BIM Integrated Workflow Management and Monitoring System for Modular Buildings

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ABSTRACT

The authors are collaborating with a manufacturer of custom built steel frame modular units which are then transported for rapid erection onsite (volumetric building system). As part of its strategy to develop modular housing, Enemetric, is taking the opportunity to develop intelligent buildings, integrating a wide range of sensors and control systems for optimising energy efficiency and directly monitoring structural health. Enemetric have recently been embracing Building Information Modeling (BIM) to improve workflow, in particular cost estimation and to simplify computer aided manufacture (CAM). By leveraging the existing data generated during the design phases, and projecting it to all other aspects of construction management, less errors are made and productivity is significantly increased. Enemetric may work on several buildings at once, and scheduling and priorities become especially important for effective workflow, and implementing Enterprise Resource Planning (ERP). The parametric nature of BIM is also very useful for improving building management, whereby real-time data collection can be logically associated with individual components of the BIM stored in a local Building Management System performing structural health monitoring and environmental monitoring and control. BIM reuse can be further employed in building simulation tools, to apply simulation assisted control strategies, in order to reduce energy consumption, and increase occupant comfort.

Keywords: Building Information Model, Enterprise Resource Planning, Modular Structure, Prefabrication, Volumetric Construction

DOI: 10.4018/ij3dim.2013010103
1. INTRODUCTION

In an increasingly technology driven world where everything is beginning not only to be intelligent but also interconnected while also driven by green pressures (such as energy efficiency, life cycle performance and costs etc.), society is placing ever increasing demands on industry to improve their products by taking advantage of new technologies. At the same time, companies have to comply with increasingly stringent performance requirements imposed by the pressures of sustainability and climate change. As part of its strategy to develop modular housing, Enemetric (a small Scottish manufacturer of volumetric building systems) is taking the opportunity to develop intelligent buildings, integrating a wide range of sensors and control systems for optimising energy efficiency and monitoring structural health, while adopting a Building Information Modeling (BIM) approach throughout the design process and in the future, deploy BIM in construction and lifetime management. Furthermore, when combining BIM with real-time monitoring of energy consumption and structural health with simulation techniques (dynamic thermal simulation, on-line structural assessment) a robust and intelligent solution for managing modern buildings can be developed.

Modern information and communication technology enables unparalleled collaboration of systems and user groups, and a wide choice of sensor/actuator topologies in terms of wired/wireless layers. This is leading to a requirement to efficiently define methods of managing the explosion of data and more importantly, appropriately linking and making sense of the information logically.

Companies and practitioners currently promote BIM as a tool to share data between various user groups as a way of efficient dynamic workflow, and effective project planning, but the concept has tremendous weight as a technology for the building to manage itself by combining the static building data with the dynamic data generated from monitoring subsystems. In other words, BIM needs to be encapsulated in the Building Management System (BMS) layer, whereby the BMS has full knowledge of the BIM and is better equipped therefore to manage itself. The combination of the BIM data with building behaviour data collected by the BMS can help to predict scenarios (to optimise or mitigate) and with the provision of data on a community wide scale, techniques such as Demand Side Management make efficient shared resource allocation possible for renewable energy sources.

The structural robustness of the Enemetric modular systems under extreme loads such as earthquake and fire have been carried out using detailed finite element models. A BMS system with structural monitoring component has been installed in a sample house, with system identification being carried out through continuous real-time monitoring of ambient and forced vibrations, as well as energy and environmental monitoring with heating and lighting control. Full structural dynamic models and thermal models of the sample house have been constructed to help assist in developing integrated control and maintenance strategies. A BIM approach has been used, combining energy and structural monitoring, with optimising procedures, optionally assisted by simulation. These concepts shall be discussed.

2. TOWARDS A BIM MANAGEMENT SYSTEM

BIM evolved as a superset of the 3D CAD model of a building, containing parametric information supplemented with object relationships, which can support the simulation of a building virtually, permitting experimentation, by modification of design parameters. BIM is therefore, geared towards automating the creation of optimised buildings (in terms of energy use and structural design), and management of building data. However the current methodology does not include further methods of data collection and storage through online monitoring, and additional manipulation through data analysis in simulated models can help to improve per-
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