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A STUDY OF THE RELATIONSHIP BETWEEN MATERIAL WASTE AND COST OVERRUN IN THE CONSTRUCTION INDUSTRY

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Abstract
While wastage of materials has become a serious problem requiring urgent attention in the construction industry, cost overrun is a problem which affects 90% of completed projects in the world. The argument on how to eliminate cost overrun has been on-going for the past 70 years as on-site wastage of materials leads to increase in the final project cost. This paper examines the relationship between the causes of material waste and those of cost overrun at the pre-contract and post-contract stages of a project. The paper adopts the desktop methodological approach. This involves comparing the causes of material waste and those of cost overruns from the literature to determine the possible relationship. The result reveals that all the causes of material waste also cause cost overrun at the pre-contract and the post-contract stages of a project. However, 96.88% and 81.81% of the causes of cost overrun also cause material waste at the pre-contract and post-contract stages respectively. There is an 86.74% overlap between the causes of material waste and those of cost overruns at all stages of a project. Other causes which are not related are mostly, the micro-economic and macro-economic factors. Based on these findings, it can be concluded that effective management of material waste would translate into a reduction in the level of project cost overrun. The study recommends that construction-project managers as well as the construction practitioners should encourage the management of material-waste causes, as it has the potential to minimise the causes of cost overrun for a project.

Keywords: Construction Industry, Cost overruns, Contract wtages, Material waste

1 Introduction

The construction industry is one of the driving forces behind the socio-economic development of any nation. However, it is faced with the severe problems of cost overruns, time overruns, and construction waste (Abdul-Rahman *et al.,* 2013; Osmani *et al.,* 2008; Nagapan *et al.,* 2012). Material wastage has become a serious problem, which requires urgent attention in the construction industry and it has affects the delivery of many projects (Adewuyi and Otali, 2013).

The problem of construction waste all over the world remains unresolved, as has been shown by various authors reporting on the situation: for example, 28.34% of the total waste sent to landfills in Malaysia originates from construction activities (Begum *et al.,* 2007): the US generates 164million ton of construction waste annually representing 30-40% of the country's Municipal Solid Waste (MSW) (Osmani, 2011): China alone generates 30% of the world's MSW, out of which construction and demolition waste represents 40% of the country's MSW

(Lu and Yuan, 2010): and 10% of the materials delivered to sites in the UK construction industry end up as waste that may not be accounted for (Osmani, 2011). Accordingly, Ameh and Itodo (2013) noted that for every 100 houses built, there is sufficient waste material to build another 10 houses.

On the other hand, cost overrun is a common problem in both developed and developing countries which makes it difficult for many projects to be completed within their budgeted cost (Memon *et al.,* 2013). Being a common problem, cost overrun was found across twenty nations and five 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 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); while on-site wastage of material leads to increase in the final cost of a building project. As materials are wasted, more is required, thereby affecting the estimated cost of the project (Ameh and Itodo, 2013; Teo *et al.,* 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. Moreover, Ameh and Itodo (2013) reported that in the UK, material waste accounts for an additional 15% of construction project cost overruns and also accounts for about 11% of construction cost overruns in Hong Kong. In the same vein, a study conducted in the Netherlands revealed a cost overrun of between 20-30% as a result of construction-material wastage. Ameh and Itodo (2013) emphasise that most managers of construction projects pay little attention to the effects of material waste generated on cost overrun. Many studies have been carried out in this field, but still, there is need for a research that provides an objective assessment of the relationship between the causes of material waste and those of cost overrun in the construction industry. Hence, this paper examines the relationship between the causes of material waste and those of cost overruns with a view to suggesting the possible ways of minimising their effects at the pre-contract and the post-contract stage of a project.

2 Literature Review

2.1 Relationship between material waste and construction cost overrun

Construction waste is generally classified into two, namely: the physical waste and the non-physical waste (Nagapan *et al.,* 2012). Physical construction waste is the waste from construction, renovation activities, including civil and building construction, demolition activities, and roadwork. 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 *et al.,* 2012 and Ma, 2011). 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 *et al.,* 2012).

Conversely, the non-physical waste normally occurs during the construction process. By contrast with material waste, non-physical waste relates to time and cost overruns for a construction project (Nagapan *et al.,* 2012). Similarly, Ma (2011) defines waste as not only associated with wastage of materials, but also to other activities such as repair, waiting time, and delays. Besides that, waste can be considered as any inefficiency that results in the use of equipment, materials, labour, and money in the construction process. 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 (Nagapan *et al.,* 2012). Memon *et al.* (2014) added that non-physical waste includes undesired activities, which can cause the physical waste, such as rework, unnecessary material movements, and so

forth. Figure 1 shows the general classification of construction waste and 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 (Source: Nagapan *et al.*, 2012)

2.2 The pre-contract stage of a project

The pre-contract stage of a project comprises a lot of activities from the inception to the final stage of award of contract. These activities include the feasibilities, outlined proposal, scheme design, detail design, bills of quantities/estimation, and so forth. These activities, if not properly managed and controlled, would contribute to the generation of material waste and cost overruns (Ashworth, 2008). Hence, it is appropriate to understand the main causes of material waste that relate to the causes of cost overrun at this stage of a project.

2.3 The post-contract stage of a project

The activities involved in the post-contract stage of a project include the following: construction on site, supervision, inspection, approvals, valuations, completion, hand over to client and user occupation, correction of defects, and completion of contract requirements and settlement of the final accounts (Ashworth, 2008). However, this aspect of research would only focus on construction related issues.

3 Research Methodology

The research employed the desktop methodological approach. This involves comparing the causes of material waste and those of cost overruns from the review of the related literature in order to determine the possible relationship. The relevant secondary source of data for this research include: published materials (books, journals) and unpublished reports, such as: periodicals, conference proceedings, building codes, and policies and guidelines relating to material waste and cost overruns in the construction industry.

The analysis was performed by comparing the causes of material waste and those of cost overrun identified from the literature. The results were expressed in frequencies and percentages and presented in tables and figures. The causes of material waste that relate to those of cost overruns are ticked as shown in Tables 1 and 2.

4 Findings and Discussion

4.1 The pre-contract stage of a project

Table 1 reveals that the causes of material waste and those of cost overruns identified from the literature are similar. These causes occur as a result of one, or combination of several causes at the pre-contract stage of a project and they are very important to identify for effective cost performance and sustainable construction.

All the causes of material waste were also found to be identified as the causes of cost overrun at the pre contact stage of a project but not *vice versa*. For instance, the causes of cost overrun and those of material waste in Table 1 shows that, 31 out of the 32 causes of cost overruns considered at the pre-contract stage of a project also cause material waste showing a 96.88

relationship (pre-contract stage). Reason being that 'the practice of assigning the contract to the lowest bidder,' which is a cause of cost overrun is not a cause of material waste.

Table 1. Causes of material waste found in the causes of cost overruns at the pre-contract stage

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	Practice of assigning contract to the lowest bidder	✓	x
11	Lack of experience of local regulation	✓	✓
12	Communication error among parties in planning	✓	✓
13	Poor knowledge of the changing requirements	✓	✓
14	Lack of design information	✓	✓
15	Designing irregular shapes and forms	✓	✓
16	Different methods used in estimation	✓	✓
17	Improper coordination	✓	✓
18	Delays in design	✓	✓
19	Optimism bias	✓	✓
20	Complicated design	✓	✓
21	Inadequate specifications	✓	✓
22	Incomplete drawings	✓	✓
23	Inexperience designer	✓	✓
24	Error in design and detailing	✓	✓
25	Inadequate site investigation	✓	✓
26	Difficulties in interpreting specification	✓	✓
27	Delay in preparation and approval of drawings	✓	✓
28	Designing uneconomical shapes and outlines	✓	✓
29	Frequent demand for design changes	✓	✓
30	Poor communication flow among design team	✓	✓
31	Unsatisfactory budget for waste management	✓	✓
32	Lack of communication among parties at pre contract stage	✓	✓
	Summary=31/32X100=96.88%		

(Sources: Le-Hoai *et al.*, 2008; Memon *et al.*, 2011; Love *et al.*, 2011; Allahaim and Liu, 2013; Olawole and Sun, 2010; Kasimu, 2012; Malumfashi and Shuaibu 2012; Nagapan *et al.*, 2012; Osmani *et al.*, 2008; Wahab and Lawal; 2011; Oladiran, 2009; Ameh and Itodo, 2013; Aiyetan and Smallwood, 2013; Osmani, 2011)

This relationship is further summarised in Figure 2, which shows that, at the pre-contract stage of a project, the causes of cost overruns also cause material waste. This means that all causes of material waste also cause anticipated cost overrun at the pre-contract stage of a project. But only 96.88% of the causes of cost overrun cause material waste. The remaining 3.12% 'the practice of assigning the contract to the lowest bidder,' are not related. This implies that, managing material waste at this stage denotes managing a 96.88% of cost overruns.

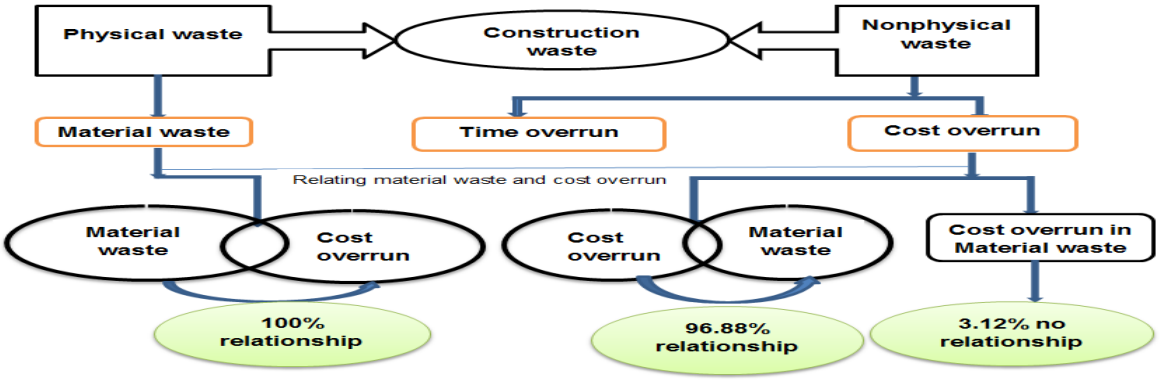

Figure 2. Relationship between cost overruns and material waste at pre-contract stage

4.2 The post-contract stage of a project

Table 2 shows the causes of cost overrun that are related to the causes of material waste at the post-contract stage of a project. Out of the 66 causes of cost overruns considered, 54 also cause material waste showing an 81.81% relationship at the post contract stage of a project.

Table 3. Causes of material waste found in causes of cost overrun at post-contract stage

S/N	Causes of Cost overrun (post-contract stage of project)	Cost overrun	Material waste	S/N	Causes of Cost overrun (post-contract stage of project)	Cost overrun	Material waste
1	Monthly payment difficulties	✓	x	34	Unforeseen geological conditions	✓	✓
2	Poor planning by contractors	✓	✓	35	Financial difficulties of contractor	✓	✓
3	Heritage material discovery	✓	✓	36	Social and cultural impact	✓	✓
4	Market conditions	✓	x	37	Inaccurate site investigation	✓	✓
5	Cash flow and financial difficulties faced by contractors	✓	x	38	Inadequate use of modern equipment & technology	✓	✓
6	Slow information flow between the parties	✓	✓	39	Obtaining materials at official current prices	✓	x
7	Escalation of material prices	✓	x	40	Labour problems	✓	✓
8	Increase in wages	✓	x	41	Increase in material prices	✓	x
9	Poor management assistance	✓	✓	42	Owner interference	✓	✓
10	Exchange rate fluctuation	✓	x	43	Slow payment of works	✓	x
11	Deficiencies in the social structure	✓	✓	44	High interest rate charged by bankers on loans	✓	x
12	Additional works	✓	x	45	Fraudulent practices	✓	✓

13	Optimism bias	✓	✓	46	Labour disputes and strike	✓	✓
14	Labour cost increased due to environment restriction	✓	**x**	47	Improper coordination amongst parties at post contract stage	✓	✓
15	Insufficient equipment	✓	✓	48	Poor technical performance	✓	✓
16	Deficiencies in the infrastructure	✓	✓	49	Equipment availability/failure	✓	✓
17	Lack of communication among parties	✓	✓	50	Number of works being done at same time	✓	✓
18	Change in the scope work	✓	✓	51	Poor financial control on site	✓	✓
19	Delay payment to supplier/subcontractors	✓	✓	52	Poor site management and supervision	✓	✓
20	Shortage of materials	✓	✓	53	Site constraint	✓	✓
21	On-site waste	✓	✓	54	Lack of skilled labour	✓	✓
22	Project size	✓	✓	55	Mistakes during construction	✓	✓
23	Lack of constructability	✓	✓	56	Delay in decision making	✓	✓
24	Unrealistic contract duration	✓	✓	57	Shortage of site workers	✓	✓
25	Delay in material procurement	✓	✓	58	Disputes on site	✓	✓
26	Poor site management and supervision	✓	✓	59	Late materials/ equipment delivery	✓	✓
27	Inexperience contractor	✓	✓	60	Unpredictable weather condition	✓	✓
28	Shortage of site workers	✓	✓	61	Mistakes during construction	✓	✓
29	Work security problem	✓	✓	62	Unforeseen site conditions	✓	✓
30	Rework	✓	✓	63	Earth conditions	✓	✓
31	Experience in contract	✓	✓	64	Management-labour relationship	✓	✓
32	Workers problems health	✓	✓	65	Inexperience of project location	✓	✓
33	Unexpected subsoil conditions	✓	✓	66	Lack of experience of project type	✓	✓
	Summary=54/66X100= 81.81%						

(Source: Flyvbjerg, Holm, and Buhl, 2004; Singh 2009; Allahaim and Liu, 2013: 13-14; Olawole and Sun, 2010; Koushki, Al-Rashid and Kartam, 2005; Ejaz, Ali and Tahir 2011; Kasimu, 2012; Malumfashi and Shuaibu 2012; Le-Hoai, lee and lee, 2008; Memon *et al.*, 2011; Love *et al.*, 2011; Allahaim and Liu, 2013; Olawole 2010; Kasimu, 2012; Malumfashi and Shuaibu 2012; Nagapan *et al.*, 2012; Osmani *et al.*, 2008; Wahab and Lawal; 2011; Oladiran, 2009, Ameh and Itodo, 2013; Aiyetan and Smallwood, 2013; Osmani, 2011)

The relationships in Table 2 are further summarised in Figure 3 below showing that, at the post-contract stage of a project, there was also a 100% relationship between the causes of material waste and those of cost overruns. This means that, all material waste causes are also responsible for cost overruns. But on the other hand, when causes of cost overruns are considered, there is an 81.81% relationship with causes of material waste. The remaining 18.19% are not related and are mostly, the micro and macro-economic factors. This implies that managing material waste at this stage denotes managing 81.81% of cost overruns.

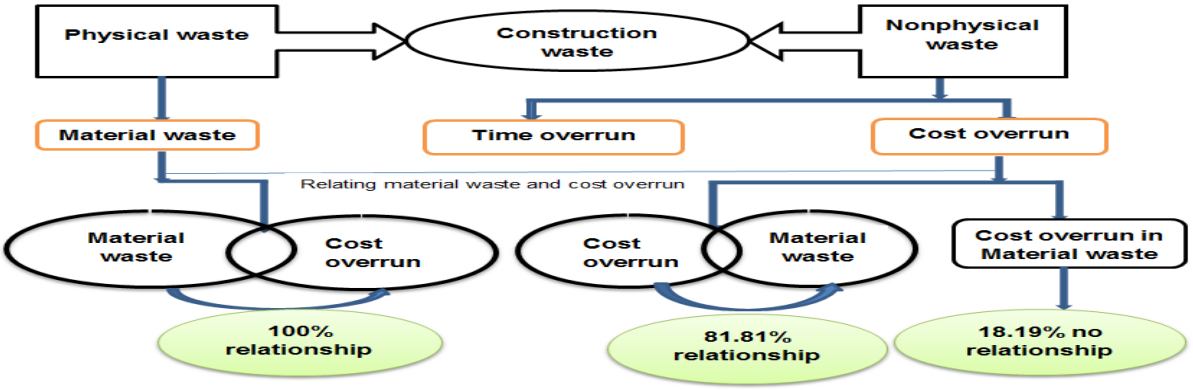

Figure 3. Relationship between cost overrun and material waste at the post-contract stage of projects

4.3 Pre-contract and post-contract stages of a project

Summing all the causes at both the pre-contract and the post-contract stages, 32+66 =98, a total of 85 out of 98 causes of cost overruns also cause material waste showing 85/98X100=86.74% relationship. These findings are also graphically represented in Figure 4.

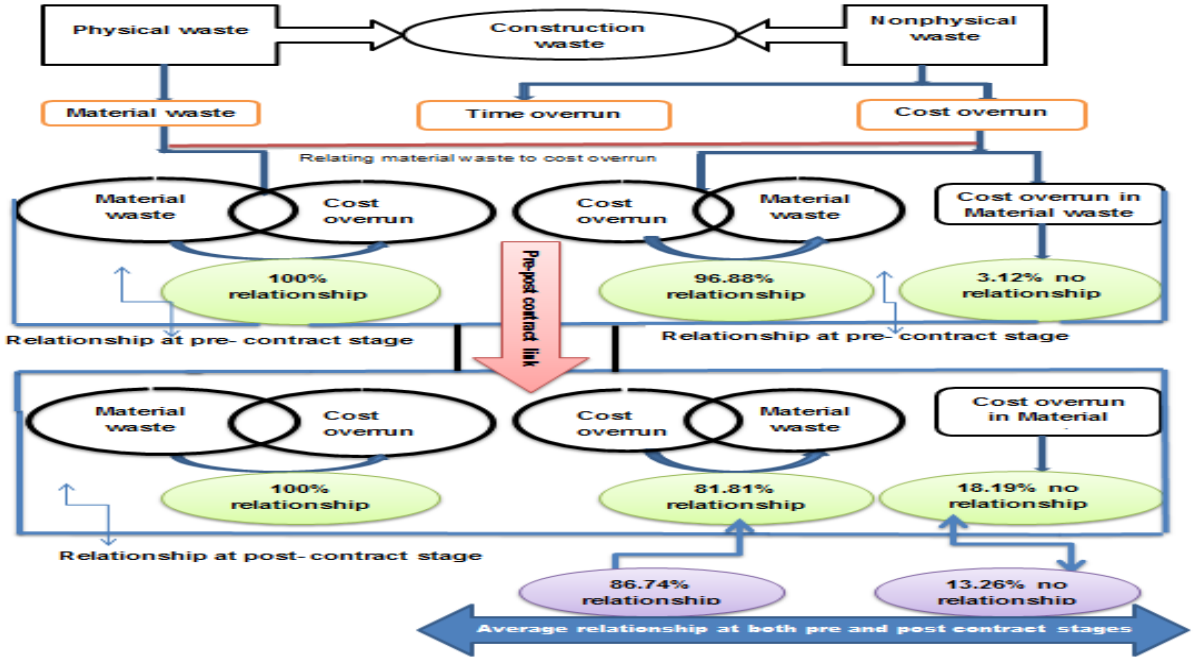

Figure 4. Relationship between material waste and cost overrun at all stages of a project

4.4 Managing material waste and cost overrun

Figures 5 and 6 show the interrelationship between project stages (pre-contract and post-contract), control measure, waste sources, waste causes and the identified percentage of cost overrun (86.74%). Figure 5 shows that unless control is tight at all sources and causes of

material waste and at the stages of a project otherwise, cost overrun is bound to occur.

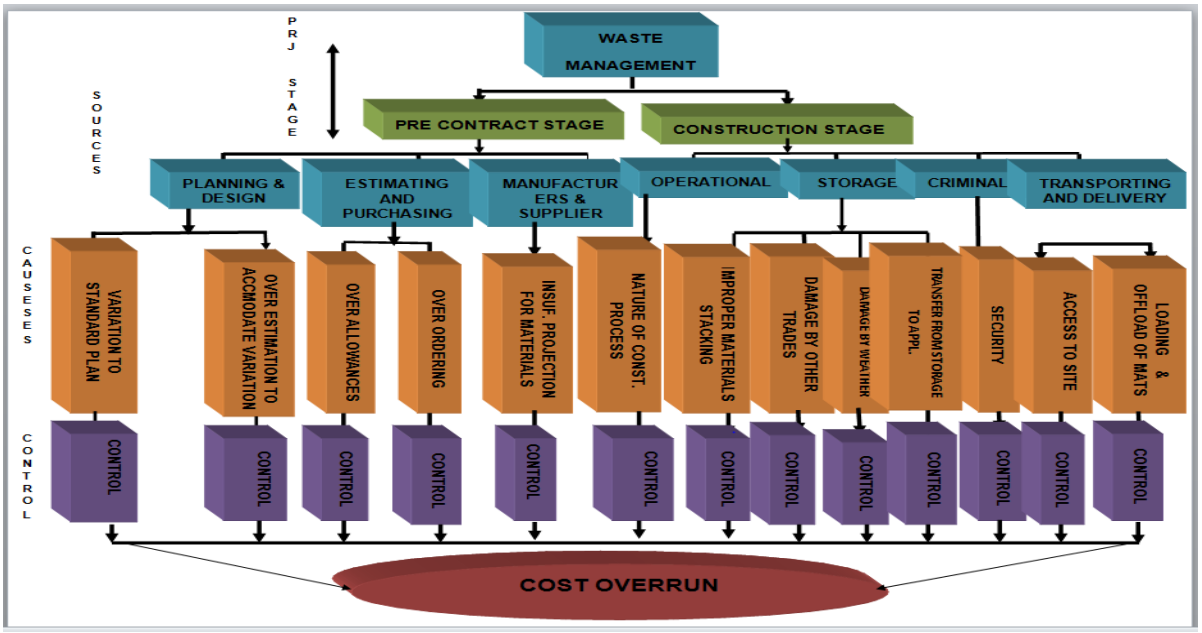

Figure 5. Summary of the relationship in Figure 4

This interrelationship is further represented in Figure 6.

Figure 6: Relationship between project stages, waste sources, waste causes, management and cost overrun

This relationship is further represented mathematically showing how cost overrun is minimised with an Effective Waste Management (EWM) from each scenario

Line 01, A-B:

$Project\ stage\ +\ waste\ sources - EWM = 86.74\%\ Cost\ overrun \ldots\ldots\ldots\ldots .01a$

Making "EWM" the subject, by having a positive EWM, the equation would therefore, minimise cost overrun by 86.7%. This means that an effective waste management at the project stages and waste sources would effectively minimise project cost overrun by 86.74%.

$EWM = Project\ stage\ +\ waste\ sources - 86.74\%\ Cost\ overrun. \ldots\ldots\ldots\ldots 01b.$

Line 02, A-C:

Project stage + waste causes-EWM = 86.74% cost overrun……...02a

Project stage + waste causes – 86.74% cost overrun = EWM…… 02b

This means that an effective management (EWM) of waste causes at project stages would effectively minimise project cost overrun by 86.74%.

Line 03, B-C:

Waste sources+ waste causes-EWM=86.74% cost overrun……03a

Collecting the like terms by making "EWM" the subject, the equation will be:

Waste sources+ waste causes- 86.74% cost overrun=EWM……03b

Therefore, an "EWM" would minimise the occurrence of "cost overrun" by 86.74%. However, Poor "EWM" would lead to occurrence of "cost overrun" as shown in the equation below:

−EWM= Project stage + waste sources+86.74% cost overrun.

Scenario 1 (Line 01, A-B), shows that **waste sources** within the **project stage.** Figure 6; cause an 86.74% cost overrun. Therefore, to effectively control the project waste, there must be an Effective Waste Management (EWM) at the ***project stages*** and at the ***waste sources,*** which will in turn, minimise ***cost overrun*** *to* ***13.26%.*** The same applies to the remaining two scenarios.

5 Conclusions and Further Research

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 waste generated on cost overrun (referring to section 1). The aim of this research was to examine the relationship between the causes of material waste and those of cost overruns with a view to suggesting the possible ways of minimising their effects at the pre-contract and the post-contract stage of a project. The study concludes that, there is a relationship between the causes of material waste and those of cost overruns at the pre-contract and post-contract stages of a project. This implies that an increase in material wastage on site leads to a corresponding increase in the amount of cost overruns for a project. 100**%** of the causes of material waste also cause cost overruns at the pre-contract and the post-contract stages of a project, while 96.88**%** and 81.81**%** of the causes of cost overruns cause material waste at the pre-contract and at the post-contract stages respectively. These results corroborates the findings of the studies conducted in the UK, Hong Kong, Netherlands, and Nigeria; that wastage of construction materials contributes to additional project cost by reasonable percentages (Ameh and Itodo, 2013). The result also supports the findings of Teo, Abdelnaser and Abdul (2009). Though, these results are literature based, they however, refute the findings reported by Ameh and Itodo (2013: 748) that in the UK, material waste accounts for an additional cost of 15% to cost overruns as stated in the section 1 of this study. Based on these findings it can be concluded that effective management of material waste would translate into a reduction in the level of cost overrun. The study recommends that management of material-waste causes should be encouraged, as it has the potential to minimise the causes of cost overrun for a project.

Since this is an ongoing research, further study would focus on the collection of empirical (field) data on the issues relating to material waste and cost overruns in the construction industry.

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