LOGISTICS MANAGEMENT IN THE CONSTRUCTION INDUSTRY

Abdulmohsen Almohsen, asalmohs@ucalgary.ca
Janaka Ruwanpura, janaka@ucalgary.ca
The University of Calgary/King Saud University / Calgary, Alberta, Canada

ABSTRACT

The construction industry is often slower to adopt new technologies than other industries. Yet the construction industry shall embrace these technologies sufficiently in order to keep up with advances in other trades. One of the most crucial elements in construction management is productivity. And the adopting of new technologies such as mobile-based application can increase construction project productivity in such areas as materials management, tool use time, and labour motivations. Most of these aspects have been thoroughly investigated in academia; however, logistics management and its contribution to construction productivity have been insufficiently investigated, especially with respect to the use of advanced technologies. In this paper, we propose to develop a new platform to utilize modern technologies in the construction industry. Hence, the main objective of this paper is to introduce mobile-based application technologies into construction industry that will improve construction productivity by enhancing logistics management practices. The use of this model will not only help increase productivity in the construction industry but also it will make this industry more competitive with other industries. In order to achieve the main the goal of the paper, different building construction sites have been selected from which to collect data using direct observation, interviews and questionnaires. In order to ensure a high quality result, all participants were selected based on their relationship to the subject being examined. By using the outcomes of the data analysis to identify a potential solution, a computerized logistical management model was developed to examine how to enhance construction productivity and to improve logistics management practices. Many positive opinions have been granted form different constriction experts. Facilitating the communications between such project participants as contactors, subcontractors and suppliers is another expected result. Also, the model would help in organizing the schedule for the use of such heavy equipment as cranes.

Keywords: logistics management, advanced mobile-based application technologies, construction materials and equipment.

1. INTRODUCTION

Completing construction projects in a timely manner with their numerous constrains requires the skilful integration of many aspects. One of these aspects, which plays a crucial role in ensuring that construction projects are completed successfully, is labour productivity. Construction project sites are impacted by several factors that affect the efficiency of a workforce by reducing their overall productivity. Such a loss of efficiency interferes with the performance of an entire project, and reduces management's chances of meeting project quality, budget, and time objectives. Conversely, by increasing overall productivity through improving labour force productivity, construction companies would reap many more benefits from their projects.

One of the most obvious causes of lost productivity is the poor management of materials, equipment, and tools—or "logistics management". Hence, construction logistics can be defined as "the management of the flow of materials, tools, and equipment (and any related object) from the point of discharge to the point of use or installation (The European Construction 1994). Bringing together and coordinating the management of these three vital components between the project's principal parties would increase productivity substantially. On a construction site, these components must be properly managed in order to ensure a project's success (Kini 1999; O'Brien 1989; Stukhart 1995). Ineffective management, on the other hand, will result in conflicts between these aspects. These conflicts will ultimately cause project delays, and cost overruns. Because the cost of materials and equipment represents a large proportion of the total project budget, it is vital to manage these costs effectively. Several studies show that these two components consume between 60 and 70% of a project's total budget (Kini 1999; Bell & Stukhart 1986). Managing the flow of materials, assuring its quality, checking the quantity, allocating the storage areas, coordinating the overall process, triggering the orders, and updating the participants are major obstacles in construction logistics management (Agapiou et al. 1998).

2. BACKGROUND

Managing construction projects requires an integrated process to ensure that they are completed on time, on budget, and within the contract specifications. Labour force productivity enhancement, which typically reduces costs and increases productivity, is one of the major factors in construction project management. Logistics management, if performed efficiently, is one the major factors in increasing labour productivity (Agapiou et al. 1998). However, planning for the availability and efficient coordination of materials, tools, and equipment is a difficult task (Liu, Georgakis, and Nwagboso 2007; Jha and Iyer 2006) Nevertheless, these resources need to be properly managed to ensure the success of any construction project (Muehlhausen 1991). Moreover, because these elements consume a sizeable portion of the total project budget, their inefficient handling will increase costs and decrease productivity (Fei et al. 2008). Although it is widely accepted that productivity can be improved by adopting effective logistic management systems, only a few studies have been published that offer logistic management models that address this issue (Liu, Georgakis, and Nwagboso 2007). Yet many difficulties in the construction industry can be overcome by following efficient logistics management systems. Tools time, for example, can be improved by implementing an effective materials management system, which eventually increases construction productivity; the project site, too, can be organized in such a way as to reduce congestion (Ruwanpura and Zhang 2008).

Effective logistic management systems will also facilitate the integration and degree of coordination among contactors, sub-contractors, and suppliers and will ultimately increase construction workers' productivity (Caron, Marchet, and Perego 1998). Using the current technologies in developing a logistics management system will help the construction industry. For example, knowing the exact time of delivery and the status of shipments will help contractors prepare for their receipt and will result in reduced preparation time and faster materials delivery on site. There are many factors that combine to make logistics a complex and dynamic process, especially on a construction site. For example, the construction environment is constantly changing and so many other elements that are related to logistics are changing as well. These elements include the efficiency of construction site gates and of storage / work areas. The necessary combination of bulk and individual components also complicates the management of logistics. Managing logistics, therefore, takes considerable time to plan and supervise because it requires a well-coordinated approach.

By looking to the market of mobile-based applications, it can be seen that there is a shortage in the availability of such applications. Also, by investigating the current practices of construction companies with respect to logistics management it can be proved that most companies did not utilize such advanced tools as well. However, the market of mobile-based application contains some simple applications that belong in a way or another to construction. For example, Apple Store has some applications dedicated to take construction measurement using cameras. Applications that allow construction drawings to be readable on the smart phones is another example. From here comes the importance of having advanced applications that benefit the industry which this paper is dedicated to (Holzer 2009).

3. RESEARCH METHODOLOGY AND DATA ANALYSIS

3.1 Research Methodology

The generic problem-solving theory was adapted for use as part of this research. This theory encompasses several steps: identify the problem, analyze the problems, generate a solution, and validate the solution (Dennis et al. 2003). Each of these steps contains several sub steps that need to be addressed. Figure 1 illustrates the basic framework of the four steps including investigate, create, evaluate, and validate

A combination of qualitative (descriptive) as well as quantitative (numerical) research methodology was used in the research design of this study. The use of this combination of methods was considered to provide the best approach to the research. Through making a literature review and direct observations, and conducting both formal and informal interviews with construction personnel, situations that affect logistics management were evaluated and identified. Direct observation, personal interviews (formal and informal), and a questionnaire survey were the primary sources of data for this research. Other sources have been used to gather data including previous studies, government documents, private documents, and the census. Each one of the collection methods is described below. Different approaches—such as the sampling method—have been adapted to ensure a suitable level of accuracy.

Initially, time was spent to observe and monitor the current practices of logistics handling on the sites which helped the researchers understand and assess the quality of current practices. Direct observation technique was also used to perform the five-minute continues methods and it also helped in monitoring the ordering process. This step facilitated the conducting of the interviews and design of the questionnaire questions because it provided the researchers with the merits and flaws in the existing logistics management system. The observations have focused on several aspects that are related to logistics management including factors that affect materials management including materials delivery, materials handling and materials storage and schedule Integration among project parties. How the communicate with each other (e.g. How suppliers update contractors about status of shipments).

The second method was the interview. The interviews are divided into two parts: 1) the formal interview that needed to be arranged, 2) the informal interview that could take place at any time between and during the observation period, and could be considered as being comprised of brief chats as well. The main objectives of the interviews were to obtain information about the current practices of logistics management, and to gain an understanding of the differing perceptions of logistics management. Different people were targeted to participate in the interviews including project management, project coordinators, superintends, foremen, and labourers. Many aspects were discussed during the interviews such as the ordering process, communications tools, and current logistical tools.

Conducting the questionnaire survey was the last step of the data collection process. Both, personal observation and interviews were used to develop the questionnaire. Both study sites were targeted in the survey. Two hundred copies consisted of 31 questions were distributed at these sites because most of the subjects were working there including the sub trades and subcontractors and the response rate was 41%. The main objective of the questionnaire was to provide the opportunity for the workers to express their views regarding logistics management. Since they were not asked to identify themselves, the participants felt more comfortable when answering the questions. This condition of anonymity resulted in obtaining more accurate and truly representative data. The questionnaire was divided into two parts. The first part consisted of multiple choice questions (e,g, What is the confidence level that the suppliers will deliver a shipment?); the second part consisted of rank order question.

- To identify the problems of poor logistics management.

- To quantify the impact of some crucial factors
- To prioritize the importance of the impact of some productivity effect elements.
- To obtain some statistical data regarding logistics management.

Most of the questionnaire responses were analyzed in order to identify their role in productivity loss and the degree of their negative contribution to logistics management. The results of the statistical analysis of the collected data were then used to construct a conceptual model that can be used to improve logistics management and to develop a more efficient daily schedule

3.2 Data Analysis

The study revealed that while most of the contractors investigated had a logistical management system built into their Microsoft Office software, because the system had only limited application, it affected the coordination between the project's parties. In fact, most of the contractors did not use the software at all and they did not train their employees to use it either.

The following points became evident as a result of this research:

- The investigation of logistics management showed that 40-45% of the material orders took double the necessary time because of the drawbacks.
- Because, the person who was responsible for issuing material orders did not allow enough lead time, deliveries were often late. There were numerous worker replacements, which resulted in a longer learning curve period.
- Equipment scheduling for the availability of cranes and skips was not incorporated into the logistics management system. Also there was no coordination of the package arrivals between the purchase personnel, and the other team members, or between subcontractors and suppliers.
- There was poor record keeping of the materials and tools, which resulted in poor storage management.

The results of the data analysis indicated that the above issues negatively affected construction productivity levels and proved that the logistics management systems used to date in the construction industry were highly inefficient. Figure 2 shows the processing of orders at the investigated sites. As it can be seen, there are several issues with respect to this process, which negatively affect the construction process. Schedule disturbance, misinformed workers, and time wasting are good examples. Several of the weaknesses that have an impact on this process will be discussed later.

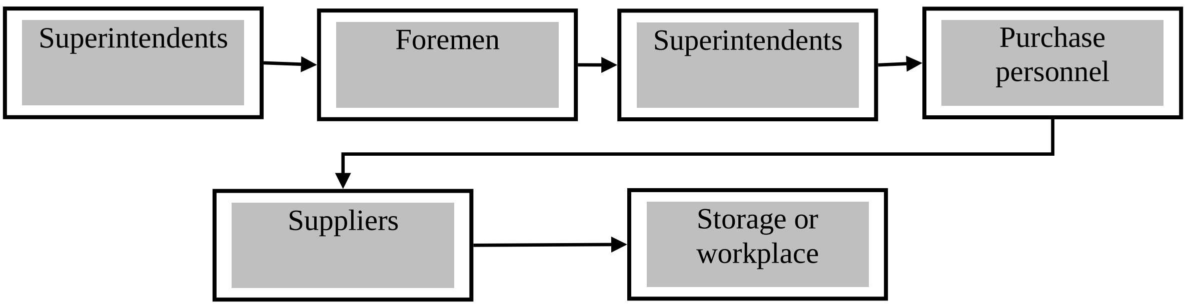


Figure 1: Shows the current order flow

As the above figure indicates, superintendents initiate the orders and ask their foremen to locate the needed materials and prepare the necessary orders. Then, the superintendents must approve or adjust the orders and send them to the purchase personnel who place the orders. After the supplier receives an order, he delivers the requested material(s) to the site (workplace or storage). The major weaknesses in the current process are illustrated in the following points:

- There is a lack of planning between superintendents and their foremen. Relying solely on intuition and experience with previous shipments, superintendents ask their foremen to check on the status of materials. So, there is no integration between the storage management the schedule planning.

- The foremen take too long to prepare a materials list. Preparing the order is very primitive as the foremen lists the needed materials on any available piece of paper or cardboard without giving full details. This haphazard method shows an absence of accountability regarding the availability of materials, which in turn affects the logistics of a project. Also this results in poor documentations.

- There are neither formal procedures nor designated people for purchasing. Superintendents have to deal with several different procedures in submitting orders to purchase personnel. Moreover, the fact that superintendents don't receive any feedback on whether suppliers can deliver the needed materials affects their judgment.

- Because suppliers will appear at the site with an order after having given only 10-15 minutes' notice, they create scheduling conflicts and project disturbances.

There are also many other minor issues that affect the construction process including receiving details, equipments needs, the superintendent to foremen ratio, the absence of technology, and the confirmation of feedback information. It's obvious that there is a need to develop a new ordering process that can address these points and enhance the efficiency of the logistics management system.

4. MODEL DEVELOPMENT

It became obvious after the investigation and analysis stages that there is a fundamental flaw in the project planning system that causes most of these logistics problems, and that it should to be addressed in building an effective logistics management model. The data analysis revealed its presence at all stages of project development. The initiation of orders, keeping track of all its implications, keeping everybody involved well informed about order progress, and simplifying access to information were the major issues. In the development of the model presented here, all aspects of the process were considered. This paper presents a reconstruction of the ordering process that can lead to the development of an effective and straightforward means of communicating among all project parties.

After having examined the results of the data analysis described in the previous section, the researchers identified the main cause of the lack of communication. It was the poor logistics of the ordering process and its implications for project planning and scheduling. The absence of communication devices that would be useful in analyzing the logistics process with respect to the availability of materials, tools and equipment is currently the major cause of poor logistics management in the construction industry. Hence, the model presented herein is designed to reconstruct and modernize the ordering process.

Building the new process model was based on three major principals. These principals served as guidelines to enhance the model design as well as prevent any weaknesses in the communication process. The three major principals of the new model are as follows:

- Simplicity of access.

The new model uses current technology and the internet-based application to simplify the accessing of logistics information. By facilitating the accessing of logistics information, the model helps personnel identify material and/or tool requirements and thus keep up to dated on the status of the inventory. It also helps in organizing equipment schedules and makes them more efficient. This principal is responsible for easing and smoothing the ordering process by allowing employees to access the necessary information at any time and from any place by using the internet.

- Authority delegation (Contributions)

The model also allows the other important parties (sub-contractors and suppliers) to be a part of the logistics process. Thus, the model improves the efficiency of the entire projec –, especially with respect to the scheduling of equipment usage and materials ordering and receiving.

- Integrations and cooperation

The presented model helps project managers and their employees interact and communicate in real time, which enhances the efficiency of the planning and scheduling processes. Hence, all the required input from each of the participants would be available before any decision was made or any action was taken. Thus, it allows each participant to contribute and helps avoid any delays or overlapping activities.

4.1 Developing the logistics process

The results of the data analysis indicated that the current process was inefficient with respect to logistics management. Failure to do so triggers many problems such as materials unavailability, equipment schedule disturbance, and disorganized sites that may contribute to productivity loss. Therefore, in order to ensure that the logistics process is professionally managed, the development of the logistics process should take into consideration all possible contributing elements. This process is divided into two sections: first, the development of the conceptual model; second, the transferring of the concept to an actual application.

4.2 The conceptual model

The concept presented attempts to overcome most of the current obstacles to achieving an efficient logistics process and is designed to integrate all the related elements as shown in Figure 3. This concept focuses on both the short and the long term order processes. The development of the conceptual model starts by identifying the sequence of activities and by constructing a flowchart of the steps in the ordering process.

As the figure 3 shows, the order may be triggered by any or all of three factors—daily work or equipment schedule, storage status, and/or the alert system (interactive map). Such a triggering would cause the appropriate personnel to properly fill the order application form and send it to the designated party. The request might then be approved or rejected by this person (usually a superintendent). Rejected requests are returned to the sender and those that are approved ones are sent to purchase personnel. The purchase personnel will then confirm the details of the request with the suppliers. After that, all the personnel involved in the order will be informed about its status and the various timing details. On the receiving day, the responsible person will be informed about the shipment’s time of arrival and he/she will accept or reject it and update their inventory accordingly. Then, a notice will be sent to all the people involved in the order that contains all the information concerning the shipment’s quantity and location on the site.

4.2.1 The mobile application

As discussed in the introduction, the use of the internet is superseding the use of other forms of computer application and research shows that its use is increasing exponentially due to the availability of the smart phone to surf the internet. One the major advantages here to users is the mobility of its application. There are now more than 1,000,000 mobile applications, which are distributed on several different types of operating systems. Apple OS, for example, has the highest number with more than 300,000 applications being available in the AppleStore. In fact, Apple has announced that the number of application downloaded exceeded a billion times. Therefore, the authors of this decided to convert the conceptual model to a mobile application and, due to the popularity of the Apple OS, they agreed.

The goal here is to simplify and facilitate the communication process on construction sites and among the project participants. The mobile device would be used to send various messages, and fill out orders more efficiently to the appropriate party. Hence, the device will help increase worker efficiency and raise the level of construction productivity overall.

4.2.1.1 Sub objectives:

- To order materials
- To receive and accept shipments
- To update warehouse inventory
- To manage and expedite the flow of information

4.1.2.1 Description:

The application is capable of integrating most aspects of logistics management including information delivery, receiving, and updating as shown in figure 4. A general outline of the points to be considered here is given below:

- Personnel have different levels of authority depending on their positions.
- All the following elements related to logistics management should be identified as icons: materials, equipment, schedule, personnel, suppliers, and subcontractors.
- Most of the application features have a “touch feature” to eliminate (or at least reduce) any need for writing.
- An interactive map of the subject site would help in locating materials, identifying their quantity and triggering shortage alerts.
- Push button notification was used to approve receiving orders and other requests.
- The application has the ability to send a request to one person rather than to all personnel.

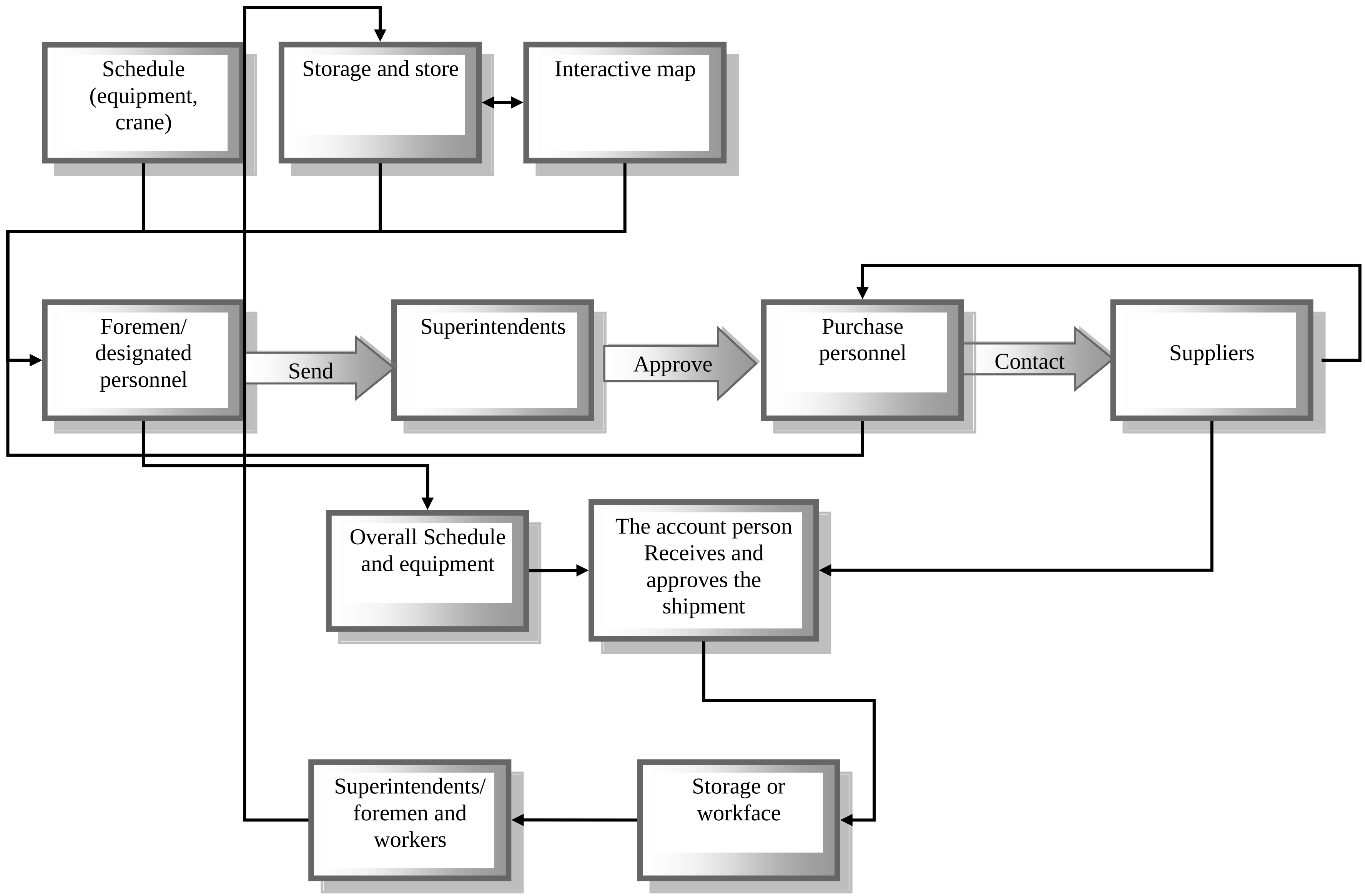
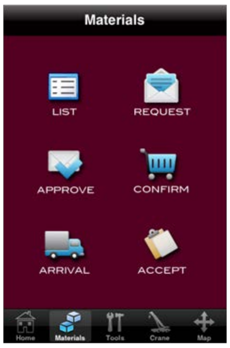


Figure 3 shows the model and its process for logistics management

4.1.2.2 The flow

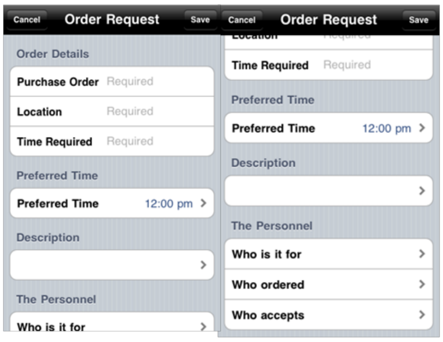
- The interactive map will indicate where there is a shortage of a certain type of material and where there is a need to order materials so that a project can be kept on schedule. Alternatively, the schedule indicates there are shortages.
- The person responsible will order the necessary materials using the application. For example, the foreman would choose the type of materials and place the order through the appropriate party. The following aspects should be included in the order:
  - ✓ Purchase order (number)
  - ✓ Preferred time (shipment arrival time)
  - ✓ Location (the site, and location on the site)
  - ✓ Time required (minutes needs to unload the material)
  - ✓ Description
  - ✓ Who it is for (name)
  - ✓ Who ordered it (name)
  - ✓ Who is to accept it (name)
  - ✓ Crane(s) requirements
- The supervisor would check the order and approve it, then send it to the purchasing personnel.
- A confirmation of the order should be sent by the purchasing personnel to any related personnel. The order confirmation should include the following details:
  - ✓ Time Confirmation
  - ✓ Truck type and plate number
  - ✓ Equipment needed (e.g. cranes)
- Once the shipment arrives, the person responsible for accepting the shipment would be notified by entering the vehicle licence plate number. So, he/she can receive the materials and update the inventory and specify the location of the newly-arrived material on the map.

Login screen

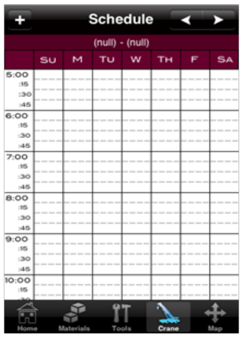


Home screen

Arrival screen



Request screens



Cranes schedule

Figure 4 shows various screen of the application

5. CONCLUSION

The combined use of the model presented and the mobile application will facilitate the communication process among project parties. It also allows all participants to make their real time contributions to the logistics management process. Also, the application will help simplify the gaining of access to any needed information. The application will help in site organization by providing decision-makers with access to all the necessary information for making any decisions with respect to the logistics process. Another benefit is that it will help in the scheduling of any necessary heavy equipment and it will allow other parties to put in their requests for such usage. The application will facilitate the communication process between project participants and will ultimately reduce most the causes of poor logistics management such as material unavailability, double handling, the overlapping of activities, and crane use disturbance. The tool times is anticipated to be improved at least 10%. It is believed that the application would help companies in construction industry to enhance their logistics management practices which ultimately improve the overall productivity. Hence, the application will act as a tool to assist members of the construction industry improves their approach to logistics management.

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