Factors Affecting Material Management in Building Construction Projects

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Abstract: The paper considers the management of materials in building construction projects. In this study, construction material management can be viewed as three categories which are measures for effective material management in building sites, factors that increase waste in building sites and problems related with material management. The principal tool used for collection of data is quantitative survey (numerical values); questionnaires for field survey. Data for the study are obtained through a structured questionnaire administered to respondents in number of 53. The respondents involve 18 project engineers, 23 site engineers and 18 contractors. The data are analyzed by the use of inferential statistics; including Relative Importance Index (RII) and the perceptions of project engineers, site engineers and contractors are tested to determine whether there is a significant degree of agreement among respondents by Kruskal Wallis test or H test. The overall results of this study indicate that the current practices of material management in local construction projects need systematic and effective control. Based on the findings of agreement analysis, it is found that the perceptions of three respondents (project engineers, site engineers and contractors) are identical in all three cases; measures for effective material management, factors increasing waste in building construction projects and problems related with material management. Hence, it is said that all of project engineers, site engineers and contractors are mainly concerned with material management and their roles and decisions are essential to improve effective material management. Moreover, all the results of this study are undoubtedly accepted to be important because of identical perceptions of three respondents.

Keywords: Construction materials, Factors, Management, Materials waste, Problems.

I. INTRODUCTION

Successful completion of projects requires all resources to be effectively managed. Considering that for a typical construction project, 10% to 15% of total cost is for engineering design and 50% to 60% is for equipment and materials, it is obvious that almost half of project cost consists of materials cost. According to Khypmesh (2011), 30 to 70 percent of project cost is consumed by materials with about 30 to 40 percent of labor. Hence, it is clearly important to manage all materials from design to construction stage in every project. Material management is a function that significantly contributes to the success of a project. As projects grow in scale and complexity, material management is required really to use them. It is also the process that coordinates planning, assessing the requirement sourcing, purchasing, transporting, receiving and inspection, storing, handling and controlling of materials, minimizing the wastage and optimizing the profitability by reducing cost of materials.

The goal of material management is to ensure that materials are available at their point of use when needed and the right quantity and quality of materials are appropriate selected, purchased, delivered, and handled on site in a timely manner and at a reasonable cost. Indeed, the management of materials will cause a huge effect on the total project cost, time and quality. Material management should be considered in construction projects as a vital management to achieve better productivity and profit, which should be translated into cost reduction and successful completion with best quality. It is surely that material management practices could increase efficiency in operations and reduce overall costs. Hence, special attention has to do in material management to obtain the successful completion of every project operation without difficulty.

II. FACTORS RELATED WITH MATERIAL MANAGEMENT

There are several factors within the scope of material management and each of these factors can give rise to potential problems. The more factors are divided, the more potential problems that exist. There are many factors which contribute to poor material management in construction projects. Zakeri et al. (1996) suggested that factors such as waste, transport difficulties, improper handling on site, misuse of the specifications, lack of proper work plan, inappropriate material delivery and excessive paperwork all adversely affect on material management. Factors related with material management can be mostly found in the following areas in local construction projects.

1. Planning and Scheduling
A. Planning and Scheduling
Planning is a fundamental, important process for every project. Material planning, which is a key function of material management, is closely linked with project planning and control set-up. Scheduling the entire material program is essential to meeting the project timetable. Indeed, planning and scheduling are significant in terms of increasing productivity, profit and facilitating the timely completion of construction projects.

B. Monitoring and Controlling
Monitoring and Controlling of all construction activities in material management are conducted to ensure the right source of materials with the exact quality, at the right time and place suitable for minimum cost construction process. It is a process in which facilities, personnel, resources and capital are monitored and controlled to a significant impact on the operations of construction projects.

C. Organization and Personnel
Material management structure is organized in such a way that it allows for integral planning and coordination of the flow of materials, in order to use the resources in an optimal way and to minimize costs. The organization must be structured to provide for the timely performance of the work, with material personnel located at appropriate level of project management and influence the decision making process.

D. Procurement
Preliminary investigations for developing sources for procurement of materials are made by floating enquiry indents. It is processed by the material procurement responsible personnel for inviting quotations with samples of materials where applicable.

E. Delivery
Delivery in terms of organizing the movement of vehicles, people and materials ensures the efficient use of workforce and production or process in construction projects. The routing of materials is one of the main causes which affect cost and time during construction.

F. Storage and Storage facilities
Material storage can be defined as the provision of adequate space, protection and control of building materials and components held on site during the construction process. A good and systematic storage of materials provides better management of materials in construction.

G. Usage
Usage of materials is the flow component that provides for their movement and placement. Material usage can be defined as the provision of proper handling techniques either manually or mechanically for the components held on site during construction process.

H. Surplus and Waste Control
All projects can expect a certain amount of surplus and waste of materials after construction. Surplus and waste materials arise at any stage of construction process from inception, right through design, construction and operation of the building facility. Hence, control of surplus and waste materials is important to successful material management.

III. AIM AND OBJECTIVES
The objectives of this study are as follows;
1. To find the current practices of material management in local construction projects.
2. To determine the degree of agreement on material management among project participants.

IV. DESCRIPTION ON RESPONDENT RATE
Formal questionnaires are distributed in numbers of 80. Mainly project engineers, site engineers and contractors are target points of this survey.

Table I. Survey Response

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PE</th>
<th>SE</th>
<th>Contractor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of questionnaires distributed</td>
<td>25</td>
<td>35</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>No of questionnaires received</td>
<td>18 (72%)</td>
<td>23 (66%)</td>
<td>12 (80%)</td>
<td>53 (66%)</td>
</tr>
<tr>
<td>No of questionnaires unreturned</td>
<td>7 (28%)</td>
<td>12 (34%)</td>
<td>3 (20%)</td>
<td>27 (34%)</td>
</tr>
</tbody>
</table>

Table I shows that 80 questionnaires are distributed into 25 for project engineers, 35 for site engineers and 20 for contractors. The response rate of project engineers is 18 (72%) while that of site engineers is 23 (66%) and the response rate of contractors is 12 (80%). Based on the results of survey, it can be found that three participants (project engineers, site engineers and contractors) are interested and enthusiastic in material management of building construction projects.

V. RESEARCH METHOD
The questionnaires are designed with close-type questions. For both measures for effective materials management and factors increasing waste in building site, the question measurement scale is stated as four scale of opinion degree such as strongly agree, agree, disagree and strongly disagree. On the other hand, the measurement scale for problems faced in material management is adopted as five scale of occurrence degree such as always, often, sometimes, seldom and never. To analyze data from three respondents (project engineer, site engineer and contractor), Relative Important Index (RII) method is used. Based on the results calculated RII method, Kruskal Wallis test or H test is also used to show
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the degree of agreement among the rankings of respondents. H test can be computed as the following formula.

Test statistic:  \[ H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1) \] (1)

Where, \( R_i \) = the sum of the ranks by the \( n_i \)
\( n = n_1 + n_2 + n_3 + \ldots + n_k \)
\( n_i \) = observations of the \( i^{\text{th}} \) sample
\( k = \) independent random samples

The significance level of a test, denoted by \( \alpha \), is the accepted risk of committing. For example, \( \alpha = 0.05 \) is commonly used. If less risk is acceptable, \( \alpha \) can be set lower, say \( \alpha = 0.01 \). If more risk is allowable, \( \alpha = 0.10 \) may be used. The rejection region is the range of values of the test statistic that would lead to rejecting the null hypothesis. In this research, 0.05 of significance level is satisfied for testing.

Null Hypothesis: \( H_0 \): There is statistically significant degree of agreement among project engineer, site engineer and contractors.
Alternative Hypothesis: \( H_1 \): There is an insignificant degree of agreement among project engineer, site engineer and contractors.

Using data from a sample, H statistics is less than chi-square distribution of 2 degree of freedom (0.05 level of significance), the null hypothesis, denoted by \( H_0 \), is accepted. Alternatively, it can be said that the alternative hypothesis, denoted by \( H_1 \), is rejected.

VI. DATA ANALYSIS

The survey data are grouped and analyzed into three major areas according to material management functions; planning, purchasing, transportation, receiving and inspection, stacking and storage, inventory control, handling, surplus materials and waste control. These three major categories are measures for effective material management, factors affecting waste in building construction sites and problems related with material management.

A. Major Categories for testing data

First category is expressed which measures for effective on material management consisting of 22 items. These items are described as followings.
- Defining accurate materials specifications
- Locating sources of materials for procurement
- Getting samples for materials approved
- Forecasting of field condition, weather and event in the future
- Forecasting materials price in market
- Preparing for material storage
- Considering required communication methods for material management
- Identifying Material Schedule
- Daily recording of using materials in the project

- Reporting the situation of materials in the project’s store
- Reporting the problems for examples (wastage and loss, storage in delivery)
- Following up the prices in the market and recording the variations of prices
- Using suitable, safe and secure storage
- Consideration efficient mechanical systems and machinery for moving materials
- Planning and monitoring construction activities
- Consideration off-site construction
- Usage of packaging in an efficient way
- Training people on how to reduce waste
- Performing recycle and reuse methods for surplus and waste materials
- Controlling over-ordering and purchasing
- Attention to weather condition
- Employment of store keeper and security personnel

In second category, there are 25 factors related with material management affecting waste in building construction projects. These factors are shown in below.

- Incomplete drawing design and specification
- Design changes
- Inadequate supervision in usage of materials
- Over-ordering of materials
- Delay in material inspection and testing
- Inappropriate coordination of Teamwork in site
- Manufacturing defects (pipe, supporting pipe, electricity)
- Poor cutting of materials (glass, tiles, plywood)
- Inefficient utilization of temporary materials (hoarding, formwork, scaffold)
- Damage due to weather
- Poor security on site (theft and vandalism)
- Lack of care in transportation
- Inadequate skill in utilization of materials
- Rework due to improper quality and mistakes
- Insufficient places for material storage
- Wrong methods and regulations in materials usage
- Poor materials storage facility
- High frequent materials movement
- Lack of supervision and proper control during storage
- Wrong material utilization
- Lack of proper work planning and scheduling
- Existence of unnecessary materials on site
- Poor quality of materials
- Shortage of materials
- Delay in material supply to sites

Final category consists of problems arising lack of special care in material management. This includes 25 problems as below.
- Receiving incorrect material type
- Unavailable required quantity
- Too early receiving of materials before usage
- Incorrect material takeoff from drawing and design
documents
- Slow response from company to site about submittals
- Delivery wrong materials
- Delivery materials with wrong dimension and quantities
- Increase materials quantity in storage
- Weather
- Burglary, theft and vandalism
- Destroy material in shipping
- High cost in material transportation
- Material Shortage during construction
- Piling of inventory materials
- Poor material selection
- Defects due to improper skill in materials usage
- Selection of type of contract for specific material procurement
- Disturbance due to poor materials storage
- Project delay due to slow delivery materials
- High price of materials in the market
- Suddenly alternation price of materials
- Ineffective control of storage
- Usage of materials without systematic control
- Management of surplus materials
- Improper selection of type of contract for material procurement

B. Significance Test
The following tables describe the rank values by three respondents (project engineer, site engineer, contractors) for each category. Required data for testing the perceptions of three respondents with H test can be obtained from these tables.

Table II. Rank Values by Three Respondents of Measures of Effective Material Management for H test statistics

<table>
<thead>
<tr>
<th>Types of Respondent</th>
<th>Rank Values</th>
<th>$\Sigma R_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Engineer</td>
<td>58 28 33 27 20 54 6 64 56.5 53 13</td>
<td>725</td>
</tr>
<tr>
<td></td>
<td>1 30 17 66 12 29 23 32 41.5 14 47</td>
<td></td>
</tr>
<tr>
<td>Site Engineer</td>
<td>42 44 45 19 22 59 8 46 51 49 2 3</td>
<td>763</td>
</tr>
<tr>
<td></td>
<td>38 7 63 4 48 16 52 55 31 39</td>
<td></td>
</tr>
<tr>
<td>Contractor</td>
<td>35 50 41.5 41.5 24 2 5 56.5 5 25 34 36</td>
<td>723</td>
</tr>
<tr>
<td></td>
<td>11 26 37 41.5 65 18 21 9 60 61 10 15</td>
<td></td>
</tr>
</tbody>
</table>

Table III. Rank Values by Three Respondents of Factors Affecting Waste in Building Constructions for H test statistics

<table>
<thead>
<tr>
<th>Types of Respondent</th>
<th>Rank Values</th>
<th>$\Sigma R_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Engineer</td>
<td>2 4 5 7 11 14 15 16 19 27 39 43 44</td>
<td>1001.5</td>
</tr>
<tr>
<td></td>
<td>45 47 53 57 60 65 67.5 69 71 72 74 75</td>
<td></td>
</tr>
<tr>
<td>Site Engineer</td>
<td>3 8 10 12.5 17 21 23 24 26 30 31 33</td>
<td>926.5</td>
</tr>
<tr>
<td></td>
<td>36 37 41 42 50 51 52 54 62 63 64 66 70</td>
<td></td>
</tr>
<tr>
<td>Contractor</td>
<td>1 6 9 12.5 18 20 22 25 28 29 32 34</td>
<td>922</td>
</tr>
<tr>
<td></td>
<td>35 39 39 46 48 49 55 56 38 60 60 67.5 73</td>
<td></td>
</tr>
</tbody>
</table>

Table IV. Rank Values by Three Respondents of Problems Related with Material Management for H test statistics

<table>
<thead>
<tr>
<th>Types of Respondent</th>
<th>Rank Values</th>
<th>$\Sigma R_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Engineer</td>
<td>2 6 8 10 14 15 16 17 22 31 32 33 35</td>
<td>909.5</td>
</tr>
<tr>
<td></td>
<td>40 42.5 42.5 42.5 46 53 58 62 66 69</td>
<td></td>
</tr>
<tr>
<td>Site Engineer</td>
<td>3 7 11 13 20 21 24 25 27 28 29 45</td>
<td>1012</td>
</tr>
<tr>
<td></td>
<td>49 50 52 54 55 56 57 58 61 65 67 71</td>
<td></td>
</tr>
<tr>
<td>Contractor</td>
<td>1 4 5 9 12 18 19 23 26 30 34 35 37 38</td>
<td>924.5</td>
</tr>
<tr>
<td></td>
<td>42.5 47 48 51 60 63 69 69 73 75</td>
<td></td>
</tr>
</tbody>
</table>

By using the rank values obtained from above tables (II, IV and V), the perceptions of project engineers, site engineers and contractors is tested with Kruskal Wallis test or H test at a 95% confidence level to determine whether there is a significant degree of agreement among three respondents (project engineers, site engineers and contractors). The degree of agreement level on each category is shown as follows.

Table V. Summary of Agreement level among three respondents for each category

<table>
<thead>
<tr>
<th>Category</th>
<th>H value</th>
<th>Chi-Square Distribution</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures for effective material management</td>
<td>0.125</td>
<td>5.991</td>
<td>Accept $H_0$</td>
</tr>
<tr>
<td>Factors affecting waste in building constructions</td>
<td>0.336</td>
<td>5.991</td>
<td>Accept $H_0$</td>
</tr>
<tr>
<td>Problems related with material management</td>
<td>0.123</td>
<td>5.991</td>
<td>Accept $H_0$</td>
</tr>
</tbody>
</table>

In all three cases that are measures for effective material management, factors increasing waste in building construction projects and problems related with material management, H values for all category are less than $\chi^2 = 5.991$ with 2 degree of freedom and 95% confidence level ($\alpha = 0.05$), the null hypothesis, $H_0$ is accepted and the alternative hypothesis, $H_1$ is rejected. Hence, it can be said that there is a significant degree of agreement among project engineers, site engineers and contractors for all three cases.

VII. DISCUSSION AND CONCLUSION
This research has examined the current material management in local building construction projects. This paper describes the material management as three categories; measures for effective material management, factors increasing waste in building construction projects and problems related with material management. Project participants such as project engineer, site engineer and contractor are mainly selected in questionnaire survey. Their roles in construction sites are vital to ensure the successful completion of project and the perceptions of these persons are important to improve construction operations. Hence, the perceptions of these participants should be considered in material management which is a supporting field to achieve better productivity and profit of construction projects.
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This paper has reported the degree of agreement on material management among respondents. By testing the perceptions of three respondents (project engineers, site engineers and contractors) with Kruskal Wallis test or H test, the results show that there is a significant degree of agreements among three respondents in all three cases which are measures for effective material management, factors increasing waste in building construction projects and problems related with material management. Hence, it can be said that all of project engineers, site engineers and contractors are mainly concerned with material management and their roles of material management are essential to improve effective material management in building construction sites. Moreover, all the results of this study are undoubtedly accepted to be important because of the identical perceptions of project engineers, site engineers and contractors which play the vital roles in material management.

VIII. ACKNOWLEDGEMENT

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IX. REFERENCES
