

Impact of Material Management on Cost Overruns in the Construction Projects in Sri Lanka

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Abstract: *The construction industry is considered to be a main contributor for development of an economy of a country. Accordingly, in Sri Lanka also the contribution of the construction sector plays a major role towards the economic growth. Meanwhile, cost overruns are inevitable consequences within the construction industry and material management identified as one of the key causes to occur cost overruns within construction projects. Relationship between material management and cost overruns was not investigated much in conjunction within the Sri Lankan construction industry in past studies. In that sense, this study aims to identify the impact of material management on cost overruns in the construction projects in Sri Lanka. Moreover, issues and solutions for proper material management in construction projects were identified as the key findings in this study. The study was conducted as mixed research approach where both qualitative and quantitative data were acquired through questionnaire survey and semi-structured interviews. The impact and relationship of material management and cost overruns were identified via regression analysis and correlation analysis with the aid of SPSS software package. The issues and solutions for proper material management were identified through the manual content analysis. The major issue of material management was identified as the wastage of materials in construction sites. It causes to incur high additional costs in the construction projects. Finally, the study was further elaborated the conclusions and recommendations to overcome cost overruns through proper material management in the construction projects in Sri Lanka.*

Keywords: *Material Management, Cost Overrun, Construction Projects*

1. Introduction

Cost is identified as one of the key parameters in a construction project. Cost overruns are identified as inevitable consequences which are global concerns in the construction industry (Durdyev, Ismail and Bakar, 2010). The magnitude of cost overruns is in different fluctuation levels from project to project. However, improper material management is one of the key causes for cost overruns which reduces the contractor's profit, resulting in significant losses and putting the project in jeopardy (Lenin et al., 2014). Therefore, any cost overruns occur within the project required to minimize as much as possible so that, it won't affect severely for the project success. Therefore, with proper material management, construction projects' goals and objectives can be achieved specially without any cost overruns.

Construction Materials can be defined as major and mandatory constituents in construction projects, since without the materials any of construction projects cannot be built. In that regard, cost for the materials in constructions are known to make a huge contribution to the total project cost. Depending on the type of the project, the total cost of materials can account up to 60% or more of the whole cost of construction (Gulghane and Khandve, 2015; Vipin and Rahima Shabeen, 2019). In Sri Lankan context, this issue is encountering a massive portion out of the prevailing problems in

construction projects. Material wastage has become an immense issue in the Sri Lankan construction sector since it happens beyond allowable limits (Kulatunga, Amaratunga, Haigh and Rameezdeen, 2006). Therefore, the way to mitigate the cost overruns through proper material management in construction industry in Sri Lanka is required to be investigated. The study is limited within the Sri Lankan construction context. Accordingly, the aim of this research is to identify the impact of material management on cost overruns in the construction projects in Sri Lanka and objectives were listed as 1) to study the concept of material management in construction projects 2) to identify the relationship between the material management and cost overruns in the construction projects in Sri Lanka 3) to identify the issues of material management on cost overruns in construction projects in Sri Lanka and finally 4) to suggest the solutions to overcome cost overruns through proper material management in construction projects in Sri Lanka.

2. Literature Review

A. Material Management

Material management refers to the availability of sufficient quantities and quality materials at the required time to avoid construction delays (Vipin and Rahima Shabeen, 2019). Therefore, material management should be contemplated at all phases of the construction process and throughout the project duration (Kasim, 2006). Material management is critical since any significant contribution made in this area would drive a long way toward increasing project profitability and return on investment (AparnaShruthi and Venkatasubramanian, 2017). Kasim (2006) stated that material management is specially challenging for large and complicated projects that need the use of sophisticated technologies and processes.

B. Components of Material Management

After referring the past studies related to the material management following key components of material management were identified.

1. Material Planning

According to Jusoh and Kasim (2017a) the identification of material requirement, material documentary maintenance, delivery frequency and temporary facility planning are included in this phase. If the material planning procedure is not followed accurately in a construction project, the entire project will be unsuccessful and the project won't be completed on time. But if it was properly maintained, the entire project cost will be reduced through low material wastage (Madhavarao, Mahindra and Asadi, 2018).

2. Vendor Analysis

In this phase material prices, quality, delivery time, inventory held by suppliers and flexibility are assessed to select the most suitable vendor (Jusoh and Kasim, 2017a). The proper vendor analysis process is highly important to enhance the quality of the project and it could affect in increasing the project performance while overcoming the barriers (Vipin and Rahima Shabeen, 2019).

3. Storage and Inventory

Storage and inventory in construction projects are critical since the time between ordering and receiving items is highly unpredictable (Jusoh and Kasim, 2017b). Misron, Khoiry and Hamzah (2018) defined that material storage management is about placing material inside the stores properly and releasing them to the site when required. However, this is a recurrent process in construction sites.

4. Material Purchasing

According to Arijeloye and Akinradewo (2016), in material management the purpose of purchasing process is to supply the required materials with proper quality and budget margin at accurate time and location. Material purchasing procedure includes

overview of the purchase, material order request, placement of the order, keeping and matching the records, ordering and arriving of materials, follow up purchase order and transfer materials (Madhavarao, Mahindra and Asadi, 2018).

5. Supply and Distribution

Distribution and transportation of materials is considered under the logistics part of the construction projects. Availability of transportation enhances material procurement on site. Inadequate transportation can lead to increased waiting time which translates into delays and eventually impacts negatively on project outcomes (Tunji-Olayeni et al., 2017). There could be several problems that might arise regarding the supply and distribution of materials such as supply delays due to quick purchase, wastage during stockpiling, handling and transporting of huge material quantities without meeting the production needs on site (Kasim, 2006).

6. On site Material Handling

According to Arijeloye and Akinradewo (2016) movement, placement and usage are the main constituents in handling of materials. The requirement for a proper handling is due to the expensiveness of materials and variety of quality standards based on the significance of materials which makes the handling process important. The focus on on-site material handling must be directed to minimize wastage, vandalism, theft and shortage (Kasim, 2006). In order to have much effective handling of materials on site is to maintain good method to cover and supply all materials as needed, including raw and processed materials, arranging all works and maintaining materials (Madhavarao, Mahindra and Asadi, 2018). If the handling of materials within the site is strictly adhered to the guidelines, it can help to minimize waste and contribute directly to increased profits and productivity (Arijeloye and Akinradewo, 2016).

C. Cost Overruns in Construction Projects

According to Rajakumar (2016), cost overruns refer to the comparison between the estimated cost and original incurred cost. A cost overrun, also known as an elevation in cost due to high unpredictable cost because of any error in actual cost calculation during the budgeting process (Vaardini, Karthiyayini and Ezhilmathi, 2016). A completed project may not be considered as a successful venture unless and until it meets the budgetary constraints imposed on it (Azhar, Farooqui and Ahmed, 2008). Vaardini et al. (2016) stated that it is unavoidable from having cost overruns which surpass 100% of estimated cost in underdeveloped and developing countries. In that regard, cost overruns characterized the majority in constructions in developing countries (Durdyev, Ismail and Bakar, 2010). Nevertheless, cost overruns have the capability to crash the projects while making instable consequences for all parties involved (Aljohani, Ahiaga-dagbui and Moore, 2017). Vaardini et al. (2016) emphasized that improper resource management, poor planning, improper site management, faulty financial control, poor climatic conditions, lack of proper planning and scheduling and material rate fluctuations as the most crucial factors which can lead to cost overruns in construction projects.

D. Relationship between Material Management and Cost Overruns

As per the cost analysis of infrastructure projects, materials and plant cost can be summed up to 70% of the total cost and depending on the type of project, the level of mechanisation and plant employed whereas commercial and housing projects account for roughly 45-50 % (Donyavi and Flanagan, 2009). Since construction materials are major cost components in any construction projects, material management is considered as one of the frontiers for cost reduction to increase profitability and productivity (Napoleon Kuebutornye et al., 2018). Koriom et al. (2019) express that because of the lack of adequate execution of materials management, construction contractors had to suffer from low productivity, project delays and cost overruns

throughout the whole time. According to Donyavi and Flanagan, (2009) cash flow is the decisive for the existence of any business if there is early purchase of supplies, capital may be held up and interest expenses on the excess inventory of material may be incurred. Materials may subject to deterioration or theft during storage. Moreover, if there are no supplies for relevant tasks, delays and additional costs may be incurred. Therefore, construction material management has become an important function in the construction projects due to its key role in to project cost (Jusoh and Kasim, 2017a).

By referring to the previous studies on material management and cost overruns in Sri Lankan construction industry, there were studies done based on the impact of material management systems in high-rise buildings in Sri Lanka and the application of modular coordination (MC) to material management in construction industry where they were focused on reducing the material wastage. But in both of them the effect to the project cost was not discussed further.

3. Research Methodology

The mixed research approach was employed in this research by using both quantitative and qualitative methods where the quantitative analysis was conducted to identify the impact and relationship between material management on cost overruns and qualitative analysis was conducted to identify the issues on proper material management and suggest solutions to overcome prevailing issues. The

target population selected for the study among the construction professionals are the project managers, quantity surveyors, site engineers and store keepers. The conceptual framework which was developed for the study was illustrated in the Figure 1.

Accordingly material management was established as independent variable and cost overruns were established as dependent variable in this conceptual framework. Under the main independent variable, there were six sub independent variables established as material planning, vendor analysis, storage and inventory, material purchasing, supply and distribution and on-site material handling. Accordingly, both null hypotheses (H_0) and alternative hypotheses (H_1) were developed as follows to test the relationship between the variables.

Null hypotheses (H_0) – There is no relationship between the independent variables and the dependent variable.

Alternative hypotheses (H_1)– There is relationship with the independent variables and the dependent variable.

In this research, simple random sampling and purposive sampling techniques were employed as sampling methods. Qualitative data was collected through semi structured interviews which includes open ended questions and quantitative data was collected through questionnaire survey which includes close ended questions. All together 10 number of construction professionals were interviewed

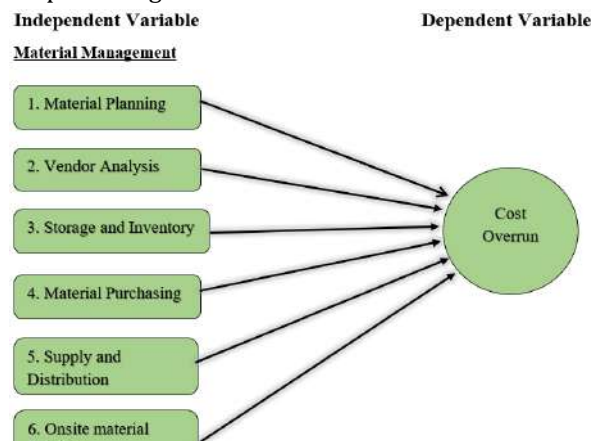


Figure 1. Conceptual Framework

for the semi-structured interviews and their details are represented in Table 1.

Table 1. Interviewees' Details

Interviewee Code	Designation	Organization type	Experience
ER-01	Project Quantity Surveyor	Contractor	15 years
ER-02	Senior Quantity Surveyor	Contractor	27 years
ER-03	Project Manager	Contractor	30 years
ER-04	Project Engineer	Contractor	21 years
ER-05	Quantity Surveyor	Consultant	17 years
ER-06	Store Keeper	Contractor	12 years
ER-07	Resident Engineer	Consultant	28 years
ER-08	Civil Engineer	Contractor	19 years
ER-09	Chief Quantity Surveyor	Consultant	32 years
ER-10	Store Keeper	Contractor	16 years

The questionnaire survey was distributed among 40 construction professionals but only 38 responses were received with 95% response rate. Among the 38 construction professionals who responded to the questionnaire, 16 were quantity surveyors, 7 were project managers, 10 were engineers and 5 were store keepers.

Regression analysis was performed to identify the impact between the independent and dependent variables and the degree of the relationship between independent and dependant variables was measured by the correlation coefficient with the aid of SPSS software. The manual content analysis was used to identify the issues of material management on cost overruns and the solutions were suggested to overcome the issues related to material management.

4. Research Findings

A. The Impact of Material Management on Cost Overruns in the Construction Projects

The regression analysis was employed to identify the impact between these two variables through the SPSS software. Regression analysis

is the analysis of relationship between dependent and independent variable as it depicts how dependent variable will change when one or more independent variable changes due to factors. The formula for the regression analysis was developed as follows.

$$Y = \alpha + (\beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6)$$

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	
	B	Std. Error	Beta			
1	(Constant)	714	340		2.101	.044
	AMP	.181	.092	.139	1.965	.058
	AVA	.084	.129	.093	.647	.522
	ASI	.119	.084	.186	3.414	.002
	AMAP	.210	.107	.264	1.958	.059
	ASD	.068	.144	.066	.471	.641
	AOS	.036	.140	.034	.259	.797

a. Dependent Variable: ACO

Figure 2. Coefficient table derived from SPSS

The formula is derived by the simple equation of $Y = \alpha + \beta X$. Accordingly, Y is the dependent variable while X is the independent variable here. α is the constant and β is used to define the slope between the variables.

Figure 2 which consists of coefficients was directly derived from the SPSS software as screenshot where it depicts the values to prove the relationship between the dependent and independent variables in related to the regression analysis formula through the unstandardized B (β) value.

$$Y = \{0.714 + [0.181*(AMP)] + [0.084*(AVA)] + [0.319*(ASI)] + [0.210*(AMAP)] + [0.068*(ASD)] + [0.036*(AOS)]\}$$

AMP – Average of material planning

AVA – Average of vendor analysis

ASI – Average of storage and inventory

AMAP – Average of material purchasing

ASD – Average of supply and distribution

AOS – Average of on-site material handling

ACO – Average of cost overrun (dependent variable)

Accordingly, as per the results obtained it depicts the variance of the cost overruns which affected by the independent variables of material management.

Based on the results of the regression analysis, storage and inventory variable has the highest impact with the dependent variable with 31.9% variance of cost overruns in Sri Lankan construction projects. On site material handling was identified as the least impact variable with the 3.6% variance of cost overruns in the construction projects.

B. Relationship between the Material Management and Cost Overruns in the Construction Projects

Based on the analysed data, all the significance values obtained for independent variables were recorded less than 0.05 which portrayed that all the independent variables have a relationship with the dependent variables. Further, the Pearson correlation value acquired for all the independent variables were recorded above 0.7 except for on-site material handling. Vendor analysis independent variable has the highest correlation value as 0.777 and the lowest as on-site material handling with a value of 0.683. Therefore, all the independent variables except on site material handling were remarked to have a strong and positive relationship with the dependent variable of cost overrun. Although on site material handling has a positive relationship with the dependent variable as well. This signifies that all the alternative hypotheses that were developed for the study was satisfied.

C. Issues of Material Management on Cost Overruns in the Construction Projects in Sri Lanka

This set of issues were identified through the means of a questionnaire survey and analysed through frequency analysis under manual content analysis. Table 3 represents the issues related to material management on cost overruns in the construction projects in Sri Lanka.

Table 2. Issues of Material Management on Cost Overruns in the Construction Projects in Sri Lanka

Code	Rank	Issues	Frequency	Percentage
E	1	Wastage of materials	31	81.6%
C	2	Low quality material purchase	24	63.2%
F	3	Price escalation of materials	23	60.5%
A	4	Improper storage management	19	50%
G	5	Improper material handling	16	42.1%

D	6	Inaccurate material ordering	15	39.5%
K	7	Poor coordination and supervision	15	39.5%
H	8	Lack of proper record keeping of materials	14	36.8%
B	9	Lack of project personnel related to material management	13	34.2%
L	10	Improper material planning	11	28.9%
M	11	Lack of timely delivery of materials	9	23.7%
I	12	Improper material distribution among sub-contractors	7	18.4%
J	13	Improper supply chain management	6	15.8%

Furthermore, Figure 3 illustrates the graphical interpretation of the issues related to material management in construction projects in Sri Lanka

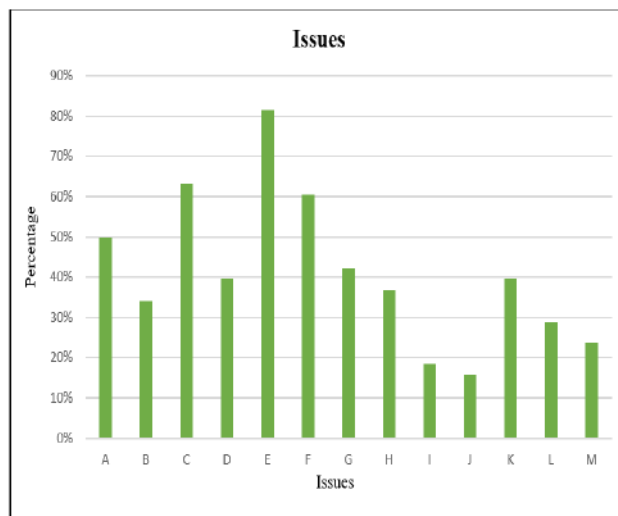


Figure 3. Issues of Material Management in the Construction Projects in Sri Lanka

As per the data illustrated in table 3 and figure 2, total 13 issues were identified which were associated with material management on cost overruns in the construction projects in Sri Lanka. Accordingly, the key issue was identified as the high wastage of materials which denoted by letter "E" in the figure. Further, issues of low-quality material purchase, price escalation of

materials, improper storage management and improper material handling also identified as some significant issues which effects to the cost overruns in the construction projects in Sri Lanka.

Apart from that lack of project personnel related to material management, inaccurate material ordering, lack of proper

record keeping of materials, improper material distribution among the sub-contractors, improper supply chain management, poor coordination and supervision, improper material planning and lack of timely delivery of materials also identified as the issues prevailing in the construction projects in Sri Lanka which related to the material management.

D. Solutions for Material Management to overcome Cost Overruns in the Construction Projects in Sri Lanka

As per the experts' opinions, this critical issue of material wastage is long lasting from project inception to the completion of the project. In regards that they highlighted; professionals who are involving in each stage should ensure to minimize the overall material wastage of the project. Accordingly experts suggested the solutions related to material management to overcome cost overruns in the construction projects as selecting competent suppliers after proper assessment of material test certificates for the selected materials, maintaining of proper documentation for material inflows and outflows throughout the whole construction duration, introducing specific professions related to material management such as material managers/material coordinators, timely planning of material requirements with reference to the construction programme and deducting any material wastage amounts from sub contractor's payment certificates beyond the allowable limits. Further experts suggested to adhere with some common concepts such as building information modelling (BIM), value engineering (VE), 3R concept and life cycle costing once they are involving in material management in construction projects in Sri Lanka.

5. Discussion and Recommendation

The study was conducted to investigate the impact of material management on project cost overruns in Sri Lankan construction projects. As per the research findings, all the alternative hypotheses (H_1) were satisfied

while indicating that there is a strong and positive relationship between the material management and cost overruns in Sri Lankan construction projects. On the other hand, it was identified that storage and inventory have the highest impact to dependent variable of cost overruns out of the defined independent variables based on the regression analysis formula. Meanwhile, wastage of materials attained the majority out of the issues discovered. In order to adhere proper material management in the construction projects, professional experts suggested some common concepts such as BIM, value engineering, 3R concept and life cycle costing in Sri Lankan construction projects.

Further, some recommendations were drawn in this research to implement Enterprise Resource Planning (ERP) systems with the requirement of major customisation along with characteristics of the local construction industry, to prepare separate comprehensive document system for material management at sites, to implement Advanced Work Packaging (AWP) where combining engineering and procurement in the early stages of the construction project to align with the construction scheduled work scope. This Advanced Work Packaging (AWP) method can make sure the construction will be completed along with the design without allowing any reworks. Other than that, Just in Time (JIT) approach is also identified to be an effective practice which can eliminate waste production within the project through proper delivery of materials. Further, allocating competent personnel for the material management at site, conducting regular meetings to discuss upon prevailing issues related to material management and forming a separate executive team to assess the material management in the construction projects also recommended.

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