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Evaluation of Material Request Order to Support Sustainable Construction

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Abstract

This study was conducted on one of Indonesia's apartment projects, in which reinforced concrete is the main structure. Based on existing project data, this project experienced a decline in the construction work's progress, thus reducing the project's overall progress. This decline occurred because the delivery of concrete reinforcement material was delayed. This study aimed to determine the process of material request order and its relationship with the work implementation, as well as the factors that influenced the delayed arrival of concrete reinforcement material at the project site. The method used in this study was observation and interview. Data were analyzed by comparing the conditions in the field with the standard operating procedure. Analysis results revealed that the material request order process in this project was implemented excellently, and it followed the existing standard operating procedure. However, material request orders were delayed due to several factors, such as an increase in material price, lack of coordination/communication, and weather disturbances. The results of this study can be used to improve a company's performance in terms of achieving sustainable construction.

Abstrak

Evaluasi Permintaan Pemesanan Material untuk Mendukung Konstruksi Berkelanjutan. Penelitian ini dilakukan pada salah satu proyek apartemen di Indonesia, di mana beton bertulang merupakan struktur utamanya. Berdasarkan data proyek yang ada, proyek ini mengalami penurunan progres pekerjaan konstruksi, sehingga menurunkan keseluruhan progres proyek. Penurunan ini terjadi karena pengiriman material tulangan beton yang tertunda. Penelitian ini bertujuan untuk mengetahui proses permintaan pemesanan material (*material request order*) dan hubungannya dengan pelaksanaan pekerjaan, serta faktor-faktor yang mempengaruhi keterlambatan kedatangan material tulangan beton di lokasi proyek. Metode yang digunakan dalam penelitian ini adalah observasi dan wawancara. Data dianalisis dengan membandingkan kondisi di lapangan dengan prosedur operasi standar. Hasil analisis mengungkapkan bahwa proses permintaan pemesanan material dalam proyek ini dilaksanakan dengan sangat baik, dan mengikuti prosedur operasi standar yang ada. Namun, permintaan pemesanan material tertunda karena beberapa faktor, seperti kenaikan harga material, kurangnya koordinasi/komunikasi, dan gangguan cuaca. Hasil penelitian ini dapat digunakan untuk meningkatkan kinerja perusahaan dalam hal mencapai konstruksi berkelanjutan.

Keywords: concrete reinforcement, material request order, standard operating procedure

1. Introduction

Infrastructure development requires the support of resources, including construction materials and equipment, whereas, distribution requires transportation and warehousing systems. The entire process forms a supply chain that involves various stakeholders [1]. Supply chain management (SCM) has become a way to influence competitiveness and improve the performance of construction companies. SCM forces companies to become more responsive and hence are expected to respond quickly, effectively, and efficiently to market changes [2]. SCM's philosophy stems from just-in-time production and logistics in manufacturing. The material management context emphasizes cooperation among

project participants to organize the material, cost, and flow of related information [3]. Therefore, SCM has three dimensions that must be noticed, i.e., material, financial, and information [4], and the following are the five standard operating procedures (SOP) that are related to SCM [5, 6]: (a) Receiving of Finished Goods from Supplier; (b) Delivery of Finished Goods to Customers (third party's warehouse); (c) Delivery of Finished Goods to Customers (Outbound); (d) Receiving of Finished Goods (Inbound); (e) Receiving of Finished Goods (Imported).

The concept of sustainable construction is also one solution that emphasizes the wise use of resources (especially natural or material resources). The concept

must be implemented continuously to ensure that future needs of material resources are met systematically, so recycled materials must be used in the field [7]. The concept of sustainable development for sustainable buildings must integrate the environmental, economic, and social aspects during the planning process, construction implementation, and maintenance operation of the environment, including the management of material sources and construction waste [8]. For example, sustainability indicators and sub-criteria in selecting concrete materials consist of technical, environmental, social, and economic factors [9, 10]. These indicators can be used to select the best sustainable construction material for selecting concrete [11].

Material is an essential component in determining the cost of a project. Material management is defined as a management system needed to plan and control material quality, material quantity, timely placement of equipment, good prices, and quantities according to needs. Material management is also a system that coordinates activities to plan and supervise the volume and time of material request order through receipt/ acquisition, change of shape and movement of raw materials, materials in process, and finished materials [12].

The material request order of a construction project is complicated. Thus, various types of materials from multiple sources must be appropriately managed [13]. The supply of materials to the project site is something that must always be maintained, and project activity must not be obstructed due to waiting for the arrival of the material. The material delay can have a remarkable effect on the project schedule, especially for large-scale projects that use a large workforce. If the arrival of materials is not under the material request order schedule, then many workers can become unemployed, resulting in delays in project completion time and project cost overruns. Construction materials include all materials needed to complete parts of the work in one construction process unit. Material management can define an organizational approach to solving material problems and thus requires a combination of managerial and technical capabilities [14, 15].

Research has been conducted in several countries. One of them explains the logistics management at construction in Abuja, Nigeria. This study revealed that the influencing factors of material management include the purchase of materials at the construction site, the accuracy of the delivery of materials, the challenges during material distribution, the benefits of shipping materials at the construction site, and the method of forecasting demand for materials at the construction site [16]. The most important cause in Brunei's material supply is the shortage of materials, relating to the origin or availability of construction materials. By contrast, the most influential cause of delay

in material supply is poor material procurement and inventory management system, e.g., late identification of the type of materials needed [17].

The waiting time for an order includes the time from when the order is placed until the order enters the warehouse. Factors that influence waiting time are as follows [14, 18]: (a) Material production process at the supplier; (b) Process of payment by contractors; (c) Availability of space for material placement; (d) Material request ordered by the project owner; (e) Increase in material prices

In addition, five factors that cause delays in the arrival of project materials are material, human, method, machine, and environmental factors. The other inhibiting factors include priority, needs, economy, maintenance, alternative goods, and services, as well as several other criteria [19]. By contrast, several improvement programs are also obtained using technical approaches, and material request order activities [20]. Similarly, efficient use of technologies can ensure accurate and effective synchronization of material flow processes [21].

Material mobilization is another factor that causes project delays. A previous study showed that the factors that cause delays in construction projects include labor availability (in relation to the contractor) and material mobilization (in relation to the owner and supervisor consultant [22]). Possible constraints during project implementation can also occur due to poor management, inappropriate resources and methods, the influence of the company's financial condition, and the environment in which the project is implemented. These factors affect time performance, thus causing delays in construction project work; it is also indirectly detrimental to the project owner or contractor [23, 24]. The availability and comprehensiveness of the operational, administrative, methodological, and safety management of material resources lead to the standard control of the production process' material costs [25], [26].

Based on all the previous explanations, material management is one of the most important things that support a company's performance in achieving sustainable construction. According to existing apartment project data, which are chosen to be the object of this research, a decrease in the reinforcement work progress of approximately 1.75% affects a project's overall progress in the 17th week (5.15%). This decrease occurs because the delivery of reinforcement material is delayed. Therefore, the timeliness of the material management process has become something that needs special attention. This study aims to determine the process of material request order and its relationship with the implementation of work, as well as the factors that influence the delayed arrival of concrete reinforcement material at the project site.

2. Methods

The data collection method used is observation and interview. Table 1 presents the indicators of the steps of material request order; these indicators are used as reference in this study.

The observation method was accomplished by identifying processes and documents, i.e., monitoring material arrival, daily reports, and the S curve. The steps of data processing are as follows: (a) Grouping data on material arrival; (b) Grouping work item data, and (c) Making a breakdown of the s curve.

Table 1. Indicators of Material Request Order Procedures

No	Indicators	Descriptions	References
1	Compilation of requisition	The purchase request list comes from the production department or other parts that require specific materials or goods. Also included in the list of requests are suppliers and suggested prices.	[11], [12], [14]
2	Preparation of material specifications required and the volume	It is in the bill of materials created.	[11], [12], [14]
3	Selection and identification of suppliers	The selection of suppliers must be examined in terms of a. contract against required orders, b. classification of items purchased, and c. supplier record or history	[5], [14]
4	Appropriate pricing	The supplier selection uses a simple bid analysis form to help analyze bids. It is also seen from the price list or through negotiations.	[12], [14]
5	Preparation of a purchase order	Purchase orders are prepared from the purchase request list and other additional required information. A copy of the requisition is sent to the supplier.	[12], [14]
6	Follow-up and acceleration of orders	If the delivery date is uncertain, the buyer must be notified in time to take corrective action, consider transportation and alternative sources, work with other suppliers to solve problems, or reschedule production.	[12], [14]
7	Material acceptance and inspection	Material inspection is implemented on previously placed orders that have arrived. goods that arrived in good condition. the number of orders received; storage, inspection, or use of material. appropriate acceptance documentation that is registered and forwarded to the appropriate parties.	[12], [14], [22]
8	Approval of supplier invoices for payment	Before the supplier's invoice (bill) is sent to the finance department for payment, an examination of the following is required: a. purchase order b. acceptance report c. bill	[5], [14]
9	Payment realization	The method of payment is implemented, following the agreement previously agreed on the contract.	[14], [23], [24]
10	Preparation of reports on request order activities	Request order records that must be kept include purchase order (PO) log. PO file, containing copies of all POs (submitted numerically). commodity file (date, supplier, quantity, price, and PO number). supplier history file. Employment contracts, which provide the union contract status (expiration date) of all major suppliers. Records, which show equipment purchased, useful life (or quantity of production) of usage history, price, ownership, and location. Minor and small business purchases, showing dollar purchases from the suppliers. Bidding history file	[11], [12], [14]

The interview method was conducted with the project manager and two other staff members to clarify and check the real data. Both methods were chosen to reach the valid data in this research.

Data were analyzed by comparing the field conditions with the standard (Table 1). Data analysis continued by giving an assessment score to each indicator. This scoring was accomplished to find out the implementation level of material request order compared to the standard [27, 28]. The scoring criteria are as follows:

- Score 1 : Procedures available, forms unavailable, documentations unavailable, not implemented
 Score 2 : Procedures available, forms unavailable, documentations unavailable, implemented 20%–less than 40%
 Score 3 : Procedures available, forms available, documentations unavailable, implemented 40%–less than 60%
 Score 4 : Procedures available, forms available, documentations available, implemented 60%–less than 80%
 Score 5 : Procedures available, forms available, documentations available, implemented 80%–100%

In accordance with four categories presented in Table 2, the scoring results were summarized and averaged for stating the material request order process regardless of whether it is implemented in accordance with the standard and SOP or not.

After the evaluation category was determined, it was evaluated for the work implementation related to the material request order schedule, especially the one related to the arrival of the material. The references found factors that influence the material request order of construction projects. The factors used as research variables are presented in Table 3.

Table 2. Category of Material Request Order Process Assessment [27, 29, 30]

Value Interval	Category
1.0–2.0	Poor
2.1–3.0	Fair
3.1–4.0	Good
4.1–5.0	Excellent

Table 3. Aspects of Material Request Order Problems

No	Aspects	Material Request Order Problems	References
1	Activities	Activities that are faster than the schedule Activities that finished too fast	[13], [22]
2	Engineer	Delays to the approval of drawings or material samples	[22], [23]
3	Supplier	Material returned because the quality did not match with specifications Difficulties in transportation Manufacturing process leads to jammed production	[9], [12], [22]
4	Contractor	The supplier holds material from the contractor because of payment Lack of coordination and communication between divisions related to the material request order process Loss or broken material because of the handling process and less storage well Quality of material request order staff Lack of material request order staff	[14], [23], [24].
5	Nontechnical	An accident occurs during material delivery Labor strike or transport Weather disturbance Natural disaster The project owner regulates the material request order.	[22], [23]

Table 3 was used as variables to determine the influence factors in the project’s material request order using the Guttman scale in the form of a checklist (yes/no). This checklist is based on evidence obtained from the observation and interview processes.

3. Results

Based on the comparison between the observations and evidence in the field about the process of material request order in this project and the material request order process in Table 1, the results reveal that the company makes a bill of demand before creating a material request order: (a) The receipt reflects specifications and the amount of material needed. (b) The company chooses one of three suppliers that submit bids. (c) The selection of suppliers following compared the criteria. (d) After the logistics and suppliers agree with the price, a contract is made in the form of a purchase order (PO) bill. (e) Material is sent by the supplier on the basis of the PO bill, and a delivery order is made. (f) The material acceptance department checks the material that arrives by using the PO receipt and the delivery permit. (g) The company makes payments in accordance with procedures and agreements with suppliers. (h) Payments between the company and the vendor are realized, following the contract. (i) The company keeps a record of material request order activities after the contract has closed.

The observation and interview results of the evaluation, as well as the application of material request order procedures in this project, are summarized in Table 4.

Table 4. Results of the Assessment of Material Request Order Procedures

No	Material Request Order Steps	Scoring
1	Compilation of requisition	5
2	Preparation of material specifications required and the volume	5
3	Process of selecting and determining suppliers	4
4	Appropriate pricing	4
5	Preparation of a PO	5
6	Follow-up and acceleration of orders	5
7	Material acceptance and inspection	5
8	Approval of supplier invoices for payment	4
9	Payment realization	3
10	Preparation of reports on request order activities	4
Average Score		4.4

Based on the category of material request order process assessment (Table 2, the average score in Table 4 shows that the material request order procedures for this project had been carried out in the excellent category and following the existing SOP. Although the material request order process in this project was implemented excellently, the material request order process and implementation of work on the project still experienced delays. Table 5 describes the deviation of work progress.

Table 5 shows that the progress of reinforcement work continued to decline starting from the 12th week, and the same condition occurred on overall progress work, which also continued to decline and began to experience delays in the 13th week (the week after the reinforcement progress has decreased). Reinforcement work is closely related to the overall project progress. Thus, reinforcement work indirectly affects the implementation of other work in the field. This occurred because weather on the 10th week was not good; thus, workers could not work for one day. Therefore, the installation of formwork was also delayed, affecting the progress of the reinforcement work and the overall project.

In addition, on the 14th week, the arrival of concrete reinforcement material was delayed due to bad weather conditions, resulting in a decreased deviation of the reinforcement work’s progress. This result is supported by a memo issued by a Construction Management (CM) Consultant, explaining that a delay in the delivery of concrete steel material occurred in Week 15. The material request order process at this apartment project went excellently, but problems in the material request order process occurred. Based on the interview with the Construction Manager and Consultant, explaining the several factors that influence the concrete reinforcement material request order referred to Table 3 can be explained in Table 6.

Table 5. Deviation of Work Progress from the 10th to 17th Week

Weeks	Deviation	
	Reinforcement Work	Overall Works
10	3.01%	2.14%
11	3.18%	1.38%
12	2.72%	0.46%
13	1.59%	-0.49%
14	0.40%	-1.99%
15	-0.26%	-2.85%
16	-1.34%	-4.31%
17	-1.75%	-5.15%

Table 6. Evaluation of Problems in the Material Request Order Process

No	Aspects	Material Request Order Problems	Situation on Project		Descriptions
			Yes	No	
1	Activities	Activities that are faster than the schedule	√		Based on the progress of the work, the project is delayed.
		Activities that finished too fast		√	No activity is quickly completed on the basis of the progress of the work. The project is delayed.
2	Engineer	Delays to the approval of drawings or material samples		√	No proof of approval delay
		Material returned because the quality did not match with specifications		√	No evidence of material return is available.
3	Supplier	Difficulties of transportation		√	No proof of delay of material delivery due to transportation
		The manufacturing process leads to jammed production		√	No evidence of error at the time of production
4	Contractor	The supplier holds material from the contractor because of payment		√	The price of concrete reinforcement material at that time has increased so that the project must make price adjustments to avoid considerable losses.
		Lack of coordination and communication between divisions related to material request order process		√	It resulted in the CM Consultant issuing a field memo because some work did not go according to plan.
5	Nontechnical	Loss or broken material because of the handling process and less storage well		√	No evidence of material damage
		Quality of material request order staff		√	No evidence that the quality of staff is not good
5	Nontechnical	Lack of material request order staff		√	No evidence of lack of staff
		An accident occurred during material delivery		√	No evidence of accident while shipping material
5	Nontechnical	Labor strike or transport		√	No evidence that a labor strike occurred
		Weather		√	Weather conditions at that time were not good.
		Natural disaster		√	No evidence of natural disaster during the project
		The project owner regulates the material request order		√	No evidence of material request order arranged by the project owner

Table 6 shows three factors that influence the material request order in this project.

- a. The supplier holds material from the contractor because of payment. The supplier intended to hold the material until the contractor has paid the previous order payment due to an increase in material prices. Based on interviews on logistics and progress, the price of concrete reinforcement fluctuated due to the rise in dollar value. This fluctuation resulted in the delay of delivery of concrete reinforcement materials because price adjustments had to be made to avoid large losses. Figure 1 shows the fluctuation data of concrete reinforcement prices from the second to the 16th week.

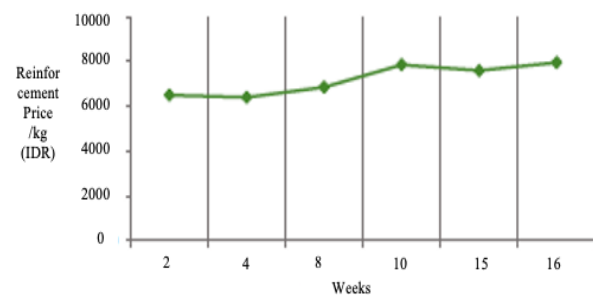


Figure 1. Fluctuations in Material Prices from the 2nd to 16th Week

Table 7. Indicators of the Lack of Coordination and Communication

No	Coordination and Communication among Divisions	Implemented		Descriptions
		Yes	No	
1	Direct contact between individuals who can increase the effectiveness and efficiency of work		√	The logistics department should first check the availability of concrete reinforcement material
2	A liaison that handles communication between departments to reduce the length of the communication channel		√	Should there be a delay in the arrival of the concrete reinforcement material, a notification letter is sent by email between the contractor, subcontractor, supervisory consultant, and owner.
3	Integration of roles		√	A role needed in continuously monitoring the availability of materials, as well as vendors who will provide material supply.
4	Scheduled meeting	√		At the weekly meeting, the contractor should notify about the arrival of concrete reinforcement material.

Figure 1 illustrates the reinforcement price fluctuations that caused project delay. This factor is related to the supplier factor, as in the previous research (Table 3).

b. Lack of coordination and communication between divisions related to the material request order process. Observation results in Table 6 reveal that lack of communication and coordination among divisions resulted in suppliers (vendors) being late at the time of delivery, as evidenced by a memo issued by the CM Consultant on the 15th week. This lack of coordination and communication is presented in Table 7.

Table 7 depicts that coordination and communication among divisions have been implemented except in unscheduled meetings affected by the lack of communication and coordination among Divisions. This factor includes aspects of material request order problems from the contractor (Table 3), which are lack of coordination and communication between divisions related to the material request order process.

c. Weather. Based on the previous explanation (i.e., bad weather occurred on the 10th week), weather problems have become one of the factors causing construction work to decline in progress. This factor affected Week 15; reinforcement work was also delayed or had a negative deviation (Table 5). Figure 2 shows a weather recapitulation from the 10th to the 17th week.

Figure 2 reveals that unstable weather causes the declining progress of reinforcement work. This factor is related to nontechnical factors, as in the previous research (Table 3).

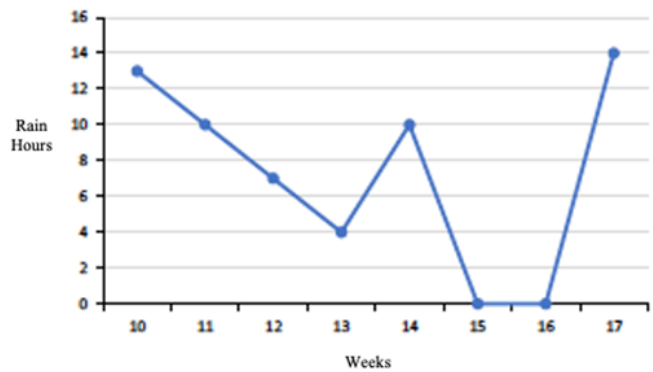


Figure 2. Weather Conditions from the 10th to 17th Week

4. Conclusions

The material request order procedure of the apartment project selected in this study was implemented excellently and followed the existing SOP. However, the material request order still experienced delays due to factors that influence the material request order process. In addition, the material request order indirectly affected work implementation, indicating that construction work has decreased, resulting in delays in implementing the overall project. Three factors that affected the request order for reinforcement concrete material of the selected project include the price increase in concrete reinforcement material, lack of coordination and communication, and weather disturbance. Further research can be conducted on several projects and a wider area to obtain additional data and capture the construction sector’s real situation.

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