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A BIM-based construction supply chain framework for monitoring progress and coordination of site activities

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Abstract

In spite of the growing implementation of Computer-aided technologies and Building Information Modeling (BIM) in AEC industry, building activities in construction sites are ineffectively monitored even now. Current formats of reporting and communicating the construction progress (e.g., textual progress reports, progress lines, and photographs) may not properly and quickly communicate the construction progress. In the proposed research the capability to communicate progress information right away and to share an Interactive Building Model (IBModel) are identified as the key components for successful management of the site and the supply chain network. This is carried out establishing the involved actors (Owner, Site Director, Site Safety Coordinator, Construction Companies and Suppliers) and setting them several options for the information management and visualization within the BIM environment. The monitoring system comes from the integration of the building and construction site model bestowing the visualization of site conditions on a set of graphical parametric rules, such as: chromatic visualization of building components referred to objects' completion percentage; thematic views, automatically extracted and updated, representing the real site conditions; and so forth. The monitoring system, supported by the BIM-based visualization model and managed in a Cloud computing seems to be one of the right directions for improving safety condition on one hand and site productivity and control on the other one.

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Keywords: building information modeling; field BIM; monitoring system; site management and control; supply chain management

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1. Introduction

In recent years, with the increasing level of competition in the AEC Industry, several research efforts have focused on the application of information technology (IT) as a way to improve the integration process of Construction Supply Chain Management (CSCM) [1]. Visual representation of the process can provide an effective tool for monitoring resources and construction process in the CSCM. At the same time, Building Information Modeling (BIM) has played a pivotal role in reforming the information flows in the construction supply chain. Extensive worldwide efforts have been undertaken to enhance different aspects of BIM implementation in various domains, including how to improve a collaborative work on the construction site. In fact, BIM enables information creation and reuse throughout the project life cycle and for that reason it also facilitates collaboration and provides a database platform for site management during its progression. This platform, when coordinated, integrated, and preserved properly, can be effectively used to support various operations.

This study proposes to integrate BIM and CSCM within an on-going site monitoring system. It is based on the implementation of a BIM-based information management and control system within a cloud environment for monitoring the progress of construction operations through the analysis of data coming from the construction site and collected by means of construction apps and mobile devices directly by the main construction actors: General Contractor, Subcontractors, Suppliers, Site Safety Coordinator and Site Director.

The paper is structured as follow: Section 2 reviews three fields that are strictly connected with the proposed workflow, such as the integration of the supply chain management in the construction process, the use of construction apps on site and the relationship between BIM and traditional monitoring systems; Section 3 explains the methodology which are tested in case study widely illustrated in Section 4; finally, Section 5 discusses results and future developments.

2. Background

From the end of the 1980s, the construction industry has seen the launch of a number of supply chain management (SCM) initiatives which have been focused on four major roles of SCM in construction [2] depending on whether the focus is on the supply chain, the construction site, or both: (a) Improving the interface between site activities and supply chain which aims to reduce their costs and duration (b) Improving supply chain itself with the goal of reducing costs, especially those relating to logistics, lead-time and inventory (c) Transferring activities from the site to the supply chain, (d) Integration of site and supply chain.

In this regards, the use of information technology (IT) is suggested to achieve better logistics processes, indeed, various IT applications have been used in the literature as a way to improve the integration process of CSCM [3]. These applications have harnessed the capabilities of IT to facilitate the mapping of time and cost resources and also transportation analysis and optimization models to improve logistics performance [4]. In the recent year the use of IT–based tools comes in the direction of BIM which on one hand combines the design and visualization capabilities with the rich parametric object and attributes modeling and on the other hand provides the integration of digital building models with construction site by using integrated BIM platforms.

Concerning the integration of site and supply chain, traditionally project information is acquired during on-site inspections and data is recorded in paper-based documents to be shared with the supply chain [5]. On the other hand, Mobile devices are more and more used on site in order to acquire and process data [6] to improve information management and to increase operational efficiency [7]. Currently there are many construction applications available for activities such as quality control and construction management. However, the majority of the mobile applications being used by construction companies on site are not construction apps, but file sharing and weather ones [8]; that is the reason why new tools are emerging containing all these potentialities into a single platform. Some of these technologies can be effectively linked with BIM authoring platforms; anyway, the full potential of mobile technologies implemented within a BIM Environment can be achieved only when the information obtained on site is effectively shared among project participants, supporting the decision-making process [9]. Traditionally, project information and construction site photographs are acquired during on-site visits and inspections and data are recorded in paper-based documents to be shared with the office team [5]. Information technologies create opportunities for increased efficiency of information exchange, eliminating the need to manually copy data already