REAL TIME PERFORMANCE INFORMATION SYSTEM USING MOBILE PHONE

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ABSTRACT

The author explained the importance of standard operating procedure documents and visualization in order to implement lean construction in IGCL12 and 13. PPC chart and Table of Reason for Failure are important tools in order to execute standard operation and visualization. But the information is often not in real time, not precise and not shared with the foreman, staff of site and head offices of both the contractor and subcontractors. In order to improve these shortcomings, author is developing real time performance information system using mobile telephone.

This paper first explains if we have real time performance information of the work and reason of the performance, we can easily eliminate waste in order to pursue the perfection of construction work flow.

The idea of this system came from POS system of convenience store._Then the author shows how the real time information of each merchandise item at a convenience store is used and how it is determined whether an item sold well or poorly. The real time performance information system on construction site using mobile phone now under development is explained.

Finally, the author explains the examples and effects of eliminating waste using mobile phone system.

KEY WORDS

Lean Construction, Real Time Performance Information System, Mobile Phone, PPC

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INTRODUCTION

In general, construction work differs from work at manufacturing factories in that the work is usually done by a team that includes foremen and engineers who are meeting for the first time. This means that it is difficult to conduct a work based on tacit understanding. In order to implement the work efficiently, sharing of explicit information is essential (Nakagawa 2004). Some of the critical information at the worksite is the amount of each type of work implemented as compared to the planned amount, as well as the reason why the planned amount was not completed. An understanding of the information will enable motivated project managers (PM), foremen, and engineers to work together to implement improvements that will make the construction lean.

Percent Plan Complete (PPC) is the number of planned activities completed divided by the total number of planned activities. The table shows the reasons that planned work was not completed is called the Table of Reasons for Failure. Since the PPC approach was first introduced in "The Last Planner" (Ballard 1994), its usefulness has been demonstrated, and it has been reported on many times (Ballard 2000, Kim 2005).

Weekly PPC are common. However, if data of each activity for planned amount, completed amount and reasons for the failure could be known immediately on a daily basis, it is obvious that the PM, engineer and foreman in the site can quickly eliminate the wastes in order to implement lean construction. In Japan, site engineers talk with foremen how to improve the material, machinery, manpower, procedure and so on using daily work data at daily meeting in order to execute lean construction. But usually, the data is verbal and not precise. That is why it is necessary to have the precise and quick data. Moreover, sharing this information among the PM, foremen, engineers, and the head offices of the contractor and subcontractor would make it possible to promote improvements to make overall operations at the site lean.

Normally, the hard-copy data collected at the site are input into a PC. In order to eliminate the troublesome task of writing and retyping all of the data and acquire the real time data, information systems are required using mobile communications (Garza and Howitt 1998, Bowden and Thorpe 2002). This system is being developed in which Personal Digital Assistants (PDAs), hand terminals and bar codes are used to quickly share information at the worksite (Lin 2004, Olofsson and Emborg 2004). The Lean Enterprise Web-based Information System for Construction is being developed using PDAs. This system shows PPC on the PC (Sriprasert and Dawood 2003).This paper describes a system for using mobile phones as a transmission device to share construction work data at site in real time. Sharing construction data could improve the transparency of the construction work flow underlying wastes in order to pursue perfection.

The idea of this system is based on the point of sales (POS) system for sales data used at convenience stores in Japan. First, an overview of the POS is presented. Next, the need of and the method for real-time sharing of information at construction sites are discussed. Subsequently, the development of a just-in-time (JIT) system for site data using mobile phones as transmission devices is described. Finally, examples of the use and the possibilities of this system are presented.

JUST-IN-TIME DELIVERY AND SHARING OF DAILY SALES AND ORDER DATA AT CONVENIENCE STORES IN JAPAN

Convenience stores constitute a major industry in Japan. As of March 2004, there were 41,000 convenience stores in Japan, with annual sales of $63billion. A convenience store offers approximately 2,500-3,500 merchandise items in a small store area of around 100 $m^{\cdot Q}$, with minimum stock to increase efficiency. Moreover, perishable foods account for 1/4 of sales. For these reasons, information on the daily sales and order quantity for each item is essential. The use of just-in-time (JIT) systems for this information is particularly important._Sales $\sum$ unit price of each item sold x quantity sold, and it is important to determine the sales trends for each item accurately without delay.

In each convenience store, if the sales quantity is lower than the stocked quantity of each item, disposal losses are produced. Conversely, greater purchase demand than the quantity stocked represents lost sales opportunities. In order to reduce these losses, detailed data on customer purchases must be collected and analyzed at the convenience store, and an ordering (sales) plan must be established based on the purchase data and the results of the analysis.

The sales quantity of each item is dependent on F (item characteristics, unit price, weather, customer gender and age, display method, date and time, region, special events in the local community). These sales data are entered into the POS system for each item, using the following three methods. Information on the item display method and special events in the local community is communicated to advisors for the local head office who visit the store three times a week.

- Bar code readout: item name, unit price, quantity
- Automatic input: date and time, store name (region)
- Manual input: weather, gender and approximate age of customer

Figure 1 shows the flow of sales and order information for convenience store merchandise items. As the figure shows, the sales data for each item entered into POS and the planned order data based on the sales data are sent from that convenience store to the local head office that oversees the region. The order data are transmitted online to and shared by the common delivery center and the manufacturer that makes the product. The sales data are used in product development planning and new branch opening planning at the local head office. The order data are used in product shipment planning at the common delivery center and production control planning at the manufacturing factory.

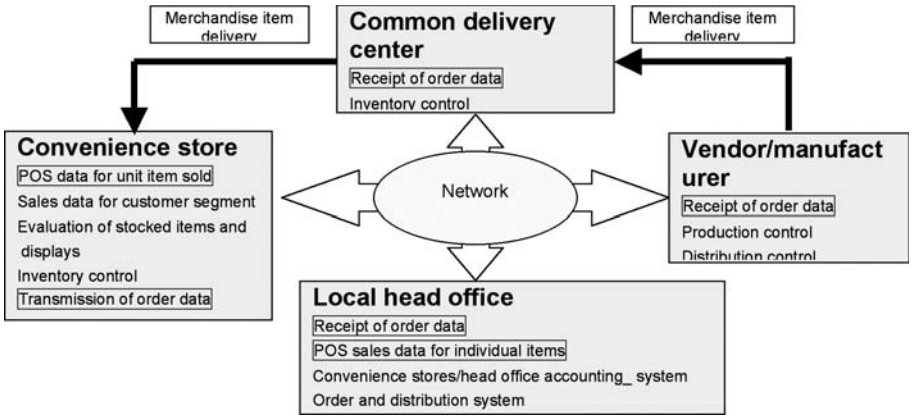


Figure 1: Sales data system for convenience stores

In other words, the order data (PLAN) and sales data (CHECK) for each item at the convenience store are shared with relevant parties and used effectively to plan the next measures (ACTION). The important thing here is not the information for merchandise item groups (for example, box lunches) but the individual items (for example, ham sandwich made by Company A). This system enables to output the sales results and causes to be managed for individual items.

SITE DATA FOR IMPLEMENTING LEAN CONSTRUCTION

Major works at construction sites include excavation, scaffolding, formwork, reinforcement, concreting and so on in case of bridge foundation. The factors that affect the completed amount of these works are as follows:

f1 Materials (quantity, quality, delivery time)

f2 Labor (number of workers, skill level, time of arrival at the site)

f3 Machinery (quantity, capacity, time of arrival at the site)

f4 Construction method (procedure, standard operation document, instructions)

f5 Safety/previous process/weather

The information for f1-f5 for each work corresponds to the F factors for individual items at convenience stores. In addition, the daily planned construction amount and the completed amount for each work corresponds to the daily planned order quantity and sales quantity for individual items at convenience stores.

The foreman in charge of each work at the construction site possesses the information for f1-f5 that will affect the amount of work to be completed. One of the reasons hindering lean construction at the site is the fact that the information held by the foreman is not transmitted to and shared by related parties in a "just-in-time" manner. This causes delays in implementing improvements.

Figure 2 shows the concept for the construction work information system.

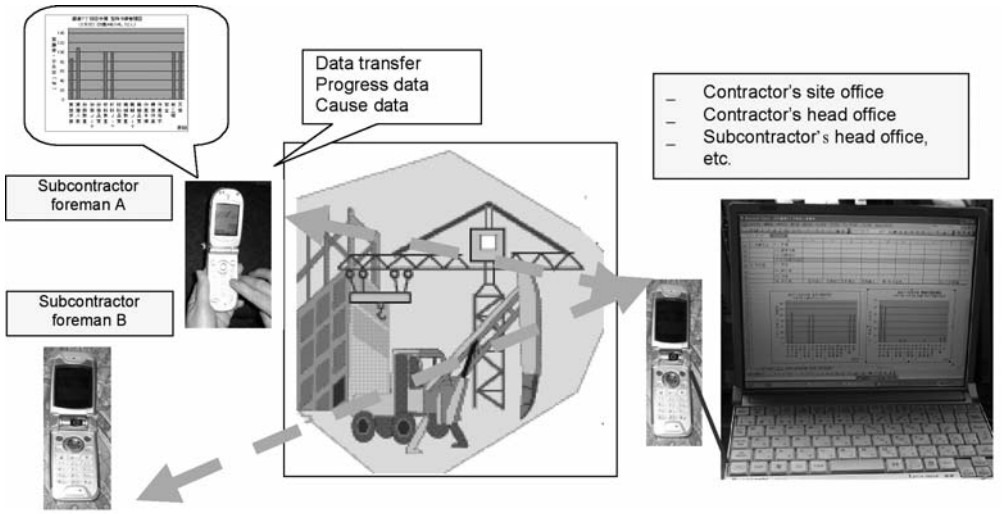


Figure 2: Construction work information system

As this figure shows, the foreman transmits construction work data by mobile phone, and the information passes through the mobile phone at the contractor's site office, etc., to the PC where it is processed. The information is shared (CHECK) by the foreman, the contractor's site office, and the head offices of the contractor and subcontractor and so on, enabling joint improvement (ACTION) to be implemented.

The amount of work completed and the number of people completing it for each progress time, together with the data for f1-f5, are accumulated in Excel data form, making it possible to determine the efficiency of the construction process. This enables problems at the site and in each type of work to be identified, and these data form a valuable database for use during the next construction job.

MOBILE PHONE TRANSMISSION SYSTEM

First, reasons for using mobile phones instead of PDA as information terminal for the construction work information system is explained.

- PDA has data functions that are superior to those of mobile phones. In particular, the display screen is larger than that of a mobile phone, making it easier to enter and read data. However, if PDA were to be used for this system, they would have to be purchased or leased. Foremen normally carry a notebook and a mobile phone in their shirt pocket. To carry a PDA is more troublesome, since a carrying bag is needed. Moreover, PDA equipped with telecommunications and camera functions are expensive.
- Almost every adult in Japan carries a mobile phone, making it unnecessary to purchase or lease a mobile phone. For this reason, even when the foreman is away, another employee can enter the information if the password is known. In

addition, most mobile phones are now equipped with cameras, making it possible to take a picture of the situation at the site and transmit it to the other parties.

Figure 3 shows the system for sharing the construction work data received by mobile phone from the foreman. The construction work data transmitted by the foreman is entered to the database that matches the site's keyword and foreman's keyword on the server at the contractor's site office and the head offices of the contractor and subcontractor, and so on. It is possible to issue a request from the foreman's mobile phone to output the records in the database to the foreman's mobile phone. The server can also be accessed by PC from the contractor's site office and the head offices of the contractor and subcontractor, and so on, and the data in the database can be converted into Excel data and the data processed to enable statistical analysis of the construction work data.

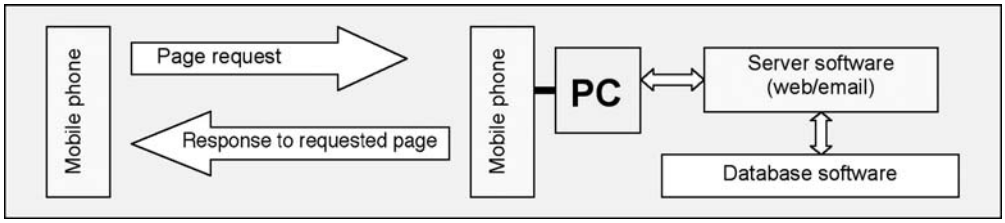


Figure 3: Construction work information system using mobile phones

SYSTEM DEVELOPMENT AND RESULTS OF SITE TESTINGS

Development and site testing of the system began in January of this year. The site was a 13-story commercial and residential complex of reinforced steel frame structure with a total floor area of 3,000 m^2. Figures 4-7 show some of the data obtained and the output results.

Figure 4 shows the data transmitted by the foreman using a mobile phone, passed through the system shown in Fig. 3 and finally recreated in the form of Excel data on a PC. Here, the data for categories 41-84 are shown with the problem level for each factor of the work displayed in four levels: 3 (poor), 2 (moderately poor), 1 (slightly poor) or 0 (normal). Categories 4-8 represent the total for three or four subcategories each. Category 9 indicates the cause in the event that a problem has occurred. Photographic data can also be attached to category 9, making it possible to actually see the problem.

Figure 5 shows the results in Fig. 4 processed to show the relationship between the percentages of work planned / completed, and the assignable causes. As the figure shows, on the days on which the planned work was not completed, assignable causes were present.

11.Site Name	Ginza 7choume New Building						
13.Name of Foreman	Ito						
23.Location of Work	**6F Slab**						
31.Kind of Work	Formwork(m²)						
	12.Working Day	27th/Jan	28th/Jan	29th/Jan	30th/Jan	31st/Jan	1st/Feb
3. Quantity per Unit	31.Planned Amount	331	105.4		137.2	502.9	49.1
	32.Completed Amount	272	131.2		237.4	502.9	42.1
	33.Completed Rate(%)	82	124		173	100	86
	34.Planned No of Worker	10	10		10	10	12
	35.No of worker Implemented	10	10		10	10	13
	36. Ratio of Worker Implemented	100	100		100	100	108
	3.Total of Quantity per Unit	27.1	13.1		23.7	50.3	3.2
4.Labor	41.Quantity						
	42.-IT						
	43.Skill Level						
	4.Total of Labor						
5.Material	51.Quantity						3
	52.-IT						3
	53.Quality						
	5.Total of Material						6
6.Machinery	61.Quantity						
	62.-IT						
	63.Quality/Capacity						
	6.Total of Machinery						
8.Construction Method	71.Procedure	3					
	72.Standard Operating Procedure						
	73.Instruction						
	7.Total of Construction Method	3					
8.Others	81.Safety						
	82.Previos Process					3	3
	83.Weather					3	3
	84.Others						
	8.Total of Others					6	6
9.Cause of Trouble		Error of Design of Door Frame				Error Fabrication of Steel Column	Prefabrication of Formwork was Delayed
		Error Cutting of Formwork				Rework	Transportation in Early Morning

Figure 4: Excel timeline data for formwork operation displayed on PC

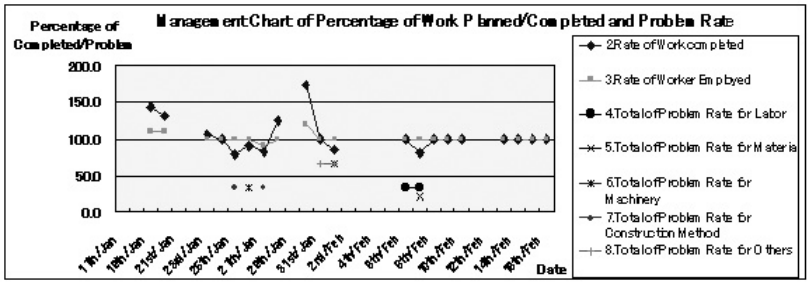
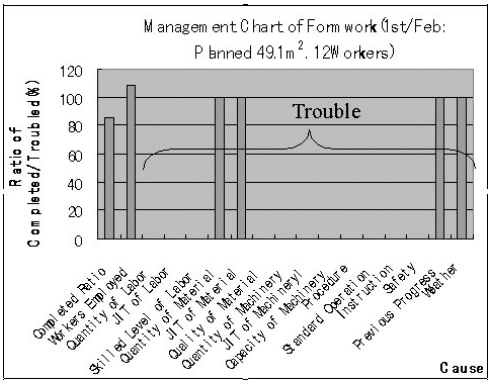
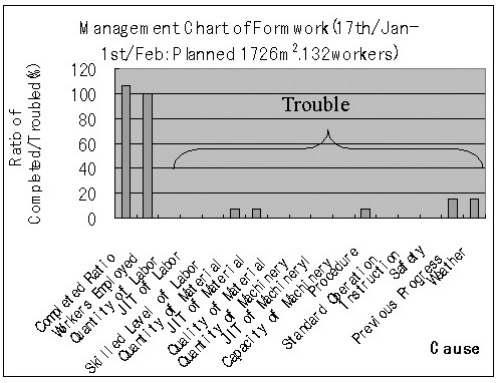


Figure 5: Timeline graph for percentages of work planned and completed / problem rate

On a mobile phone, it is possible to display a graph showing the percentage of work completed and the problem rate for a designated day and a designated period. The results are shown in Fig. 6 and Fig. 7.





(Converted from Excel data)

Fig. 6 Day-to-day results displayed on mobile phone Fig. 7 Average results for the period displayed on mobile phone

RESULTS AND DISCUSSION

The just-in-time sharing of construction work information using mobile phones as transmission devices made it possible for the foremen, the project manager, the engineers, the head offices of the contractor and subcontractor, and so on to join together and implement improvement activities, enabling lean construction to become a reality. This accumulated data transmitted by mobile phone enables not only problems at the site to be identified in order to execute lean construction but also to be progressed the efficiency of the construction process using knowledge management system in the future project. This system is particularly effective for large-scale worksites and worksites that cover a wide area. The accumulation of actual data in the future will improve this information system.

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