APPLICATION OF GPS FLEET TRACKING AND STOCHASTIC SIMULATION TO A LEAN SOIL EXCAVATION PRACTICE

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ABSTRACT: The unpredictable traffic condition around the construction site and the operator's uneven productivity often make it difficult to rapidly identify an optimum combination among various excavation and hauling units in a soil excavation process. Construction professionals often end up increasing the number of vehicles to manage unpredictable risk, which obviously increases the project cost. Kaizen, which is a Japanese lean production tool for a repetitive process, may facilitate construction professionals to rapidly identify the optimum combination between excavation and hauling units. This paper presents our investigation to figure out whether the GPS fleet tracking technology integrated with a stochastic construction simulation could facilitate the application of the Kaizen strategy to the process of figuring out the optimum number of hauling units for a soil excavation process.

Keywords*: Lean Construction, Kaizen, GPS, Simulation*

1. INTRODUCTION

Getting the optimum combination between hauling units at the early stage of any construction projects has been challenging. The unpredictable and dynamic traffic conditions around the job site, combined with inability of figuring out the hauling unit's operational pattern in real time, often hinder construction professionals from logically predicting the productivity of the fleet assigned to a project, which is a fatal shortcoming in terms of getting the optimum fleet combination identified. In order to handle the risk associated with the dynamic traffic conditions around the jobsite, construction professionals often increase the number of vehicles to be assigned, which obviously would end up increasing the project cost.

2. KAIZEN

Kaizen refers to a Japanese management strategy that demands constant and repetitive improvement in a repetitive process. A PDCA (Plan-Do-Check-Act) cycle represents the Kaizen's typical practice for detecting and eliminating waste in the operational process. It facilitates to 1) establish the objectives and processes to test new ideas, 2) implement the test, 3) monitor and evaluate the outcome of the test, and 4) apply actions to the outcome for necessary improvement. It is known that the Kaizen is more effective 1) when there are repetitive components in the process and 2) when it is applied to a new project that no one has ever experienced. For example, the Kaizen practice may work effectively for a soil excavation process in a foreign country.

3. TOOLS FOR KAIZEN IN CONSTRUCTION

At least two tools are needed to implement the Kaizen practice: 1) the tool for developing a test, and 2) the tool for monitoring the outcome of the test. For the fleet management process in a soil excavation process, these tools could be: 1) the tool for assuming the combination of the hauling units, and 2) the tool for monitoring the hauling unit's operational pattern.

Stochastic simulation can be utilized as a tool for assuming the combination of the hauling units. The Construction Industry Institute (CII) expected that construction simulation based on stochastic probability would facilitate to develop a reasonable construction plan that minimizes the impact of unforeseen variables [1]. Sensitivity analysis of the network provides the optimized balance among hauling units. FIATECH presented the construction simulation as one of the top 10 future technologies sought by many construction companies [2].

Geographical Positioning System (GPS) can be utilized for monitoring the operational pattern of the hauling units suggested by the simulation model. The city of New York used the GPS to monitor the operation of the dump trucks assigned to remove the debris from the WTC site, and was able to finish the project earlier than scheduled with less number of trucks than planned [3].

4. IMPLEMENTATION OF KAIZEN

Our research team applied the Kaizen theory to the soil excavation process of a road construction project in Sejoing City located in South Korea. Upon collecting the traffic condition of the designated routes, the capacity of various hauling units and excavators assigned to the project, and the variation of elapsed times required for the hauling unit's round trip, the research team developed a stochastic simulation model using the Arena Simulator. By implementing a series of sensitivity analysis, the research team suggested the optimum combination of the hauling units, loaders, and excavators.

As a next step, the research team developed a GPS-based fleet tracking system that can track down the locations of hauling units and display them on the Web browser in real time. The system is designed to identify the location of a truck using GPS, and transmit it to the Web-server over the wireless telephone communication. The research team then monitored the location of the hauling units in real time using the GPS-based fleet tracking system. The data collected here were compared with the outcome of the stochastic simulation model.

The difference between the simulation model and actual hauling units' operation can be used to come up with modified parameters for the stochastic simulation model. This process can be iterated until the gap between the simulation model and fleet's actual performance is minimized.

5. CONCLUSION

The application of the stochastic simulation model and the GPS-based fleet tracking system to the pilot soil excavation process demonstrated the potential of speeding up the process of getting the optimum balance between excavation equipments and hauling units assigned to the excavation process. We also had a chance to monitor the impact of the frequency of displaying the truck's location on the map to the process of understanding the operation pattern of the trucks. The privacy issue associated with the GPS-based fleet tracking system was also exposed. Although the type of contract has some controls over this issue, it would not be easy to apply the GPS-based tracking system unless its tangible and immediate benefits to the hauling unit operators are demonstrated. Our system may be better applied to an overseas project, where the general contractors purchase and operate construction equipments by themselves. Using the cons and pros discovered from the pilot application, our research team is currently improving the fleet tracking system using alternative wireless commutation technology.

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