

A DECISION SUPPORT MODEL FOR PROCUREMENT OF REUSABLE MATERIALS IN MULTIPLE PROJECT MANAGEMENT

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ABSTRACT : To compete with large construction companies whose dominance in market share is deepening recently, the needs for improving field production system of mid-size construction companies have increased rapidly. The development of an adequate model that focuses on the organizational size and work process of the mid-size construction companies are needed to increase productivity through the informatization in the construction industry[0]. The authors of this study used case studies on the problems of the mid-size construction companies in procuring work and presented a method to solve such problems so that the managers in head office of those mid-size construction companies can effectively deal with multiple sites[0].

Key words : Decision Support Model, Procurement, Multiple Projects Management, Reusable Material

1. INTRODUCTION

Unlike large-size construction companies, the mid-size construction companies manage 5 to 15 sites in the company's head offices mainly based on individual field management systems. How to increase the efficiency in multi-site management is an important factor in success or failure in the construction business. The mid-size construction companies currently manage multiple sites in a single field operation mode. Thus, the workload is relatively large, compared to a unit construction site. In addition, the demand for a method to solve such problems is gradually increasing.

To efficiently operate multiple sites, a rational method that can support a decision making process for material procuring work which account for approximately 40% of the total construction cost is required, simultaneously considering multiple sites in terms of reusable material. The purpose of this study is to present a decision support model for material procurement, which considers multiple sites simultaneously from the aspect of reusing material, so that objective and systematic material procurement can be achieved.

This study targeted reusable material, including common installation material, fixtures and furnishings, tools, experimental instruments, equipment, other furniture and office supplies that are used during the construction project for a certain period of time. They are removed when the construction is complete, and reused at other construction

sites. For the purpose of this study, "Procurement" is defined as "the plan for the reusable material, material request and procurement, material transportation management, use and inventory management, and material purchase while managing the purchase of the materials." The decision support model in procuring reusable material enhances efficiency in procurement system through an economic analysis in project information and delivery schedule of individuals material in the multiple sites, considering the transportation cost, from the installation of the construction site until the completion.

The major findings in this study are as follows.

1) The problems of procurement for reusable material through case studies are identified. 2) The basic concept of a support model of decision-making for material procurement to solve the problems in procurement is provided. 3) A decision support model for procurement of reusable material is developed, which focuses on the basic concept, as described.

2. ANALYSIS OF REUSABLE MATERIALS PROCUREMENT SYSTEM

To identify the current procurement system of reusable material which is directly purchased by the head office in order to reuse in the multiple sites for a certain period, the authors conducted case studies by visiting mid-size construction companies, ranked between 40th and 100th in terms of an appraisal of the companies' execution capacity

by Korean government in 2003(see table 1). Most of them were active in doing business for residential building.

	Participant company & Interview Content			Case study method & Content	
	Company W	Company D	Company S	Interview staff in charge of procurement in the head office	Case study method & Content
1st Case Study	July. 19. 2003.	July. 21. 2003.	July. 24. 2003.	Interview staff in charge of procurement in the head office	Status of reusable materials · characteristics of reusable · kinds of reusable materials
2nd Case Study	Aug. 02. 2003.	Aug. 05. 2003.	Aug. 09. 2003.	Interview staff in charge of procurement in the head office and site	· Procurement process of each reusable materials · finding out information each phase of process
3rd Case Study	Aug. 16. 2003.	Aug. 18. 2003.	Aug. 22. 2003.	Interview staff in charge of procurement in the head office	· Decision marking status on performing procurement

Figure 1. Case studies overview

2.1 Characteristics and Types of Reusable Material

In most cases, reusable material is considered insignificant in material management, because of a perception that these are temporary material and equipment. Reusable material have the following Characteristics.

- 1) The head office of a construction company, not in the field, purchases and manages reusable material.
- 2) Reusable material is used repeatedly and frequently at different construction sites.
- 3) The net material cost can be reduced if reusable material is delivered in a timely manner because the cost of reusable material can be increased on depreciation, which is in proportion to the use period at construction sites.
- 4) In order to perform a timely procurement, the head office should keep track of the status of the materials used at different construction sites in a real time basis.
- 5) Procurement should be performed in consideration of the various aspects, such as the time length of the reusable material, the distance between the construction sites and the transportation method.

The following table 1 shows the current stack status of reusable material by company, as identified from the case studies. The construction companies targeted for the study, except for D Construction Company, held the reusable material by each type. If these are classified in detail by dimensions, those companies hold three times of quantity for the materials.

Table 1. The holding status of reusable materials

Type	Item	Stack status of reusable materials			
		Company W	Company D	Company S	No. of stack types
temporary installations		○	○	○	41
furnishing tools		○	○	○	28
Experimental instrument		○	○	○	32
equipment		○	-	○	18
Other furniture and office supplies		○	○	○	16

2.2 Problems in Procuring Reusable Materials

As a result of these case studies, the problems in performing the procurement of identified reusable materials can be summarized as follows:

1) Absence of established procurement process

- Non-establishment of a detailed process for decision-making to perform appropriate procurement activities.
- Absence of data base for material usage.
- Absence of basic standards to decide priority for adequate procurement.

- Difficulty in agreement for procurement plans and implementation among staff in charge of procurement.

2) Overworked staff in charge of procurement at the companies' head offices

- 3 to 4 staff members in charge of procurement at multiple sites; thus the workload is relatively high per person.
- The job type is non-systematic, due to manual procurement.
- The procurement work is time-consuming, and the work itself is too inefficient in performance.

3) Absence of decision-making support information

- Absence of information and the information system to support decision-making that occurs in the course of procurement work.

4) Difficulty in identifying the real time status of material used at the multiple sites

- The use of reusable materials is not reported in real time basis.
- The absence of keeping track of previous procurement plans and execution decisions(proposals).

5) Absence of decision-making methods

- Absence of an analysis system to compare the material used at the multiple sites.
- Decision-making based on the experience and standard of staff in charge of procurement.
- Decline of reliability in procurement.

3. PROBLEM-SOLUTION METHODOLOGY

To solve the problems in the procurement process related to reusable material by identifying the real time status of material usage at the multiple sites, a new procurement process should be developed. To resolve the problems in support information about decision making for efficient procurement. Information System for Supporting Decision Making(ISSDM) was developed through a close examination of related information. In order to solve the problems regarding the distribution of the workload, ISSDM can play an important role by establishment of a resource pool. This decision support model for procurement of reusable material, which is regarded as a support tool to efficiently conduct procurement process by dealing with all those problems mentioned above, is presented as shown in Fig. 2.

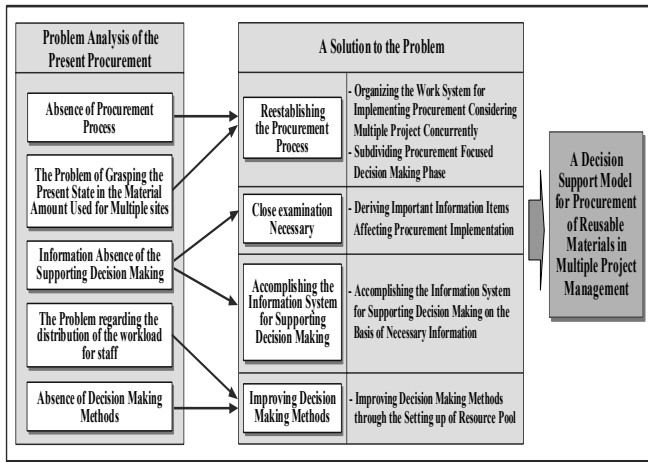


Figure 2. Overview of problem solving methodology in reusable material procurement

4. DECISION SUPPORT MODEL FOR PROCUREMENT OF REUSABLE MATERIAL

4.1 Improvement of the conventional Procurement Process

The existing procurement process is not systemized. The proposed model focuses on the part that requires decision making by integrating the fragmented elements in conventional procurement process. In addition, a material usage report function has been added on a real-time basis at the multiple sites. The flowchart for the improved procurement process is shown in Fig. 3.

4.2 Identification of Information and Establishment of ISSDM

A) Required Information

The required information was identified through on-site interviews by providing the respondents with the proposed procurement process and asking whether to add any particular information to improve the process. The required information is summarized as follows:

- Work package level information using reusable material.
- Schedule information of the specific work package.
- Real-time information for material usage at the multiple sites.
- Inventory information in a material warehouse.
- Location information of the multiple sites.
- Distance information of the multiple sites.
- Information about vehicle type.
- Material up loading method and fare information.

B) Development of Information System for Supporting Decision

① Forecast System for the Outgoing Reusable Material Quantity

A staff in charge of procurement at the head office who received a material procurement request from a particular construction site investigate the status of the material usage at the multiple sites and predicts the amount of the outgoing reusable material at the construction site that can be provided with the appropriate amount of material after a certain period of time(i.e., a month).

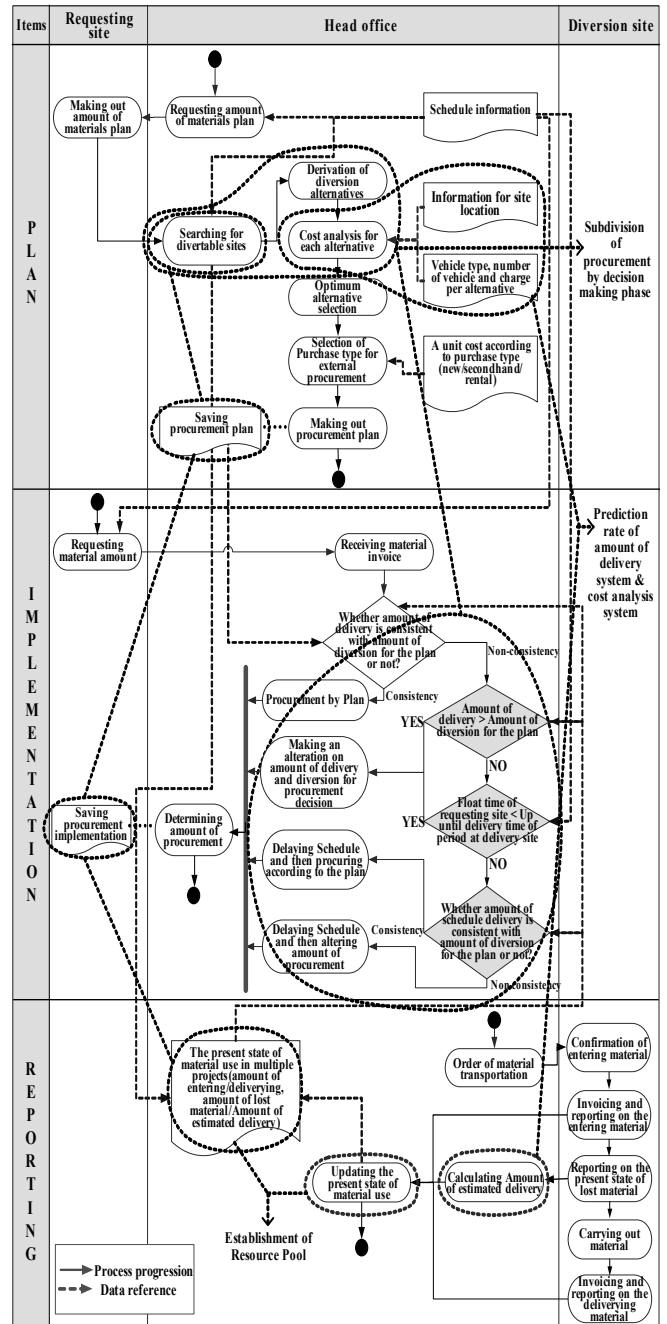


Figure 3. Reestablishing the Procurement Process

The estimation of such outgoing reusable material quantity should be forecast to be close to the outgoing real reusable material quantity, in order to enhance the rate of the reusable material. The inconvenience of job handling, due to a plan change by doing this, can also be minimized. The authors of this study computed the average depreciation and loss rates of reusable materials for the recent three years for case study companies. These rates vary according to different timings, which includes at the time of material installation, during the use of material, and at the time of removing the materials. Thus, depreciation and loss rates are different, according to the type and timing of the reusable material(see Table 2).

Table 2. Loss Rate of Reusable material(partial)

Item	Type	Unit	Loss rate (%)	Loss rate (%)		
				On setting	Under construction	On dismantling
Hoist	Vertical member	EA	5.0%	3.0%	2.0%	3.0%
	Horizontal member	EA	5.0%			
	Bracing	EA	11.0%			
	Sub-total	EA	21.0%			
Clamp	Fixing	EA	23.1%	0.0%	3.0%	0.0%
	Automatic	EA	22.0%			
	Sub-total	EA	23.0%			

② Economic Analysis of Vehicle Distribution

The staff in charge of procurement at the head offices who receive material procurement request check the material usage status at the multiple sites and develop a reusability alternatives on the “scheduled-to-be-delivered” construction sites. Suppose that there are “n” construction site that are scheduled to deliver certain types of material, the number of alternatives for delivery would be $2^n - 1$. For example, if the construction sites are three, the number of alternatives are $2^3 - 1 = 7$. Thus, an effective vehicle distribution analysis for delivering reusable material would enhance economic efficiency. The economic analysis should be based on a thorough investigation of the alternative delivery plans(See Table 3). The optimum alternative should satisfy several criteria; low procurement cost, appropriate procurement schedule, appropriate amount of requested quantity.

Table 3. Structure of Economic analysis for vehicle distribution

Goal	Optimum schedule & Reasonable amount for procurement	The lowest procurement cost
Constraint variable	<ul style="list-style-type: none"> • Delivery Date • Amount of delivery 	<ul style="list-style-type: none"> • distance <ul style="list-style-type: none"> - between diversion site and demand site - between diversion site and ware house • kinds of truck and a number of truck
Delivering cost	[No. of roots]Σ Types delivery cost per vehicle type x number of vehicle	

4.3 Improvement of Decision Making Method for Material Procurement

Most existing material procurement models are used as tools to restore the material usage information at the construction sites. These models are focused on the establishment of database. Such historical information, however, is not sufficient in forecasting the outgoing material quantity for reuse at other construction sites or supporting the decision making for the staff in charge of procurement. In order to improve current decision marking process for material procurement, a resource pool should be established. Based on this resource pool, a decision –maker can effectively elicit the optimum solution by analyzing the historical material usage information on multiple construction sites. The basic concept for resource pool structure is depicted in Fig. 4.

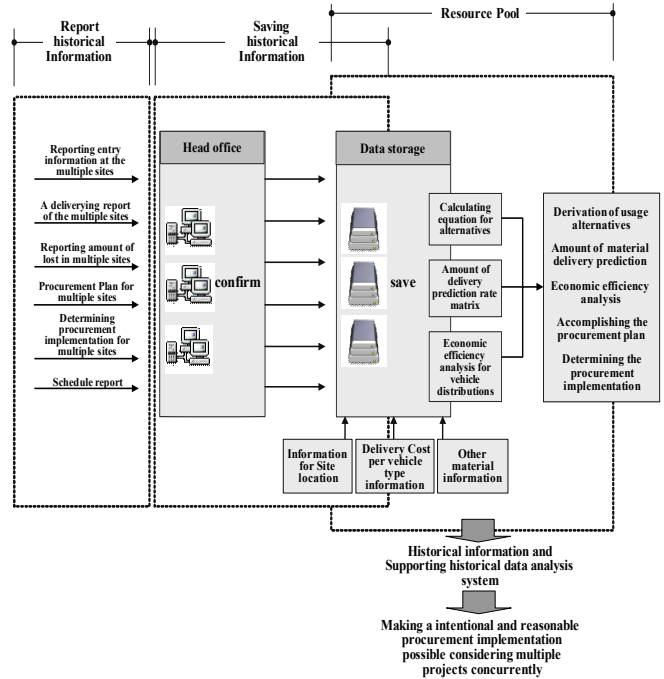


Figure 4. Basic concept for Resource Pool structure

4.4 Decision Support Model for Procurement of Reusable Material

Decision Support Model for Procurement of Reusable Material(DSMPRM) is a tool for the staff in charge of procurement at the head office. This model can be used as a decision support tool in eliciting optimum material procurement solution. In this model, the historical information about material usage at the multiple sites can be stored in the resource pool and be effectively used through a comparison and an analysis via new-developed information system as a support the decision making.

This Model is more beneficial when a real-time process at the multiple sites is incorporated into the system. The model, however, is developed under the assumption that the construction progress at the multiple sites is updated via MS-Project software to the resource pool in real time basis.

The proposed model in this papers follows three steps.

1st step, determines the reuse rate for the requested material. 2nd step, checks and confirms the scheduled procure plan, finally take related actions. 3rd step, regards the updating and reporting the both outgoing and incoming material based on the decision support model for procurement of reusable material(see fig. 5).

3rd step, regards receiving report of amount of incoming, outgoing and losing material based on the decision support model for procurement of reusable material. Finally update the real-time status of material using information to resource pool(see fig. 5).

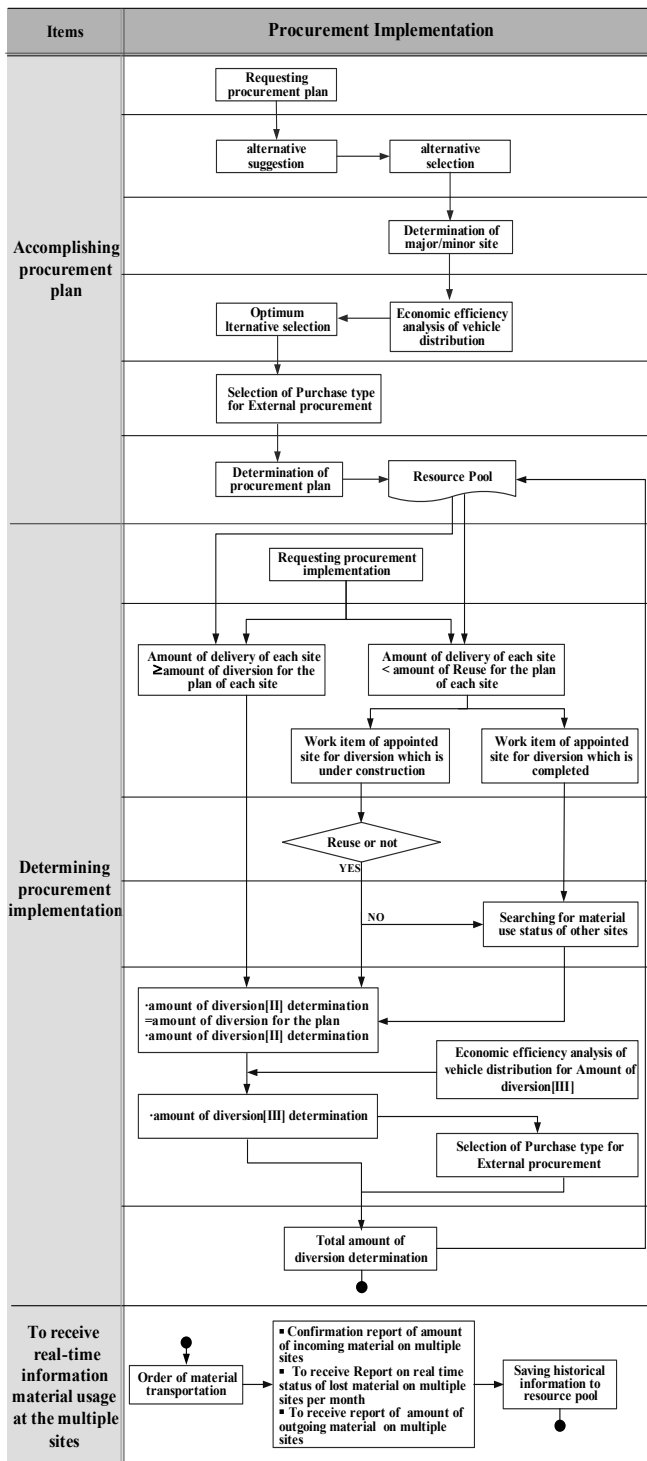


Figure 5. Decision Support Model for Procurement of Reusable Materials

5. CONCLUSION

As a result of analyzing the current status of reusable material procurement process of mid-size construction companies in Korea, the authors conclude that material procurement process is less efficient in its performance because of the following reasons.

- The absence of the systematic procurement process.
- The large amount of workload of staff in charge of

procurement at the head office of construction companies.

- The absence of appropriate support information for a sound decision making.
- Difficulties in identifying the status of reusable material usage at the multiple sites.
- The absence of an analytic decision-making method for material procurement.

In this paper, an innovative material procurement process is suggested by breaking down the procurement system and its relevant activities. In addition, an information system in support of decision making has been developed by identifying the relevant information required to support decision making based on improved process through the on-site personal interview of the selected construction companies. To achieve the research objective, various investigations on current material procurement system have been conducted regarding the forecasting system for the outgoing reusable material quantity, economic analysis of vehicle distribution, and resource pool structure. Decision Support Model for Procurement of Reusable Materials(DSMPRM) is a tool that the staff in charge of procurement at the head office can use efficiently in order to support the multi-site material procurement.

If the construction companies, which individually manage multiple sites, utilize this model, a “simultaneous” procurement process can be achieved by considering multiple sites in a real-time basis. Furthermore, the efficiency and productivity in material procurement can be enhanced. However, regarding the model presented in this paper, a more in-depth research on the methodology is required by assuming multiple-site construction process. In addition, the effectiveness of the model must be verified by applying it to a real case procurement and management work.

ACKNOWLEDGMENT

The writers would like to acknowledge the financial support provided by Grant No. R&D / 01-Objective D-20 from the Korea Institute of Construction & Transportation Technology Evaluation and Planning.

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