	Design for reuse and recovery	2	2	0	0	4 (13.3%)	16	Very little
3	Design for offsite construction	3	0	0	0	3 (10%)	17	Very little
4	Designing for deconstruction	2	0	0	0	2 (6.7%)	19	Very little
5	Use of prefabricated units and standard materials	2	4	0	1	7 (23.3%)	14	Very little
6	Communication & coordination of design process	4	4	1	0	9 (30%)	12	Little effect
7	*Designing economic shapes and outlines		6	0	1	19 (63.3%)	10	Moder ate
8	Incorporation of large-panel metal formworks	0	0	0	0	0 (0%)	23	No effect
9	Reduction in the rate of design change	9	3	0	0	12 (40%)	11	Little effect
10	Utilization of modular designs	2	0	0	0	2 (6.7%)	19	Very little
11	Reduced design complexity	12	9	5	0	26 (86.7%)	6	High
12	Explicit detailing	15	9	5	1	30 (100%)	1	Very high
13	Interpretable design and specifications	15	8	4	1	28 (93.3%)	3	Very high
14	Experienced Designer	15	9	5	1	30 (100%)	1	Very high
15	Proper management of design process	13	8	5	0	26 (86.7%)	6	High
16	Error-free Design	13	9	5	1	28 (93.3%)	3	Very high
17	Standardization in Design	10	5	4	1	20 (66.7%)	9	Very little
18	Readability, constructability and maintainability	11	7	4	1	23 (76.7%)	8	High effect
19	Proper design Information and consultation	13	9	5	1	28 (93.3%)	3	Very high
20	Adherence to clients brief	2	2	1	0	5 (16.7%)	15	Very little
21	Sufficient time for design	3	2	4	0	9(30%)	12	Little
22	Early engagement of designer	0	1	0	0	1 (3.33%)	21	Very little

23	Improving on previous design mistakes	1	0	0	0	1 (3.33%)	21	Very little

4.3 Comparative views of respondents on the effects of material-waste causes and control measures on project cost overruns at design management stage of a project

Table 4.3 shows the results of ANOVA analyses performed to compare the views of professionals (Project managers, Quantity Surveyors, Site Engineers and Senior Technical Officer) on the 'effects of material waste, causes, and control measures on project-cost overruns' at the design management stage of a project.

It was apparent from the analyses that the values of f-calculated (0.150 and 0.319) for the two analyses (material waste sources and causes, and control measures), respectively, were both less than the value of f-tabulated (1.701); and the probability values (0.861 and 0.730) were greater than 0.05 (5%) level of significance within the mean-squared group of 0.90 to 6.02 and 1.39 to 4.35, respectively.

The evidence is not statistically significant. These results imply that the respondents were of the same views on the effects of material-waste causes and the control measures on cost overruns at the design management stage of a project.

Table 4.3 Results of ANOVA analyses for the test of differences in professional views on the effects of material-waste causes and control measures on cost overruns

S/n	Variables $X1$ PMs	$X2$ QSs	$X3$ SEs	$X4$ STO	Type of Analysis	Observation: Mean square within group	F-cal	F-tab	Probability value	Inferences: Remark
1	Sources & causes				One-way ANOVA	0.90 6.02	0.150	1.701	0.861	Not statistically significant
2	Control measures				One-way ANOVA	1.39 4.35	0.319	1.701	0.730	Not statistically significant

5. CONCLUSION AND RECOMMENDATIONS

Material waste and cost overrun are identified as global problems which affect the success of many construction projects. Moreover, most managers of construction projects pay little attention to the effects of material waste generated on cost overrun.The aim of this research was to examine the effects of material-waste causes and their control measures on cost overruns at the design management stage of a project. It was found that material-waste causes and their control measures were identified to have significant (very-high, high, medium, low, and very-low) effects in causing/controlling cost overruns at the design management stage of a project. Also, there was no statistically significant difference in the views of the respondents on these issues. The respondents have the same views on the results of the effects of material-waste causes and control measures on cost overruns at the design-management stage of a project. Based on these findings, it can be concluded that effective management of design related material waste would translate into a reduction in the level of cost overrun for 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 at the design management stage; as these would assist in achieving a reduction in the rate of material waste and cost overrun for a project. 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.

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.

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,* 2010, Uganda, 305-311.

Baloyi, L. and Bekker, M., 2011. Causes of Construction Cost and Time Overruns: The 2010 FIFA World Cup stadia inSouth Africa. *Acta Structilia,* 18,(1): 51-67.

Love, P. 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.* 12.

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

Memon, A.H. Abdul-Rahman, I. and Memon, I.,2014. Rule Based DSS in Controlling Construction Waste. *Life Science Journal*,11 (6), 417-424.

Memon, A., Abdul-Rahman, and A. Abdul-Aziz., 2011. Preliminary Study on Causative Factors Leading to construction Cost Overrun. *International journal of Sustainable Construction Engineering and Technology* 2 (1): 57-71.

Morenikeji, W., 2006, *Research & Analytical Methods for Social Scientists, Planners and Environmentalist,* Jos, Jos University Press Limited.

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. 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.

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,* 20-22, May 2009, Istanbul, Turkey.

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.

Shanmugapriya, S. and Subramanian, K., 2013. Investigation of Significant Factors affecting Time and Cost Overrun in Indian Construction Projects. *International Journal of Emerging Technology and*

Advanced Engineering, 3, (10): 734-740. Accessed August 15, 2014.

Saidu, I. and Shakantu, W.M.W., 2015. A Relationship between Quality-of-Estimating, Construction Material Waste Genration and Cost Overrun in Abuja, Nigeria. *Fourth Construction Management Conference, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.* Edited Emuze, F.A.; 95-104, 30 November-1st December, 2015.

Tam, V.W.Y. Shen, L.Y. Tam, C.M., 2007. Assessing the Levels of Material Wastage Affected by Sub-Contracting Relationships and Projects Types with their Correlations. *Building and Environment*, 42: 1471–1477.