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BIM and CMMS for IBS building maintenance in Malaysia

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Abstract. IBS construction is gradually increasing in many building projects in Malaysia. The projects have involved modern, contemporary and innovation design for construction. The increase of demands for IBS construction every year indirectly contributes the building and infrastructure development but maintenance management however is poor, possesses low defect diagnosis and limited decision making process to repairing. These problems become more complicated in complex and high-rise building projects like Malaysia to which IBS building construction is practiced. Conventionally, the repairing maintenance method (fragmentation approach) has been criticized for serious unacceptable quality or productivity, budget and concept of the IBS building maintainability (reworks and delay). Therefore, a novel and more sophisticated technique is proposed for improving defect diagnosis and decision making process by employing BIM and CMMS integration in maintenance management on IBS buildings in Malaysia.

1. Introduction

An Industrialised Building System (IBS) is the new construction technology involving the use of on-site and off-site (factory producing) prefabrications for installation to improve the construction efficiency (e.g. components keeping and sustainable building projects) [1,2]. The adoption of IBS construction (IBS or a hybrid IBS) can be considered as an alternative option in maintaining sustainability in construction using pre-fabricated components that are systematically done using machine, formwork and other forms of mechanical equipment. The IBS construction provides the most advantageous solutions in terms of better control maintenance cost, shorten construction period and increase the quality of buildings [3,4,5]. However, as IBS construction projects grow in scale and complexity, repairing maintenance method (fragmentation approach) can be noticed in a problematic maintenance management to monitor the defects comprising diagnostic testing for the corrective and preventive maintenance action [6,7]. The repairing maintenance method to the project delivery and its failure to form effective communication channel between complementary knowledge on IBS construction and construction members that is conducted in the sequential manner has resulted in ineffectiveness for managing building maintenance, where a paradigm shift within the IBS traditional approach is necessary. Furthermore, the need for sophisticated tools and techniques using an appropriate Information and Communication Technology (ICT) (e.g. Building Information Modelling (BIM) and Computerised Maintenance Management System (CMMS)) for implementing an integrated approach in the design and construction could facilitate new maintenance management processes for IBS building construction projects in the future [8,9].

This paper reviews BIM and CMMS on maintenance management and explores the factors affecting BIM and CMMS requirement. The roles and effects of BIM and CMMS integration on IBS



building maintenance are also highlighted. The paper concludes with a discussion of the findings showing the outline features of a research framework for more effective applications of BIM and CMMS integration in maintenance management on IBS buildings in Malaysia.

2. Building Information Modelling (BIM)

Building Information Modelling (BIM) technology is an accurate virtual model of a building which is digitally constructed (Three-Dimensional) 3D Models [10]. Today, BIM application is in full swing practices and the concept of BIM is to collect the vital information from the model to analyze the beneficial alternative in the early stages of the construction design [11]. BIM also has provided the integration for the information database of building components to document a building design and construction [12]. Furthermore, it has been articulated that BIM has saved 683 hours for the management efficiency compared to the 2D Computer Assisted Design (CAD) application for a particular project in different phases in construction. The tasks involved are schematic, design development, construction documents, inspection and coordination. Besides, the construction documents use of a building design took minimum rate hours, 815 hours to BIM and saved 208 hours more than using 2D CAD application. The BIM platform enables to assemble all information into one location and cross-links that data between associates objects compared to 2D CAD which has no linkage between the created data [13].

3. Computerised Maintenance Management System (CMMS)

CMMS software was seen first around 1976 and today, it is widely used in maintenance management all over the world. CMMS provides inventory activity for facility assessment to reduce maintenance problems [14]. This application covers the wide spectrum of building and infrastructure components such as specifying work location, labour, material and equipment needed as well as desired completion date [15]. CMMS also supports the maintenance management budget and long term financial commitment to attain returns benefits of financial management.

4. Factors affecting BIM and CMMS requirement

The absence of available diagnosis tools and guidelines of cooperation among construction parties create an additional cost to redesign the project when measuring the maintenance delivery in IBS construction [16]. The repairing maintenance method (fragmentation approach) restrict contractors and manufacturers from being involved in the design stage of a performance project, which often results in design changes and a corresponding maintenance and operation cost increase including construction time, production and labour cost [17,18]. According to [19] and [5], the management level in Malaysia, monitoring, diagnosing technology and repairing maintenance method of IBS buildings is far behind some developed countries. Compared with the relatively high level of IBS construction in the USA and Japan, the supporting technologies and large-scale production systems (such as supervision systems and matching construction technologies) are used to improve the construction maintainability of components and could diagnose the maintenance problems with safety monitoring process to prevent the building construction accidents [20]. Low defect diagnosis for building maintenance may cause great economic losses and personal casualty incidents due to the disaster building defect. For example, concrete roof of the Gong Badak stadium collapsed in Kuala Terengganu on June 2, 2009 [21]. The roof structure crash occurred under construction for SMK Taman Connaught in Kuala Lumpur and three labours were injured on Jan 15, 2010 [22]. In addition, a few of ceilings at a Hospital Serdang in Selangor collapsed for a third time as a result of its structural failure (steel corrosion) on November 14, 2013 [23]. Thus, the management of maintenance in the complex and high-rise buildings claims a high emphasis on the systematic process for the improvement of maintenance management system of IBS construction.

The inefficiency in decision making process has been found to be a major cause of aesthetic and functional faults [24]. The defects include cracks, blemishes, moisture penetration, water leakage due to improper jointing and poor thermal insulation [25]. Many factors stimulate ineffective decision

support to provide the sufficient information of maintenance strategy with the extensive coordination on technical knowledge requirements and schedules prior to maintenance operations of project implementation, however poor maintenance management or repairing maintenance method (fragmentation approach) deficiency can give a major impact to the IBS building maintenance activities [24]. According to [16], the main reasons for not optimum decision making on IBS building construction projects were lack of knowledge and exposure to IBS technology, since the resolution implementation were based on familiarity and personal preferences (e.g. experience of the design team) rather than rigorous data between team members through regular meetings. This is also supported by [26], who agree with that the incorrect strategic decision at the initial project phase was a major cause of cost overrun and supply chain integration problem due to lack of comprehensive principles in the maintainability approach such as measuring convention, standardisation, buildability score and open system practices among IBS construction teams. The integrated decision making process with the maintenance strategy from the design stage to the installation of components is needed that can significantly improve the repairing maintenance method of IBS building construction projects [27]. This could realise with a good management system with the implementation of ICT, to enhance managing efficiency for both defect diagnosis and decision making process, thereby establishing a more effective maintenance strategy for an IBS building construction.

As a result of the inherent weaknesses in maintenance management at IBS building construction, an alternate maintenance management model is proposed, namely, Computerised Maintenance Management System (CMMS). The CMMS model is engaged in the sophisticated system (e.g. BIM model) to improve the characteristic element with the defect diagnosis and decision making process. The significant factor to select a CMMS is much more advantageous than just a way to schedule maintenance management processes and able to perform the task needed without stressing the budget [28]. The CMMS does not make decision, rather it provides the maintenance manager with the best information which affects the operational efficiency of a facility [29]. Meanwhile, the BIM model could assist in communications and quick decision-making in the inspection to be efficiently operated the building projects [30].

5. Roles of BIM and CMMS integration on IBS building maintenance

CMMS are among the approaching technologies utilised for reducing the downtime of equipments and facilitate the accessibility information to the staff for maintenance management [31]. CMMS is the technology management and includes all computer systems and networks, building automation systems such as control systems and programmable logic controllers, design drawing databases, an all diagnostic and monitoring systems [32]. The system is implemented to record numerous data from papers and forms in order to ease the information administration and optimised a building maintenance to strike a balance between cost and reliability in the organisation [33]. Quality CMMS is also able to provide the maintenance assessment resulted from the coherent fashion for analysis of relevant information in the database [34]. The specification of data such as the history of defect structure from the previous years is collected into the system for assisting staff to suggest the maintenance implementation effortlessly in managing complex building during design and construction stages. The schedule planning and the work orders enable the monitoring of the concrete structure and manage the budget constraints strategically [35].

BIM is defined as the use of ICT technologies to improve the building construction processes to be more operationally maintenance throughout the building lifecycle [36]. BIM has allowed implementing manufacturing concepts such as lean design and modularisation (e.g. IBS building components) into construction. Lean design is a tool for improving the component design on the conventional method (e.g. in situ construction). Besides, BIM is also assisting to monitor the specification of IBS building site planning, for instance, building fabrication, assemblies and subassemblies economically as well as technologically [37]. The use of BIM application in construction sites has been observed for a prominent benefit of better production quality toward the documentation output. The data transfer in the documentation is flexible and exploits automation for

the maintenance diagnosis information which enables to trace the concerned recorded of building components in the construction projects [38,39]. Furthermore, the design changes can be resolved more quickly in a BIM system because modifications can be shared, visualised, estimated and resolved without the use of time consuming paper transactions. Some modifications can be made automatically based on the established parametric rules or through clash detection [40]. The parametric rules consist of geometric definitions, associated data and rules in order to extract consistent drawings and reports of geometric parameters [39]. According to [41], the maintenance management practices in the construction projects become intelligent by developing a BIM model in remote construction project. This BIM model can provide the effective design and technical review to improve the consistency and accuracy drawing for the construction management in the future such as changes to specifications, specified materials, effective maintenance planning and scheduling [42,43].

6. Effects of BIM and CMMS integration on IBS building maintenance

The deployment of sophisticated system (e.g. BIM and CMMS) resulted to improve IBS building maintenance as discussed in Table 1.

Table 1. Effect of BIM and CMMS Integration on Various Applications.

Research	Type of System	Function
Motawa & Almarshad [44]	Knowledge BIM-Based System	To use priority in the maintenance planning and strategy for maintenance execution in the design/construction/operation of buildings using case-based reasoning (CBR)
Liu & Issa [45]	BIM-assisted Facility Management	To provide automatically identifying equipment and facility including supporting operational and strategic management of buildings in the design and construction phases
Stack <i>et al.</i> [46]	BIM-based Computer-Aided Facility Management (CAFM)	To support the building and energy efficiency analysis and monitoring the maintenance operation with a combination of Integrated Project Delivery (IPD)
Asen, Motamedi & Hammad [47]	BIM-based Visual Analytics Approach (Integration with COBIE)	To identify, assess the defect problems based on the visual analytics for building
Sue, Lee & Lin [48]	BIM-based Facility Management (BIMFM)	To support the 3D CAD-based models for identifying, tracking, coordinating and accessing particular building maintenance into a database system

The improvement of BIM and CMMS integration as stated in Table 1 will support the defect diagnosis and decision making process on IBS building maintenance.

7. Concluding remarks

Taking into account that BIM and CMMS integration to be a promising technique for improving defect diagnosis and decision making process. A focused research in a more comprehensive area is desired for more effective application of BIM and CMMS in IBS building maintenance. This review has highlighted that BIM and CMMS integration is a potential method in maintenance management on IBS buildings in Malaysia.

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