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Influential Factors for Effective Materials Management in Construction Projects

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Abstract

Construction projects are plagued with the issue of poor project performance such as low productivity, wastage, time overrun, compromised quality and cost overrun. Research literature reveals that this issue occurs partly due to ineffective materials management. Nonetheless, the effective management of materials seems like a viable solution to enhance the performance of any construction projects. Despite its importance, not much literature has explored the influential factors for effective management of materials. Since the identification of factors is an essential step to recommend any improvement efforts, thus, this paper examines the influential factors for effective materials management. A questionnaire survey was conducted with practitioners from contractor organisations and 111 valid responses were obtained. Data was analysed using exploratory factor analysis via the IBM SPSS version 21 software. Results indicate that only 50 influential factors were relevant in Malaysian construction project and these were categorised into 8 specific components namely: management, purchasing, expediting, transportation, site storage and condition, supplier, contractual and governmental interference. Summarily, findings reported in this paper constitute part of a questionnaire development process for a research project undertaken to develop an effective materials management model for better projects performance. Thus, the outcome of this study may assist practitioners in decision making process by understanding the identified influential factors that contribute to effective materials management.

Keywords: *Influential Factors, Materials Management, Construction Projects, Exploratory Factor Analysis*

1.0 Introduction

Construction materials contribute significantly to project cost. Several authors claim that this contribution may be up to 70% of the project cost [1-3]. This contribution varies according to the type of contract that is agreed upon in every construction project [4]. Even though materials management is important, this area has received less attention from academician and researchers, as stressed by previous authors [5-8]. More importantly, past studies do not sufficiently address the influential factors that contributes to effective materials management. These studies only mentioned the factors briefly without further investigation: some only highlight few factors only [1, 3, 9, 10]. Likewise, there are various and complex factors associated with effective materials management. These factors could originate from suppliers, contractors, logistics provider, government, consultant as well as clients [3, 9, 11, 12]. Hence, identifying these factors is an important step needed to recommend any improvement efforts in ensuring appropriate solutions to the problem of ineffective material management in construction projects [13, 14]. By carrying out this study, results obtained may be useful to construction players especially contractors by providing them insights and understanding of the influential factors needed for effective materials management. With this understanding, contractors may be able to focus their effort, resources and incorporates the most crucial factors in the overall firm’s policy to mitigate or eliminate some materials management problems that occur in order to improve materials management implementation in construction projects. Thus, this paper aims to explore the influential factors for effective materials management using factor analysis.

Materials management is hence defined as the process of controlling the inventory, planning, handling, receiving, distributing, storing, controlling site usage as well as monitoring [15, 16]. Some authors interpret materials management as a concept that integrates all function of acquiring the construction materials as well as equipment under one management function [1, 17, 18]. Despite the various depiction of the materials management term, it is acknowledged that the ultimate aim of this management is to ensure the availability of construction materials at the most appropriate time, right location, appropriate quantity and that they are obtained at reasonable cost across all stages of construction [3, 19, 20]. As such, it can be concluded that materials management refers to a concept that integrates all function of planning, controlling, receiving, storing, handling, distributing, usage and monitoring all construction materials as well as equipment under one management for the purpose of ensuring their availability on site.

2.0 Influential Factors of Effective Materials Management

Materials management can be affected due to several factors. Several authors have highlighted that among the factors contributing to effective materials management are adequate planning, appropriate site management, efficient supervision, efficient handling, proper storage, efficient control of materials, adequate storage space, proper inventory control and good site accessibility [3, 21]. Meanwhile, among the factors affecting materials management effectiveness are unsystematic flow of materials, fluctuation of materials price, extensive multiple handling, improper sorting of materials, improper materials delivery, poor layout for materials handling, unavailability of up-to-date inventory status, delay in materials delivery, excessive paperwork, equipment breakdown, shortage of equipment, poor coordination, inefficient communication, delay in procuring materials, errors in ordering, lack of materials storage, poor materials planning and so on [6,16, 22, 23]. Since these factors affect the material management process and are responsible for ineffective materials management, then, it is necessity to mitigate and addressed these factor in enhancing an effective materials management [1, 10, 24, 25]. By addressing these, an effective materials management can be achieved. For this reason, the factors in the original form (i.e., negative perspective) need to be rephrased to become positive perspective. For instance, 'unsystematic flow of materials' becomes 'systematic flow of materials.' By doing so, these factors constitute the influential factors that contribute to the effective materials management instead of the factors that adversely affect the materials management effectiveness.

Meanwhile, the basis that have been adopted in deciding whether the factors are associated with materials management or not is according to the relevancy of the factors itself. Firstly, the priority is given to the factors that are retrieved from prior literature in the area of materials management. These factors must relate to the process and function of materials management in order to be selected. After the identified factors are listed, then the factors are retrieved from literature related to poor project performance are reviewed. By comparing those factors, the decision is made to ensure their suitability in representing the influential factors contributing to effective materials management.

Apart from that, during the reviewing process, there was a situation whereby certain factors were neither related and overlap with each other or termed differently but reflect the same meaning. Therefore, to avoid duplication and redundancy among the list of influential factors, some filtering and modifications were made as recommended by the previous author [26]. Summarily, a total of 56 influential factors were identified and categorised into 8 group as shown in Table 1. Regarding the influential factors and their group classification, since prior researchers do not explicitly specify the classification scheme, the author conducted a preliminary study with 10 experienced practitioners for the purpose of ensuring the appropriateness of the identified factors represent the influential factors of effective materials management as well as their group classification. This approach also has been adopted by prior studies [27, 28]. Meanwhile, **Appendix A** shows the comprehensive list of the influential factors, sources and country investigated.

Table 1: Summary of Identified Influential Factors and Groups

No.	Group	Number of Influential Factor
1	Management	15
2	Material Procurement	9
3	Logistics	10
4	Supplier and Manufacturer	5
5	Storage	4
6	Site Condition	4
7	Contractual	5
8	Governmental Interference	4

3.0 Methodology

The survey questionnaires were distributed to the practitioners that working in contractor organisations only. It is suggested that the appropriate sample size for this stage is based on the purpose of conducting this stage and the method of data analysis to be employed [29, 30]. In this process especially for self-developed instrument, it is crucial to determine the nature of latent variables underlying an item set [31], that is, appropriately classifying which influential items belong to which component group. It has been acknowledged that the most suitable technique to determine this is by factor analysis [31, 32]. Therefore, exploratory factor analysis was used as the principal component analysis technique that computed via IBM SPSS Statistics. In relation to the exploratory factor analysis, prior studies have highlighted the purpose of this analysis which includes; reducing the number of items, examining the structure between variables and evaluating the construct validity of a scale [32-34]. As the above mentioned reasons, the factor analysis was used for analysing the data in this study.

Meanwhile, there are various opinion about the preferable minimum sample size to perform factor analysis. Some authors recommend using a sample size based on the ratio of items involved (either 10 to 1 ratio or 5 to 1 ratio), while some recommend using a preferable sample as much as 50, 100 or larger [32, 34, 35]. Regarding the purpose of instrument development, some suggests a sample between 25 to 40 or 30 samples only [29, 36]. Whereas some asserts that the modest sample size is 150 for the instrument development process [31]. Since this stage involved in instrument development process and factor analysis was used, hence, a total of 150 questionnaires seem adequate and were distributed randomly to targeted respondents. The researcher administered the questionnaire by email, mail, and hand to respondents. In this questionnaire, the scale that have been adopted is a 7-point Likert scale structure in assessing the significant level for each influential factor contributing to effective materials management. A total of 118 responses were received, but only 111 were useable. The analysis began with the screening data for missing data and outliers. After the screening process, 16 responses needed to be dropped as they were classified as outliers. Outliers are recommended to be dropped because they influence the results of the statistical analysis resulting in skewed distributions [33]. Hence, only 95 responses were retained and used for factor analysis.

The details of respondents profile as listed in Table 2. This table indicates there are two aspects of experience which are experience in industry and experience in managing materials. The latter experience is required because it represents the credentials and the ability of respondents in contributing the findings for this study. Respondents' experience in the industry are presented in descending order they include; less than 6 years (28.4%), followed by 6-10 years (24.2%), 11-15 years (20%) and 16-15 years (12.7%). While between 21-25 years and more than 25 years of experienced fall within the 4% to 11% range (4.2% and 10.5% respectively). Regarding the experience of respondents in managing materials, almost half of them have experiences less than 6 years. Likewise, the remainder of respondents has experience between 6-10 years (24.2%), 1115 years (10.5%), 16-15 years (11.6%) and more than 25 years (4.2%). Apart from the respondents' experience, their current positions are also sought. Respondents were represented as site engineers (30.5%), quantity surveyors (29.5%), project managers (18.9%), site supervisors (14.8%), managing directors (4.2%) and contract/architect manager (2.1%).

Table 2: Respondents Profile

Item	Number	Percent (%)
1) *Years of experience in industry*		
Not more than 6 years	27	28.40
Between 6 to10 years	23	24.20
Between 11 to 15 years	19	20.00
Between 16 to 20 years	12	12.70
Between 21 to 25 years	4	4.20
More than 25 years	10	10.50
2) *Years of experience in managing material*		
Not more than 6 years	47	49.50
Between 6 to10 years	23	24.20
Between 11 to 15 years	10	10.50
Between 16 to 20 years	11	11.60
Between 21 to 25 years	0	0.00
More than 25 years	4	4.20
3) *Current position in the firm* Managing director	4	4.20
Contract/Architect manager	2	2.10
Project manager	18	18.90
Site engineer	29	30.50
Quantity surveyor	28	29.50
Site supervisor	14	14.80

4.0 Results and Discussions

The exploratory factor analysis type adopted was the principal component analysis (PCA) technique which was computed by IBM SPSS Statistics 21. Since the PCA produces 'components' while factor analysis produces 'factors' [35], thus the term 'components' is used in this study instead of 'factors.' Besides, the term 'items' also represent the influential factors due to the reason that 'items' are used to represent the statements contained in the scale. In the initial step of PCA analysis, the adequacy of the sample and the strength of relationship among items need to be assessed in ensuring the appropriateness of data in this analysis [32]. In this study, the results of the adequacy of the sample by means of Kaiser-Meyer-Olkin (KMO) indicates a value of 0.795. This value supports the adequacy of the sample as the minimum cut off recommended value by several authors is 0.60 [32, 35]. Likewise, the strength relationship threshold value for this study is 0.45 [31]. This indicates that the factor loading value for each item needs to be greater than 0.45 in order to be retained in the scale.

The second step is component extraction which determines the smallest number of component that is best in representing the interrelationship between the set of variables [32]. The components extraction according to the Kaiser's criteria (Eigenvalue >1 rule) resulted in 8 components extracted. Lastly, the rotation of component is used to maximise the variance explained among the components [33, 35]. Although several authors have suggested 'varimax' rotation [35, 37, 38], the appropriate rotation for this study is 'equamax.' The decision on which rotation to use depends on the criteria of having a simple and interpretable structure [31, 32]. Therefore, because 'equamax' rotation demonstrates the most simple and interpretable pattern compared to all other types of rotation after they have been computed, this type of rotation was selected.

After the PCA was computed to 'cluster' inter-related influential factors, the results of components and each item under it were reviewed. Accordingly, regarding with the extraction of components and modification, certain factors were excluded, relocated and combined. As a result, the group name also needed to be altered in order to represent all the influential factors under it. Table 3 indicates the summary of this analysis.

Table 3: Summary of Suppression of Factor Analysis

Before factor analysis		After factor analysis		
Name of construct	Number of items	Name of construct	Number of items >0.45	Remarks
• Contractual	5	• Contractual	5	
• Governmental interference	4	• Governmental interference	4	
• Logistics	10	• Expediting • Transportation	5 5	The underlying items were split
• Management	15	• Management	12	
• Materials procurement	9	• Purchasing	8	
• Storage • Site condition	4 4	Site storage & condition	6	The underlying items were merged
Supplier & manufacturer	5	Supplier	5	
Total item	**56**	**Total item**	**50**	

The Table 3 indicates that after the factor analysis, only 50 influential factors remained. This implies that 6 influential factors were dropped as they were less than the threshold value of 0.45 respectively. Apart from that, some of the influential factors were split into two groups, whilst some influential factors were combined after the analysis was conducted. Being that some of the influential factors were modified, hence the group name was also amended as indicated in the table above. The reduction of factors and modification of group verified that only 50 influential factors that categorised into 8 groups are relevant in Malaysian construction industry. Table 4 lists the finalised items of influential factors with their factor loading value that will be adopted for the main survey.

Table 4: Summary of Finalised Influential Factors

Bil	Construct	Influential Factor (Factor Loading)
1	Contractual (5 items)	Clear in material specification (.762), Materials meet specification (.714), No discrepancy between specification & drawings (.713), Minimisation in changes of design (.695), Minimisation in changes of material specification (.632)
2	Governmental interference (4 items)	Minimisation in changes of government regulation (.802), No bureaucratic procedure (.762), On time in custom clearance for imported materials (.750), Appropriate policy in materials procurement (.705)
3	Expediting (5 items)	Efficient use of equipment while handling (.691), Efficient communication on sites (.594), Easy movement for equipment (.537), Systematic flow of material (.515), Adequate qualified & experience staff (.459)
4	Transportation (5 items)	Proper material delivery to site (.734), Functional of equipment (.535), Sufficient protection during unloading (.527), Proper storing of materials (.520), Materials are not damaged while handling (.509)

Table 4: Summary of Finalised Influential Factors (Cont'd)

Bil	Construct	Influential Factor (Factor Loading)
5	Management (12 items)	Proper material usage (.698), Adequate IT infrastructure & application (.679), Proper material control (.654), Efficient site management (.609), Proper training on new technologies (.602), Efficient supervision (.576), Reasonable and systematic paperwork (.562), Efficient co-ordination (.554), Systematic inventory documentation (.507), On time informing material specification (.484), Acceptance of new technologies (.507), Proper planning (.551)
6	Purchasing (8 items)	Sufficient of raw materials in market (.725), On time delivery of materials (.712), Correct delivery as ordered (.693), Financial capabilities (.540), Acceptable quality of materials (.478), Correct in ordering (.576), Accurate in taking off (.483), On time in material procurement (.455)
7	Site storage & condition (6 items)	Enough of material storage (.667), Suitable location of site storage (.613), Satisfactory of site condition (.597), Accessible of site access (.559), Efficient function of site layout (.510), Uncrowded site (.491)
8	Supplier (5 items)	Materials supplied with pallet (.762), Constant demand of materials in market (.762), Sufficient of competent suppliers (.641), Equal materials control among suppliers (.639), Properly marked materials (.475)

5.0 Conclusions

In conclusion, the results of this analysis indicate that the influential factors have been explored equally in fulfilling the purpose of this factor analysis. The achieved purpose of this analysis with the number of items was reduced, the structure between variables and the construct validity have been examined. The outcome of this analysis is used in the main survey for a research project that aims to develop the effective materials management model.

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Appendix A

Bil	Influential Factors	[1]	[3]	[6]	[10]	[11]	[20]	[21]	[22]	[23]	[25]	[39]	[40]	[41]	[42]	[43]	[44]	[45]	[46]	[47]	[48]	[49]	[50]	[51]	[52]	[53]	freq.
1	Proper planning		√		√	√	√	√	√	√	√	√	√				√		√				√	√	√		15
2	Financial capabilities		√																							√	2
3	Adequate qualified & experience staff					√			√																		2
4	Efficient communication on site			√	√	√									√	√									√	√	7
5	Proper material usage		√												√												2
6	Efficient site management		√				√		√		√	√		√													6
7	Efficient coordination			√			√		√	√					√		√								√		7
8	Efficient supervision		√					√																			2
9	Systematic inventory documentation	√	√	√	√	√	√				√					√			√							√	10
10	Proper materials control		√	√							√			√					√								5
11	On time informing materials specification			√							√							√									3
12	Reasonable & systematic paperwork			√	√		√			√		√															5
13	Adequate IT infrastructure & application			√	√		√					√		√	√						√		√				8
14	Acceptance of new technologies						√																				1
15	Proper training on new technologies		√				√																				2
16	Sufficient of raw materials in market								√	√						√		√									4
17	Acceptable quality of materials																		√								1
18	Correct in ordering	√		√				√			√													√			5
19	Materials price in control		√		√														√								3
20	On time materials procurement	√		√				√			√			√	√			√						√		√	9

21	Accurate in taking off										√																1
22	Materials in good condition				√				√									√									3
23	Materials supplied with pallet																			√							1
24	Constant demand of materials in market					√																				√	2
25	On time delivery of materials	√		√		√	√	√		√	√				√	√	√	√				√				√	13
26	Correct delivery as ordered			√											√	√		√								√	5
27	On time in manufacturing					√			√																		2
28	Sufficient of competent suppliers						√					√														√	3
29	Equal materials control among suppliers					√																					1
30	Proper materials handling		√	√	√				√						√	√	√			√		√				√	10
31	Sufficient of suitable equipment for handling	√								√								√			√						4
32	Materials are not damage while handling															√		√		√							3

Appendix A (Cont'd)

Bil	Influential Factors	[1]	[3]	[6]	[10]	[11]	[20]	[21]	[22]	[23]	[25]	[39]	[40]	[41]	[42]	[43]	[44]	[45]	[46]	[47]	[48]	[49]	[50]	[51]	[52]	[53]	freq.
33	Functional of equipment																			√							1
34	Proper materials delivery to site		√		√		√													√		√			√	√	7
35	Easy movement for equipment			√		√			√	√							√					√					6
36	Efficient use of equipment while handling	√					√										√								√		4
37	Systematic flow of materials	√					√		√				√		√					√	√		√	√	√	√	11
38	Sufficient protection during unloading																			√							1
39	Properly marked materials								√						√							√			√		4
40	Suitable site storage			√							√			√			√			√	√	√	√				8
41	Enough of materials storage	√	√	√				√							√	√	√		√	√	√	√					11
42	Proper storing of materials														√		√					√					3
43	Materials stored near from working area									√						√											2
44	Accessible of site access		√														√										2
45	Satisfactory site condition										√																1
46	Efficient function of site layout																					√	√				2
47	Uncrowded site								√								√									√	3
48	Minimization in changes of materials specification										√								√								2
49	Minimization in changes of design							√	√																		2
50	Clear in materials specification			√						√									√								3
51	No discrepancy between specification & drawings															√								√			2
52	Materials meet specification																							√			1
53	Appropriate policy in materials procurement					√																					1
54	On time in custom clerance for imported materials					√																					1
55	Minimization in changes of government regulation																			√							1
56	No bureaucratic procedure					√																					1
	Total	8	13	16	9	12	13	7	13	9	13	5	2	5	12	10	11	8	8	10	5	9	5	6	7	12	
	Country investigated	Nigeria	Nigeria	Not specificed	India	Nepal	US	Nigeria	Turkey	Chile	Not specificed	US	India	India	Not specificed	India	UK	UK	Nigeria	UK	Not specificed	US	UK	Brazil	Denmark	Malaysia	