The 6th International Conference on Construction Engineering and Project Management (ICCEPM 2015)
Oct. 11 (Sun) ~ 14 (Wed) 2015 • Paradise Hotel Busan • Busan, Korea
www.iccepm2015.org

Application of BIM-integrated Construction Simulation to Construction Production Planning

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***Abstract:** Traditional construction planning based on historical data and heuristic adjustment can no longer incorporate all the operational details and guarantee the expected performance. The variation between the expected and the actual production leads to cost overruns or delay. Although predicting reliable productivity on construction site is getting more important, the difficulty of this increases. In this regard, this paper suggested to develop BIM-integrated simulation framework. This framework could predict productivity dynamics by considering factors affecting on construction productivity at operational phase. We developed the following processes; 1) enabling a BIM model to produce input data for simulation; 2) developing the construction operation simulation; 3) running simulation using BIM data and obtaining productivity results. The BIM-integrated simulation framework was tested with structural steel erection model because steel erection work is one of the most critical process influencing on the whole construction budget and duration. We could improve to predict more dynamic productivity from this framework, and this reliable productivity helps construction managers to optimize resource allocation, increase schedule reliability, save storage cost, and reduce material loss.*

***Keywords:** Computer Simulation, BIM, Production Management, Just-In-Time*

I. INTRODUCTION

As construction projects become larger and more complex, traditional construction planning based on historical data and managers' heuristics cannot incorporate all the operational and managerial data. Thus, variations between the expected and the actual production occur every construction site. This fluctuation leads to problematic situations. For example, if the actual production is lesser than the expected production, materials will be remained, so material management cost increase and delay will happen. On the other hand, if the actual production is greater than the expected production, materials will be scarce, so money for enough labor and equipment will be wasted. Finally, the fluctuation between the operational productivity and plan makes managerial failure such as cost overruns or delay on construction project.

The reasons of difficulties predicting reliable productivity are construction's uniqueness and complexity. Every construction project has a unique characteristic because they differ in location, design, labor combination, and so on. Thus, the current construction planning based on historical data can no longer guarantee to reflect on the reliable productivity dynamics. Moreover, construction projects have many stakeholders; owner, contractors, politicians, local residents, and so on. And, stakeholders' interests are tangled. Therefore, practitioners heuristic can no longer include all the operational and managerial details.

In this regard, we developed BIM-integrated simulation framework to establish reliable construction planning. Building Information Modeling (BIM) includes project's information, so we could consider projects' uniqueness by using BIM data. Furthermore, we could incorporate diverse factors and consider those synthetically in simulation's virtual environment. In this framework, simulation used input data extracted from BIM. And, we could obtain dynamic productivity using running simulation. From the BIM-integrated simulation, we could obtain more reliable productivity dynamics, and this productivity will be contribute to optimize resource allocation. Until now, although the framework is under developed, we are planning to develop this framework to manager supply-chain and optimize resource allocation.

II. LESSONS LEARNED

A. Construction Simulation

While computer simulation has been developed in construction to improve estimating and planning [1], simulation parameters are mostly quantified based on historical average value [2]. This research suggest to use BIM data as input data for construction simulation in order to increase reliability of simulation values.

B. BIM Application

Whereas Building Information Modeling has been used for analyzing building quality [3], in construction management field, BIM data are only used for simple purposes such as using materials' quantity [4]. Thus, this study tried to expand the usable range of BIM data in construction management domain.

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C. *Lean Construction*

According to the Parade game theory in construction, the uncertainties of demander raise suppliers' inventory buffer [5]. In this research, we presented to establish reliable production plan on construction site from the BIM-integrated simulation, so we can contribute to achieve the expected level of efficiency the whole supply-chain.

III. BIM-INTEGRATED SIMULATION FRAMEWORK

A. *BIM-integrated simulation framework*

We developed BIM-integrated simulation framework, which is presented Figure I, for reliable construction planning. First, we developed commands which can extract BIM data, and BIM data interchanged to resource input which can be used for simulation. Second, we developed construction operation simulation included on critical factors affecting on productivity. Then, we ran construction simulation using BIM data, and obtained dynamic productivity then before.

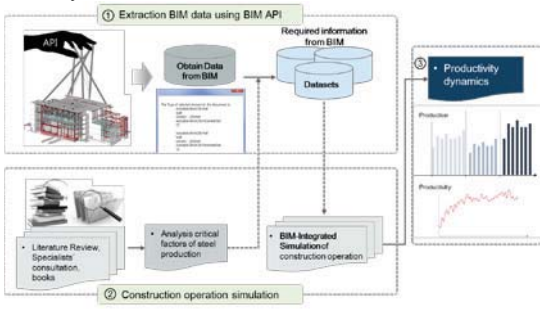

FIGURE I
BIM-INTEGRATED SIMULATION FRAMEWORK

B. *Application of BIM-integrated simulation framework*

1) Pre-processing BIM and producing input data: The developed BIM-integrated simulation framework was tested to steel erection work because steel work is one of the most critical process which influences on the whole project's duration and budget. First, we prepared a simple structural steel model, and developed commands using BIM APIs, which is shown in Figure II.

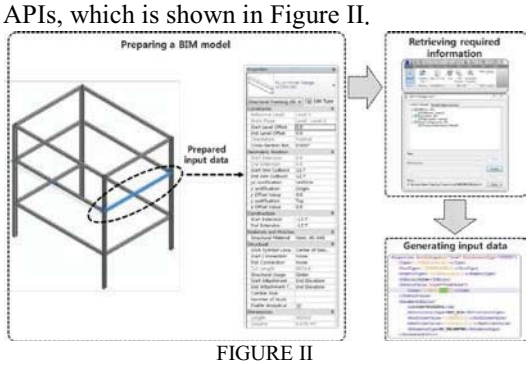

FIGURE II
DATA RETRIEVAL PROCESS FROM BIM TO SIMULATION INPUT RESOURCE

2) Developing steel erection work simulation: By reviewing literatures and interviewing experts, we investigates steel erection processes and critical factors affecting on steel work productivity. Then, we composed steel erection work simulation using Anylogic software, which is shown in Figure III.

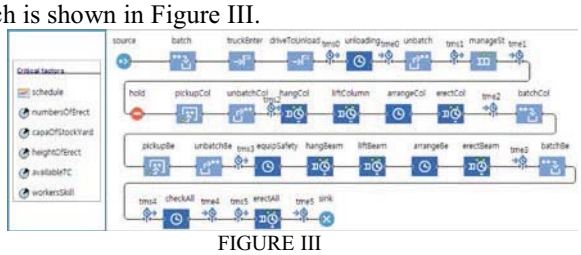

FIGURE III
STEEL ERECTION WORK SIMULATION MODEL

IV. RESULTS AND DISCUSSION

We supposed there are four individual models and erection works are performed as a sequence. Figure IV and Figure V provide the results of running steel work simulation based on BIM Data.

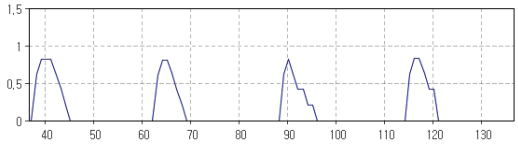

FIGURE IV
PRODUCTIVITY OF COLUMN ERECTION

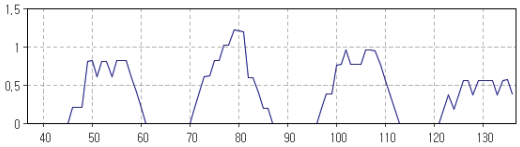

FIGURE V
PRODUCTIVITY OF BEAM ERECTION

We checked that construction managers can obtain more dynamic productivity planning by using the BIM-integrated simulation framework which is presented on this research. Furthermore, we could consider projects' unique characteristics by using BIM data, and projects' complexity through simulation. Moreover, if construction managers apply this framework to establish schedule, they can save time and cost to reproduce building information by reusing BIM data.

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