

# A Development of a Web-Based Mobile Daily Logistics Management Application for Construction Project

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Inefficient site logistics slows down the construction work and ultimately leads to cost overrides for the entire project. Various systems and applications have been developed to improve the efficiency of on-site logistics management. However, due to limitations, such as the cost of purchasing and maintenance, these applications are not actively used in the construction industry. The recently introduced online database management program development tool allows anyone without special knowledge to develop a database management system that can solve their problems. This paper introduces how this database development tool can be used to develop an online application that can help manage the on-site logistics. This application was developed to allow project managers and subcontractor managers to share material delivery information and plan lifting equipment usage. This paper also discusses the merits and limitations of the program developed based on the evaluation of experts.

**Key Words:** Construction Management, Logistics Management, Lifting Equipment Reservation, Construction Mobile Application, Knack

## Introduction

An efficient material management system can significantly reduce manpower and enhance the productivity of construction projects (Bell et al. 1987). As construction projects get bigger and more complex, there is an increase of a kind of materials and amount of quantity. Therefore, material management is becoming the main issue in construction projects. Previous research has shown that the efficiency of material management can be improved by using Information Communication Technology (ICT) (Irizarry et al. 2013), such as an introduction of Enterprise Resource Planning system (ERP), an application of Radio Frequency Identification (RFID), and a development of the tower crane location optimizing system (Marzouk et al. 2016). However, the rate of adoption for those systems is lower than what it was expected to be, because they require extra expense and equipment. For instance, the implementation of the ERP system requires a huge cost and its process is complex (Negahban. 2008; Ahmed et al. 2003), and personnel cannot recognize the RFID tag without identification devices (Kim et al. 2014). Several studies have shown that the limitations of utilization of ICT at a construction site can be reduced by using mobile applications (Nourbakhsh et al. 2012; Kim et al. 2013). However, developing a mobile application requires computer programming skills. This research developed a web-based mobile and online application to enhance logistics-management-work efficiency for project managers and subcontractor managers. It utilizes an online data management development tool that does not require knowledge of programming languages. Finally, the usability and effectiveness have been evaluated through the reaction of experts in the construction industry.

## Motivation

Most materials are delivered early in the morning. It causes congestion on the construction site, and subcontractor managers ask and claim that their material should be unloaded firstly. Therefore, it causes minor disputes between subcontractors. In the worst-case scenario, some truck drivers have to wait until afternoon to unload a transported material. Construction managers or field engineers of general contractors who manage and organize daily logistics

conditions should spend lots of their time to control unloading and placing materials. This unsystematic situation every morning interferes with daily construction progress. Finally, it delays the schedule of the whole project. To solve this problem, the web-based mobile Daily Logistics Management (DLM) application has been developed. Before subcontractor managers deliver their materials, they can access the DLM application by using their smartphone or laptop, and they can put the quantity of material and also its delivery time. The project manager can collect all the request data and adjust the schedule and inform the subcontractor managers very easily. By using the DLM application, project managers and subcontractor managers can enhance their work efficiency by reducing time to control material delivery and lifting equipment operation schedule.

## Development

### *Description of the Knack Platform*

In order to develop an intuitive and a simple web-based application, the Knack platform is selected. The Knack provides simple tools to transform on-site data into an online database and connects input data by linking related records together (Knack, 2017). The interface view of the Knack consists of Data view and Pages view. In the Data view, a developer can make an object and decide which information will be included in this object (Figure 1). Each data object can be connected by selection of “+Add connection” button (Figure 2). Developers also can make an application display page based on data objects. Each data object can be chosen whether it will be shown or not. In addition, a developer can designate the access right of each page as per “User role.”

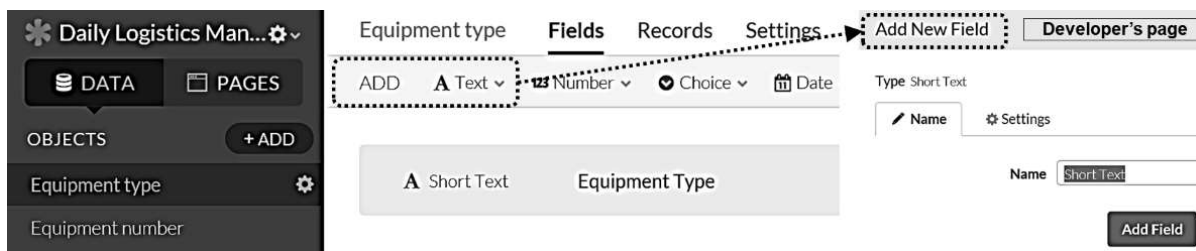


Figure 1: Interface view of the Knack platform

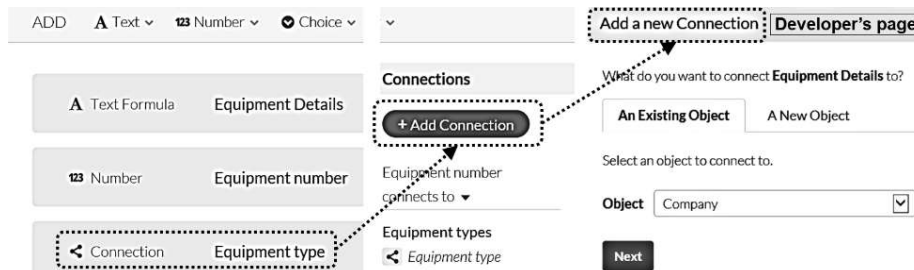


Figure 2: Data objects connection interface

### *Process of the Daily Logistics Management Application*

The DLM application is developed for project managers and subcontractor managers. Project managers have “Administrator” rights, and subcontractor managers are assigned as a “User.” Figure 3 describes the overall process of the DLM application. Subcontractor managers, who want to deliver their materials, put the delivery information into the application, such as a quantity of materials, and delivery time. In order to unload and lift materials, subcontractor managers must request a reservation of lifting equipment. Project managers can collect all of the material delivery information and lifting equipment request data. If there is an overlapping request at the same time, project managers can adjust the schedule and inform subcontractor managers of the adjusted schedule without any additional

action. When lifting equipment reservation data is input, the barcode will be generated automatically. Based on this barcode, project managers and subcontractor managers can check the status of their materials, for instance, warehousing status. They also can find the person who is in charge of those materials. Figure 4 shows the DLM application operation screens by using mobile phones.

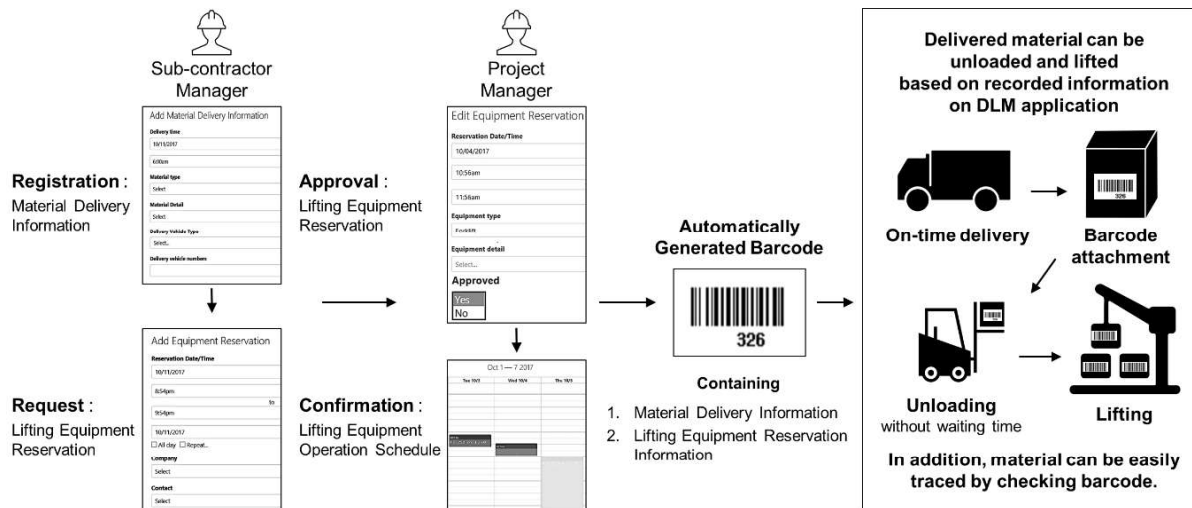


Figure 3: Process of the Daily Logistics Management Application

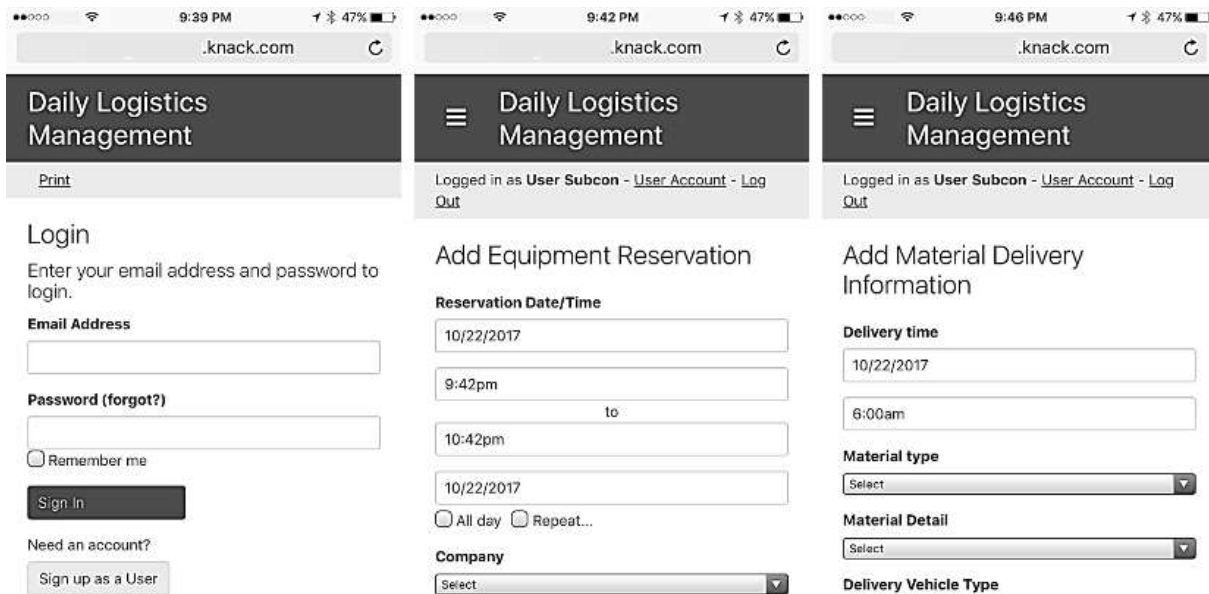


Figure 4: Mobile application operation screens

*Access Rights and Information Management Interface of Project Manager*

The project manager has the rights to access and edit all the information about subcontractors, materials, and equipment. Through the company master page, contact information about the person in charge of each material management can be added or deleted. For subcontractor manager’s information, the site plan can be uploaded and shown on the application screen. By checking this site plan, subcontractor managers can easily select a material unloading area and choose lifting equipment precisely (Figure 5).

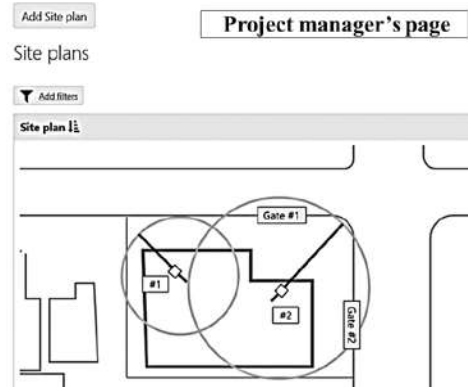


Figure 5: Site plan upload interface (Project manager’s page)

In the material master page (Figure 6), project managers can handle detail information of materials, such as material type, detail dimensions and weight per packing unit. Most importantly, the estimated quantity of each material can be recorded and traced. Through the equipment master page, project managers can input information about lifting equipment. Equipment type, model, and capacity information can be recorded and managed.

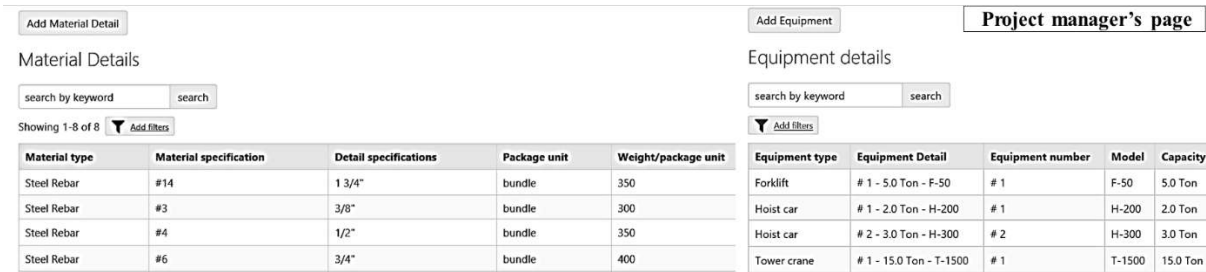


Figure 6: Material and equipment master interface (Project manager’s page)

### Lifting Equipment Reservation Process and Interface

Subcontractor managers can put material delivery information, such as delivery time, material type, delivery vehicle type, access gate and lay-down area or destination area in the “add material delivery information” page. This page provides the “material input status report” to project managers and subcontractor managers. By checking this report, all users can recognize input quantity and the remainder of each material that has to be entered or delivered (Figure 7).

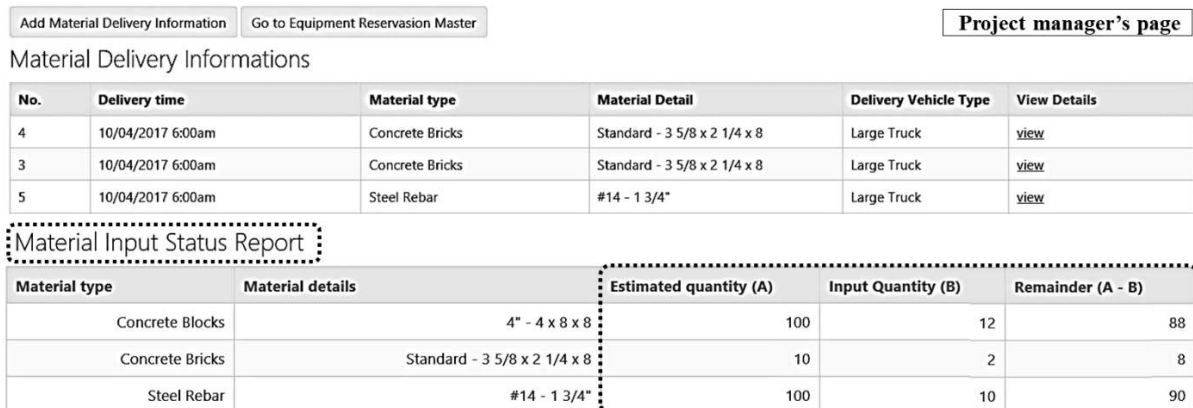





Figure 7: Material delivery information master interface (Project manager’s page)

Based on the material delivery information, subcontractor managers can make reservations to use lifting equipment for unloading and lifting delivered materials. In this request, subcontractor's name and contact information will also be included. To improve the current manual-based material tracking and take advantage of material tracking technology (Grau et al. 2009), the barcode generation and tracking function has applied in the DLM application. Through the barcode function, managers can get real-time data of delivered and stocked materials on the site (Chen et al. 2002). After submission of the equipment reservation form, all requests from every subcontractor manager will be reviewed and approved by project managers. If project managers approve one of the requests, the barcode will be generated automatically which includes material delivery information and lifting equipment reservation status. When materials are delivered to the construction site, subcontractor managers will attach this barcode to the materials. By attaching this barcode, project managers and subcontractor managers can scan and trace the materials in the construction site (Figure 8).

Equipment Reservation Status

search by keyword  search

**Project manager's page**

Application No. 12	Reservation Date/Time	Company	Contact	Equipment type	Equipment detail	Approved	Barcode image
30	10/02/2017 11:51am to 12:51pm	F-company	David Ahn	Tower crane	# 1 - 15.0 Ton - T-1500	Yes	
31	10/03/2017 10:13am to 11:13am	E-company	Sera Kim	Tower crane	# 2 - 25.0 Ton - T-2500	No	
32	10/04/2017 10:56am to 11:56am	F-company		Forklift		No	

Edit Equipment Reservation

Reservation Date/Time  
10/04/2017  
10:56am

Equipment type  
Forklift

Equipment detail  
Select...

Approved  
 Yes  
 No

Submit

Figure 8: Equipment reservation master interface (Project manager's page)

The equipment reservation master page shows reservation status with a calendar and a timetable. Each color illustrates a different subcontractor. Therefore, project managers can recognize which subcontractor made a reservation. If request overlapping has occurred, project managers can reorganize and adjust lifting equipment reservation time by using drag & drop feature. Through the entirety of this process, project managers can efficiently control daily logistics problem of the site (Figure 9).

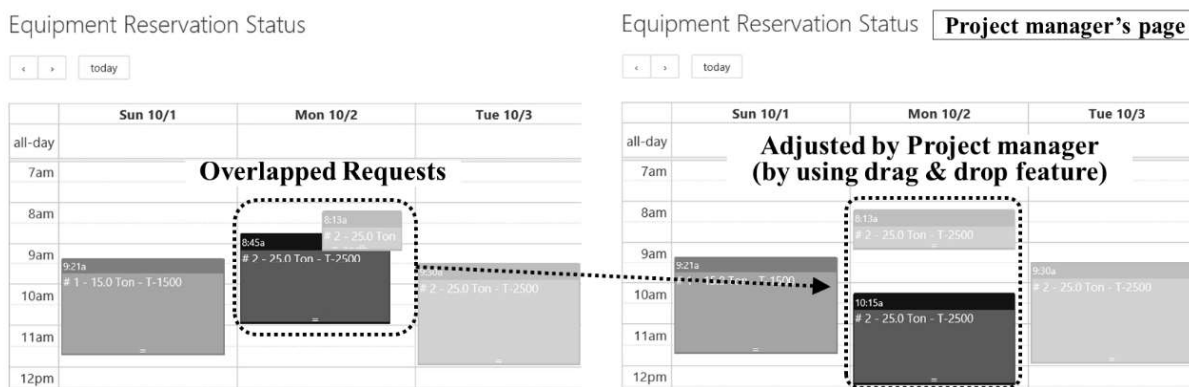


Figure 9: Equipment reservation status time table (Project manager's page)

## Evaluation

For the evaluation of the usability of the DLM application, an online survey was established to collect reaction and response from construction experts. 30 questionnaires were distributed to construction experts from general contractors, subcontractors and project owners in two countries, and 18 were returned (Table 1). In the questionnaire, there is no question asking for any personal identifying information. Figure 12 shows respondents' information.

Experts from general contractors account for 78 percent, while subcontractors and project owners both account for 11 percent, with 50 percent of respondents having more than 5 years of experience (Figure 10). Respondents were requested to use this application for a week and to evaluate it. Their feedback and comments were collected and analyzed for its benefits and limitations.

Table 1

*Survey response status*

	Number	Percentage
Total number of questionnaire distributed	30	100
Total number of questionnaire received	18	60
Total number of questionnaire unreturned	12	40

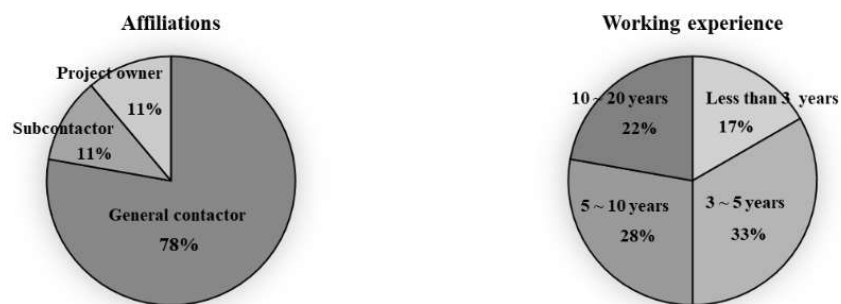


Figure 10: Affiliations and working experience of survey respondents

As per the experts' comments, by using this application, they could reduce the time on handling and organizing delivered material. Before using the DLM application, they usually spent lots of time on material handling. 44 percent of respondents spent 1-2 hours per day, 17 percent spent more than 2 hours per day for material management in a site (Figure 11). However, after using this application, 56 percent responded that they could save approx. 0.5 hours - 1 hour per day, and 16 percent reduced more than 1 hour per day.

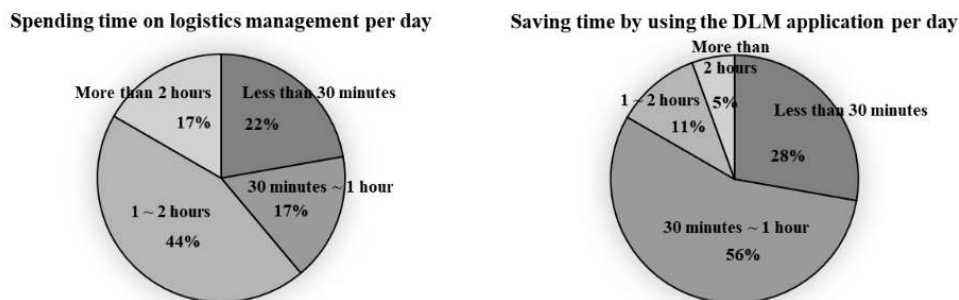


Figure 11: Time saving efficiency by using the DLM application

The survey was conducted based on a '1' (strongly disagree) to '5' (strongly agree) for each criterion. In particular, organizing a lifting equipment operation plan is more convenient. Table 2 shows the result of the application evaluation. The results are summarized as follows. In usability evaluation, almost 70 percent of respondents agreed that the DLM application is easy to access and use. About the usability of an automatically generated barcode, almost 58 percent agreed that it is useful. In satisfaction questions, about 72 percent agreed that it is helpful to manage on-site logistics, and almost 83 percent of testers responded that they will adopt the DLM application to their construction projects.

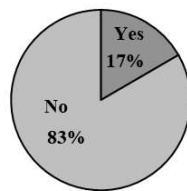
Table 2

*Application evaluation*

		1	2	3	4	5
Usability	It is easy to access and use	0	1	5	8	4
Usability	Automatically generated barcode is useful to manage material	1	0	7	7	3
Satisfaction	Using this application is helpful in logistics management	0	1	4	9	4
Satisfaction	I will adopt it to my construction project	1	2	0	10	5

Notes. 1=strongly disagree, 2=disagree, 3=to some extent, 4=agree, 5=strongly agree

To compare the difference between the DLM system and other systems, the presence of similar systems in the respondent's company was asked (Figure 12). 17 percent of respondents' companies have similar systems, but it is inconvenient to use because of the lower accessibility and the difficulty to share information. Although some large construction companies have material management systems included in their own ERP system, project managers have the same problem because of its systematic exclusion and accessibility is lower than the web-based database system. As a result of its lack of openness, project managers and subcontractor managers have difficulty interacting and communicating with each other.



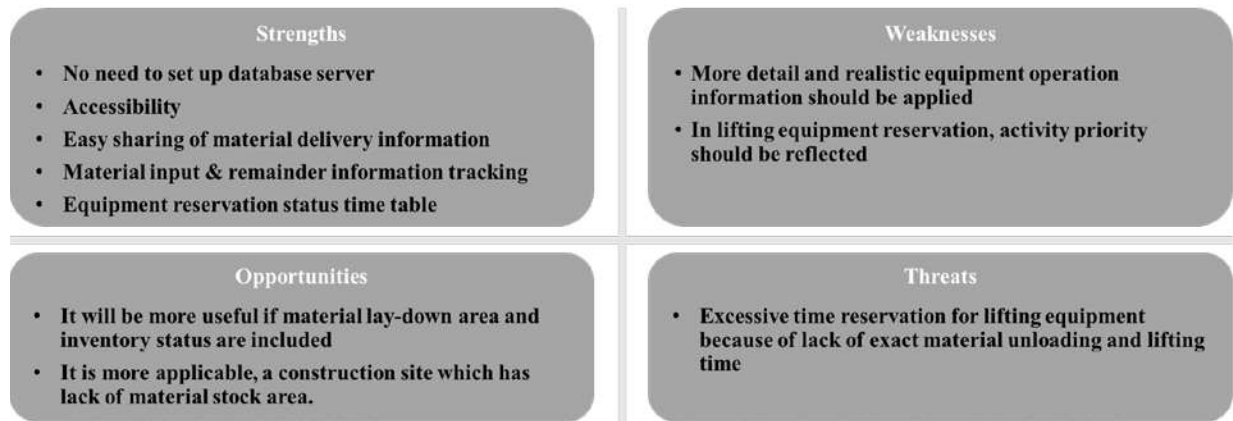
◆ If yes, what is the most inconvenient aspect of that system?

- Only general contractor's manager can access the system
- It is hard to share information with subcontractors.

Figure 12: The presence of similar system in respondent's company

### Benefits, Limitations and Future Work

Based on respondents' feedbacks and comments, Strengths, Weakness, Opportunities and Threats (SWOT) analysis was carried out as indicated in Figure 13. The web-based DLM application does not require setting up the database server. It is easy to share of material delivery information, the quantity of input and remainder information. Moreover, the lifting equipment reservation status timetable was evaluated as intuitive and convenient. Construction experts responded that this application would be more useful if material lay-down area and inventory status are included, and it would be more applicable to a construction site which lacks material stock area. Respondents also mentioned, to enhance the applicability of this application on site, more detailed and realistic equipment operation information should be applied, and to reflect construction progress condition, the priority of activities should be reflected. Although the DLM application has lots of benefits, it also has some limitations. When some subcontractor managers make a reservation for using lifting equipment, they request unrealistic time to use the equipment rather than the actual time because they cannot assume the exact unloading and lifting time. As a result of this excessive time request, idle time for some equipment had occurred. To solve this problem, more complex system has to be organized. For instance, as per the amount of delivered material and the type of lifting equipment, an unloading and lifting time should be estimated automatically. Based on this estimated time, project managers and subcontractor managers can handle on-site daily logistics more efficiently. To develop such complex application, the Knack platform also provides the developer customization tools that can be combined with some programming languages.



*Figure 13: SWOT analysis of the DLM application*

## Conclusion

This paper evaluates the development process and usability of the online Daily Logistics Management (DLM) application developed to prevent cost overruns and delays in construction projects due to unstructured and inefficient site logistics management. The program helps identify which materials have been delivered to the site and which equipment is reserved for lifting. It also automatically generates barcodes to help track the material logistic status at once. Construction experts evaluated that our program could reduce the time spent by project managers and subordinate managers in managing their materials. They point out that the strength of our program is to help them see at a glance how much material should be delivered to the site. They also anticipated that project managers would be more confident to decide which activities need to be accelerated and what lifting equipment to use.

This paper also discusses how the Knack platform can be used to develop the DLM. Online database development tools, such as the Knack, provide a breakthrough opportunity to develop online database applications relatively quickly and easily, which can solve the unique problems of construction sites without the need for computer programming skills. This approach also provides an opportunity to solve problems at a minimal cost because there is no need to install and maintain a database server. Although the program presented in this paper does not provide all the solutions for the problems in the field, it can be a stepping stone to help us adopt new ways to develop web-based mobile construction information management applications.

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