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Material Management Method and its Implication on Construction Project Performance: Case Study in Pulau Pinang

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Abstract: Construction industry such as building infrastructure, house development requires a huge number of materials use. Based on the growth population there is a great demand on the building materials and supply management. Proper material management methods are needed to ensure the construction projects run smoothly. The objectives of this study are to identify methods of reinforcement steel management and determine the impact of material management applied in the construction industry around Pulau Pinang. The researcher uses two methods of analysis, which is using the Statistical Package of Social Science (SPSS) and the Average Index Analysis method to support the analysis of data from the first method. Next, to obtain results and data, researchers use questionnaire survey methods that will focus on material management in the construction industry around Pulau Pinang. A total number of 109 questionnaires have been received from the research targeted respondents in Pulau Pinang. Based on the data that has been collected from the survey, the results have been successfully obtained by the researcher found that the respondents gave good feedback on materials management methods and impact on the construction industry. Thus, the results obtained from the study is that the application of proper materials management in construction project brought positives impact towards the construction progress such as improve in project and building performance, able to control cost of project from overrun, give easiness for workers to do works, avoid human error and communication issues in handling materials, prevent damage of materials and enhance collaboration with future client based on the previous project performance. Therefore, the objectives that have been listed by the researcher were successfully achieved. In conclusion, the study that has been conducted by the researchers can be classified as successful and this study can also help a little bit of people involved in the construction industry in improving the existing management methods to a better level.

Keywords: Materials Management, Reinforcement Steel, Construction Industry

1. Introduction

Materials managements is an importance character on completing a project within time given and to produce a better-quality performances of buildings structure. Every material that are used in construction projects have their own specific requirements according to the building's functions. Previous study stated that materials management is a role that greatly contributed in a project's progress that coordinates the preparation, assessment, procurement, transport, reception and review of specifications, storage, handling and management of goods, mitigating waste and maximizing profitability by reducing resource costs [1]. This paper will focus on the method of materials management especially reinforcement steel applied in construction industry and the effect of material management towards the project and building performance. Reinforcement steel is one of the common materials used in every construction project in Malaysia where the material work as a tensional device in reinforcement concrete to strengthen and aid the concrete of structure under tension. It absorbs the vibration of the earthquake for a few of time for the structure to collapse and people will feel sway alarm and they will find better place immediately. Any failure in the structure will brought to the high probability of buildings to collapse.

1.1 Importance of materials management.

Material management is a method of management that combines buying, shipping, and control of supplies from manufacturers. According to [2], material management defined as a system of preparing, implementing and monitoring the correct material supplier of the same consistency, at the right time and at the right location. So, the importance of material management in construction industry is basically to control the cost of project construction from overrun and to completed the project within the timeline. A good organization of material management also can increase the productivity in the site where the employees can complete a single work faster based on few factors such as the material availability and good organization for easy access of the materials. Due to the increase of productivity of the employees it results in a 5% reduction in project labour expenses [3]. Some of technologies were used by certain construction company in order to control the flow of the materials management in construction projects. The technology used is Radio Frequency Identification (RFID the bar-coding scanning system, Just-in-Time (JIT) concepts which to provide any materials that has been order according to the amount needed at the exact time it is needed, tracking materials while delivering and tracking in the site location using the Global Position System (GPS) and Geographical Information System (GIS) and the usage of Information and Communication Technology (ICT) to control the technologies used.

1.2 Effects of Material Management in Construction

A proper material management will bring many benefits towards construction projects where it will lead to a better financial flow progress in terms of expenses in construction materials. A study by [4] stated that loss of control over material management always leads to loss of control over building costs. Moreover, proper material management in construction project will also achieve the timely flow of the materials and equipment to the jobsite, allowing for better work face planning, higher worker productivity, better schedules, and lower project costs [5]. Material shortages lead to the delay in completion project time which give big impact to the construction project. Therefore, time is really important towards the contractor and developer to ensure the successful delivered of construction project. In addition, with the availability of the schedule, it also can monitor time of materials placement order and to tracking the purchases order to arrive at the construction site within the required time. A study stated by [6] most of the project failure are due to the failure of contractor to order the materials and equipment on time make the delays in project. The use of advance technology in the material management will allow to reduce the issues of planning, scheduling and managing the materials which faced by many of construction worker and help the contractors, site engineer, site supervisor and project manager to plan their construction project to have better progress of the projects.

1.3 Limitations and challenges in managing materials in construction projects.

Effective materials management in construction projects is a way to accomplishment of the projects in a positive way. Therefore, it is not excluded that materials management has its own challenges since

during the construction and post construction. The phase of buying and supplying materials, materials are not same with the requesting purchase, forgot to order materials, more or not enough materials, quickly or slowly of delivery time, absence of Just-in-Time (JIT) policy, absence of preparation and appropriate management, poor coordination and interactions between manufacturers, failure to order materials on time, delivery at the wrong address or at the wrong time, wrong materials or error in materials use requiring re-work are the problems which will drag the time of construction projects and supply chain companies are the main challenges [7]. According to [8], a temporary storage only will be provided due to the uncertain period between ordering and receiving materials. Besides of advantages on having storage in construction site, there will be some disadvantages. The existence of larger and proper storage will enable contractors to purchase further material needed and will receive materials before they are required, causing more inventory cost and chances of deterioration in quality.

2. Materials and Methods

The study focuses on the method used in reinforcement steel management by the company and the effect of material management applied in construction industry around Pulau Pinang area which are from Seberang Perai Utara, Seberang Perai Tengah, Seberang Perai Selatan, Timur Laut and Barat Daya. The researcher targeted about 100 respondents from the construction industry such as Engineers, Quantity surveyor, Contractors, Project manager and Site worker.

2.1 Materials

A questionnaire as a research tool are used by researcher to collect the data. The questionnaire has been divided into 4 parts. The Likert scale was used for respondents to answer the survey questions. Scale 1 to 5 is the measurement scale for respondents to the question posed. The format, wording and structure of the questions in the questionnaire should be considered before the questionnaire is distributed to ensure the reliability and sustained engagement of the respondents [9]. Part of questionnaire are following as:

- Section A: Background of respondents.

- Section B: Effect of construction material management methods in construction industry.

- Section C: Reinforcement steel management used by company.

- Section D: Barriers in implementing materials management in construction industry.

2.2 Methods of Questionnaire Development

Before the questionnaire was distributed randomly to the targeted respondents, the validity of the questions needs to be check or known as pilot study. The pilot study is basically a small scale or more precise is a 10% from real targeted number of respondents of the survey which allow the researcher to recognize questionnaire's weakness and remove unnecessary or unrelated questions in order to have a good question and relatable with the purpose of study. The Alpha Cronbach's coefficients were used to determine the internal accuracy of the queries. The alpha coefficients can be 0-1. The alpha coefficients that exceed 0.7 considered acceptable [9].

There were samples of 10 questionnaires distributed through google forms for the respondents performing pilot test. Any comments from the respondents will jotted down for the purpose of redesigned. Based on the results obtained from the pilot study, the data analyzed and the Alpha Cronbach's obtained in section B is 0.832 section C 0.655 which is acceptable, but only section D achieve 0.147 which is unacceptable. Therefore, some items in the section are redesigned and some have been removed due to the respondents not responds to the items and the result of Alpha Cronbach's obtained after the redesign is 0.724 which is acceptable for the section D.

2.3 Methods of Questionnaire Distribution and Collection

Next, after the questionnaire had been redesigned the actual survey were distributed around Pulau Pinang region to the targeted respondents. The researcher targeted about 100 respondents from the

construction industry such as Engineers, Quantity surveyor, Contractors, Project manager and Site worker. At first, the researcher used online platform as the main method of data collection. The questionnaires are distributed through the company email. The results and respond of the first method of distribution are not as expected. Therefore, the researcher used manual distribution method which is distribute hardcopy of questionnaire from company to company and the results gain from this method are much faster. The questionnaires were manually distributed around Pulau Pinang region and mostly around Seberang Perai Utara since crossing other regions are not allowed by government due to the Pandemic Situation of Corona Virus Diseases (COVID-19). The collected questionnaires from the survey obtained 115 surveys but only 109 surveys were accepted.

2.4 Methods of Data Analysis

Based on the respond obtained from the questionnaire, the data were analysed by using the Statistical Package for the Social Science (SPSS) software and Average Index Analysis based on Likert scale method. The analysed data from the SPSS software are included Frequency of respondents, percentage, Mean, Mode, Median and graph for each statement. These two methods were used due to the easiness in calculating data of the survey and simple to be used [10].

The first method used is descriptive analysis using the SPSS software. This method used to show the percentage data and figure which will be much easier to look and to be understand by researcher and the reader. The Statistic used in this study is Mean Score, Mode, Median and percentage. The results from the analysis of the Likert Scale question using the descriptive analysis to determine whether the respondents are Strongly Agree or Strongly Disagree with each of the item. According to [10] stated that Mean Value that achieve more than 3 are relevant and below than 3 are not relevant.

Next method used is average index analysis which to support the result of analysis data from the SPSS software. The value of the Average Index (AI) analysis achieved by using the formula given will refer to the Table 3.6 the range scale of class to make sure whether the respondents are Strongly Agree or Strongly Disagree with each of the statement.

2.5 Equations

Below is the equation used to determine the Average Index for each item of the Likert Scale components:

$$Average\ Index\ (AI) = \frac{\sum(ai.xi)}{\sum xi} \quad \text{Equation 1.0 [10]}$$

Where:

x_i = number of respondents agreeing with a choice

a_i = score at I (Likert scale)

i = 1,2,3,4,5

The class of Average Index (AI) scale using the 5-point scale of scale was mentioned as below:

Table 1: The Table shows the class of Average Index (AI) scale that are calculated using the formula given [10]

No.	Rating Answer	Range value
1	Strongly Disagree	1.0<AI>1.5
2	Disagree	1.5< AI>2.5
3	Neutral	2.5< AI>3.5
4	Agree	3.5< AI>4.5
5	Strongly Agree	4.5< AI>5.0

3. Results and Discussion

3.1 Descriptive Analysis

Based on the study data obtained through 109 respondents, Table 2 shows 60.6% of respondents are male and 39.4% of the respondents were female. The highest function of company was in contractor firms which is 46.8% (56 respondents) than other firms. as for education level, it is 57.8% which is 63 respondents with Bachelor's degree holders and follow with others. Then for current designation highest frequency is Engineers with 47.7% (52 respondents) than other designation. The working experience are mostly below 10 years of experience which is 46.8% of 1-5 years' experience and 28.4% of 6-10 years' experience and follow with others. most of the respondents' company office-based location is located in Seberang Perai Utara, Pulau Pinang which have 55% (60 respondents) and follow with other areas. The highest frequency of company's CIDB grade is No limit or G7 which has 62.4% (68 respondents) and follow with other grades. Next for current project cost approximation is 50.5% which is 50 respondents of cost over MYR 10,000,001 and follow with other cost of project. Then for the percentage cost of Reinforcement Steel is majority of the respondents which collected 52.3% (57 respondents) has 21-40% cost of reinforcement steel over the total cost of project.

Table 2: Respondent Demographic

Item	Frequency	Percentage (%)
A1. Gender		
Male	66	60.6
Female	43	39.4
A2. Function of company		
Developer	28	25.7
Consultant	30	27.5
Contractor	56	46.8
A3. Education level		
Doctor of Philosophy (PhD)	1	0.9
Master's Degree	15	13.8
Bachelor's Degree	63	57.8
Diploma	28	25.7
Other	2	1.8
A4. Current designation		
Directors	4	3.7
Managers	11	10.1
Engineers	52	47.7
Quantity surveyors	27	24.8
Other	15	13.8
A5. Total working experience		
1-5 years	51	46.8
6-10 years	31	28.4
11-20 years	21	19.3
above 21 years	6	5.5
A6. Office based location in Pulau Pinang		
Seberang Perai Utara	60	55.0
Seberang Perai Selatan	15	13.8
Seberang Perai Tengah	25	22.9
Timur Laut	5	4.6
Barat Daya	4	3.7

Table 2: Respondent Demographic (Continuous)

Item	Frequency	Percentage (%)
A7. Level of company's (CIDB) grade		
<200,000 (G1)	0	0
<500,000 (G2)	6	5.5
<1,000,000 (G3)	6	5.5
<3,000,000 (G4)	4	3.7
<5,000,000 (G5)	12	11.0
<10,000,000 (G6)	13	11.9
No Limit (G7)	68	62.4
A8. Current project cost approximation		
10,000 - 200,000	0	0
200,001 - 500,000	5	4.6
500,001 - 1,000,000	4	3.7
1,000,001 - 3,000,000	4	3.7
3,000,001 - 5,000,000	15	13.8
5,000,001 - 10,000,000	26	23.9
10,000,001 - No limit	55	50.5
A9. Percentage cost of Reinforcement Steel		
5%-10%	6	5.5
11%-20%	23	21.1
21%-40%	57	52.3
41%-60%	23	21.1

Table 3 shows the Average Index analysis of the items for section the effect of construction material management methods in construction industry. For items B1 it shows the average index analysis is 4.68 which is based on Table 1 is strongly agree with the statement, next is B2 statement is 4.55 which also strongly agree with the statement, then for B3, B4, B5 and B6 has 4.35, 4.36, 4.24 and 4.31 respectively of average index which is agree with the statements. Therefore, it can be concluded that majority of respondents are agree with the statements of item B1 to B6 about the construction material management methods applied in construction industry in Pulau Pinang will affect the construction project itself.

Table 3: Average Index analysis of the items for section the effect of construction material management methods in construction industry

Effects of materials management in construction industry	Frequency, ai					Total $\sum xi$	Average Index (AI) value
	1, xi	2, xi	3, xi	4, xi	5, xi		
B1. Improved working performance and work quality.	0	1	3	26	79	109	4.68
B2. Able to control the cost of project from overrun.	0	0	0	49	60	109	4.55
B3. Many works can be done in a day with the proper material management.	0	0	9	53	47	109	4.35
B4. Able to avoid human error in construction project.	0	0	9	52	48	109	4.36

	1	2	3	4	5		
B5. Able to avoid communication issue.	0	1	14	52	42	109	4.24
B6. Able to enhance collaboration with future client based on company performance.	0	0	14	47	48	109	4.31

Table 4 below shows the method that used for reinforcement steel management by construction company in Pulau Pinang. the respondents allow to choose the methods more than one method since different type of construction project use different type of material management. The most and frequently used method is to provide storage for the reinforcement steel has 76 respondents then follow with bulk purchase from the supplier 64 respondents, then 51 respondents order gradually from the supplier, 41 respondents used JIT method, follow with 30 respondents used RFID technologies and 12 respondents used GPS and GIS system.

Table 4: Method of reinforcement steel management used by construction company in Pulau Pinang

Material management method used by company	Frequency
1. Just-in-Time (JIT) method	41
2. Provide storage to store the reinforcement steel.	76
3. Bulk purchase from the hardware store or supplier of the reinforcement steel.	64
4. Order gradually from the supplier of the reinforcement steel.	51
5. Radio Frequency Identification (RFID)	30
6. Geographical Positioning System and Geographical Information System (GPS and GIS)	12
7. Other	0

Table 5 below shows the Average Index (AI) Analysis effect of reinforcement steel management used in construction company. The result of Average Index (AI) value for item C2 was 4.35 agree, C3 was 4.20 agree, C4 was 4.28 agree and C5 was 4.06 agree. Therefore, it can be concluded that majority of respondents are (Agree) with the statements of item C2 to C5 about the effect of reinforcement steel management methods applied in construction industry in Pulau Pinang.

Table 5: Average Index (AI) Analysis effect of reinforcement steel management used in construction company

Effect of reinforcement steel management used in construction company	Frequency, a_i					Total $\sum x_i$	Average Index (AI) value
	1, x_i	2, x_i	3, x_i	4, x_i	5, x_i		
C2. Able to improve project performance?	0	0	10	51	48	109	4.35
C3. Able to improve building performance?	0	0	9	69	31	109	4.20
C4. Able to give ease for workers to do their works?	0	0	14	50	45	109	4.28

C5. Can prevent Reinforcement Steel from rust or damage?	1	4	15	56	33	109	4.06

Next for item C6 is to determine whether the company reused the unused steel reinforcement steel from past or previous projects, where 71 respondents (65.1%) admit with the statement. Meanwhile, the other balance of 38 respondents (34.9%) denied the statements.

Table 6: Frequency and percentage (%) of company reused the unused reinforcement steel from past or previous projects

C6. Does the company reuse the unused reinforcement steel	Frequency	Percentage (%)
Yes	71	65.1
No	38	34.9

Based on item C6 in Table 6 the level condition of the reinforcement steel will be rate by respondents that reused the unused reinforcement steel from previous project. Therefore, the average condition level of reinforcement steel that has been used as shown in Table 7 is 3.60 which in good condition level.

Table 7: Average Index (AI) Analysis condition level of reinforcement steel that have been reused for the construction

Items	Frequency, ai					Total $\sum xi$	Average Index (AI) value
	$1, xi$	$2, xi$	$3, xi$	$4, xi$	$5, xi$		
C7. If YES, indicate the condition level of the Reinforcement Steel that have been reused for the construction.	0	3	30	31	7	71	3.60

Next is the barriers in implementing materials management in construction industry. The average index of respondents responds to the barriers in implementing materials management in construction industry is shown in Table 8 below. The result of Average Index (AI) value for item D1 was 4.13 agree, D2 was 4.26 agree, D3 was 3.97 agree, D4 was 3.94 agree and D5 was 3.76 agree. Therefore, it can be concluded that majority of respondents are agree with the statements of item D1 to D5 about barriers that caused material management are difficult to be applied in construction industry in Pulau Pinang.

Table 8: Average Index (AI) Analysis of barriers in implementing materials management in construction industry

Barriers in implementing material management in construction industry	Frequency, ai					Total $\sum xi$	Average Index (AI) value
	$1, xi$	$2, xi$	$3, xi$	$4, xi$	$5, xi$		
D1. Limitation of cost in implementing the material management.	0	6	20	37	46	109	4.13
D2. The ordered construction materials arrived not on time	2	2	7	53	45	109	4.26
D3. Lack of general knowledge about the material management method	0	4	25	50	30	109	3.97
D4. Lack of knowledge about the current technology used in material management	0	3	31	44	31	109	3.94
D5. There is no enforcement from client or consultant	2	11	26	42	28	109	3.76

4. Conclusion

After all the data obtained from the survey that has been conducted by using the questionnaire and had been analyses in the previous chapter, it can be concluded that all the objectives of the study have been achieved. The data of average index analysis collected for section C allows the first objective to be achieved where the material management for reinforcement steel applied by the company give positive effect in the construction project progress. The failure of the building structure reported are mostly due to the failure of reinforcement steel structure and building materials. Therefore, the purpose of this section to collect the information about the method of reinforcement steel management that used by the construction company in Pulau Pinang and the effects of the methods towards the construction.

Based on the selection of reinforcement steel management used by their company, the respondents are asked to rate the level of effectiveness of the method. Therefore, the results of average analysis for the ability of method chose to improve the project performance is 4.35, then for the ability of the method chose to improve building performance is 4.20, then for the ability of method chose to able give ease for workers to do works is 4.28 and lastly for the ability of method chose in prevent it from rust or damage is 4.06. Therefore, it can be concluded that each method chose by the company for reinforcement steel management may give positive impact for construction at the quality of material itself.

Then for item C6, the respondents were asked whether the company reused the unused steel reinforcement steel from past or previous projects which have about 65% to 35% of respondents say yes and no respectively. Therefore, based on the data collected, the 65% of the respondent need to rate the condition level of the reinforcement steel that had been reused by their company which the results of the average condition level are in value of 3.60 which are averagely in good condition level.

Next, the data of average index analysis collected for section B allows the second objective of this study to be achieved where the effect of material management application in construction industry caused the positivity effect in the construction project progress where the material management are really important to be applied by the construction firm where proper material management applied at the construction site will bring many benefits to the construction project such as able to control the cost of project from overrun, completing the project within the timeline, able to increase the productivity on the site and can protect the quality of materials to be in the best shape before used in in the construction.

Based on Chapter 4, average index analysis of material management can improve work performance and quality is 4.68, follow with material management able to control cost of project from overrun is 4.55, then average index for many works can be done in a day with proper material management is 4.35, average index for material management able to avoid human error and communication issue is 4.36 and 4.24 respectively. Lastly average index for item material management able to enhance collaboration with future client based on the company performance is 4.31. The data of average index analysis collected for this section allows the first objective to be achieved where the effect of material management application in construction industry caused the positivity effect in the construction project progress.

Acknowledgement

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