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BIM-based integrated approach for detailed construction scheduling under resource constraints

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ABSTRACT

Building information modeling (BIM) has been recognized as an information technology with the potential to markedly change the Architecture, Engineering, and Construction (AEC) industry, and has drawn attention from numerous scholars within the construction domain. Despite the reported advancements pertaining to BIM in previous studies, the extended use of BIM has not yet reached its full potential. This paper thus presents a BIM-based integrated scheduling approach which facilitates the automatic generation of optimized activity-level construction schedules for building projects under resource constraints, by achieving an in-depth integration of BIM product models with work package information, process simulations, and optimization algorithms. A developed prototype system for panelized building construction as an add-on tool for Autodesk Revit is described. A case study is subsequently presented to demonstrate the methodology. Building on the existing body of research in this field, the key contribution of the proposed research is the in-depth integration of BIM product model with work package information, process simulations, and an optimization model, which provides solutions addressing the challenges of the existing practice with respect to detailed construction scheduling under resource constraints.

1. Introduction

Building information modeling (BIM), described as "*digital representation of physical and functional characteristics of a facility*" [23], has been regarded as a potential solution to challenges within the Architecture, Engineering, and Construction (AEC) industry due to the following capabilities: (1) BIM is able to store all the information pertaining to a facility, which lays the foundation by which the BIM tools perform a variety of analyses, such as structural analysis and schedule planning analysis [29]; and (2) BIM can facilitate information exchanges and interoperability between software applications during the project life cycle [13], which boosts work efficiency and enhances communication and collaboration among project participants. Applications of BIM have thus garnered much attention within the construction industry in recent years. In particular, researchers and construction practitioners have explored different ways to perform schedule planning with the support of BIM. However, BIM in most cases functions as a database of 3D building components and provides only limited information of each component (e.g., quantity take-offs) for the downstream scheduling analysis. Rich building information embedded in BIM is not being fully utilized in order to facilitate the automatic generation of project schedules, entailing substantial manual work, especially in information exchanges between BIM modeling tools and scheduling tools. In this case, BIM in current practice offers only limited advantages over traditional 3D object models.

Construction schedules and plans should be formulated at the appropriate level of abstraction and detail [9], and construction activities need to be manageable from the construction perspective. As such, construction activities can be formulated by three rules: 1) type of work (distinct activities requesting different resources); 2) operationally significant function (distinct activities carried out on components with different functions); and 3) operationally significant location (distinct activities carried out in different zones) [10]. Nonetheless, these three general rules are not sufficient to cater for the needs of some projects such as panelized building projects. Defining activities/processes in panelized construction should distinguish each individual building component, instead of distinguishing each construction zone, in that each pre-fabricated component is unique and needs to be installed at its own designed location and be scheduled individually in order to manage and coordinate factory production and on-site construction processes. In the current practice most construction schedules generated from BIM are formulated at the project level where constructing one building component is usually assumed to be one construction activity, or at the construction zone level where activities are defined for particular construction zones. These activity-level schedules do not delve into different construction operations which request different resources in accordance with specific construction methods in order to build individual building components. Moreover, when construction

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