Improving Building Maintenance Performance with BIM Technology in Hospital Building: A Systematic Literature Review

Mardhiah Farhana Omar*, Zul Atfi Ismail

Faculty of Civil Engineering & Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia

ABSTRACT

The adoption of traditional methods in the building maintenance team with a set of documents such as as-built drawings, 2D plans, specifications, and manuals still used for building operation and maintenance makes the maintenance techniques performance for hospital buildings ineffective and unsatisfactory. This finding highlights the importance of proper building maintenance management for government buildings to maximize the value of the allocated budget and extend the life cycle of the building. The lack of descriptive tools for understanding, visualizing and documenting sensor results has encouraged researchers to use powerful tools such as Building Information Modeling (BIM). Technology from BIM can help improve building maintenance and facilitate monitoring of damage to existing structures and infrastructure. The benefits of BIM for building maintenance include information management capabilities, design integration, and manageable project delivery. This study was conducted to examine approaches and techniques for identifying building deficiencies and future plans in this area. This analysis used PRISMA (pre-recorded systematic review and meta-analysis technique), a published guide for conducting a systematic literature review (SLR). Key papers on this topic published between 2011 and November 2022 were examined. After reviewing nine journal publications, research trends, methods, methodologies, gaps, and future goals related to BIM in monitoring and maintenance were identified. Key topic areas and resources used by BIM to improve project outcomes are illustrated through data summaries and article content. In addition, this publication has attempted to define future research perspectives to advance this area of research. However, the design-build drawing process and its relationship to the BIM model of the entire management life cycle require further research or investigation. In summary, BIM has gained importance due to the widespread use of tools in the architecture, engineering, and construction industries to represent and manage information about structural systems and situations.

Keywords: Thesis, building defect, building maintenance technology, BIM.

1. INTRODUCTION

Building defects are caused by design defects, material defects, workmanship defects, and aging of the building. Criteria for construction defects include concrete in the structure, defective floor tiles, damaged ceilings, collapsed gutters, leaking pipes, cracks in the foundation, deformation in the foundation, and settlement in the foundation [1]. Unfortunately, studies such as [2,3,4] show that maintenance techniques for government buildings are ineffective and unsatisfactory. These findings highlight the importance of proper maintenance management for public buildings (e.g., schools, offices, and hospitals) to maximize the value of the budget allocated to public facilities and extend the life cycle of the building. However, the main problems in building maintenance are the use of traditional systems for maintenance management, including paper-based reports and disorganized databases. Therefore, BIM can play an important role in automating construction maintenance operations to be more effective and faster. The two most important aspects of building condition assessment during building maintenance monitoring that can be improved through the applications of BIM are speed and accuracy. Modeling can improve facility monitoring standards and management practices [5-8]. Although BIM maintenance monitoring programs

* Corresponding authors: mardhiahf@studentmail.unimap.edu

and techniques have gained widespread recognition over the past two decades, important questions regarding the use and importance of building information models in building maintenance monitoring still need to be answered. These questions include the methods are used to identify construction defects, the latest issues and advanced techniques in construction defects and the future plans in this field.

2. METHODOLOGY

This analysis used PRISMA (pre-recorded systematic review and meta-analysis techniques), a published guideline for conducting a systematic literature review (SLR). In general, publication guidelines are necessary to assist authors in assessing and verifying the accuracy and thoroughness of the review with relevant and important details. Randomized review of study evaluations which can be a critical component of reporting systematic reviews for other types of studies is another aspect of PRISMA that is highlighted [9].

2.1 Identification

The methodology for comprehensive review of all work related to building defect management is applied in the context of building maintenance management. Web of Science and Scopus were reviewed for searches conducted on November 22, 2022. In selecting a set of appropriate papers for this report, the systematic review consisted of three main phases. The first step is to identify key words and search for related, similar terms based on thesauri, dictionaries, encyclopedias and previous studies. Accordingly, after all relevant keywords were determined, a search string was created in Web of Science and Scopus. In the first step of the systematic review, 25 papers were found from both databases.

2.2 Screening

In the first screening phase, duplicate publications were ignored. In the second phase, 16 publications were screened based on a set of inclusion and exclusion criteria established by the researcher, while six articles were excluded in the first phase. The first criterion is literature, as it is the primary source of useful knowledge. In addition, publications in the form of systematic reviews, meta-syntheses, book series, books, chapters, and conference proceedings were excluded from the current study. In addition, the study was limited to English-language studies. The time frame was selected for a two-year period (2011–2022).

2.3 Eligibility

The third step, called qualification, requires the creation of 13 articles. In this step, all article titles and main text were carefully reviewed to ensure that they met the inclusion criteria and research objectives of the current study. Two papers were excluded because they were not purely scientific papers based on empirical data. Nine papers were finally made available for analysis.

2.4 Data Abstraction and Analysis

Nine papers were carefully reviewed by the authors for assertions or details that address the issues raised in this study. After analyzing the investigation of construction defects and the development of BIM, the authors and professionals form an important group. Defect investigation, knowledge and problem solving are the three main outcomes of this strategy. Both search results were combined into one list excluding literature reviews and duplicate articles, resulting in 278 articles that correspond to the research topic. After reading the articles, they are classified into different groups according to the topic. Since the use of BIM in building maintenance monitoring is a new topic for researchers, there is no comprehensive approach for

a specific topic. Therefore, articles related to BIM in terms of maintenance and monitoring steps are also reviewed. Flow diagram of the proposed searching study and PRISMA SLR is shown in Figure 1.

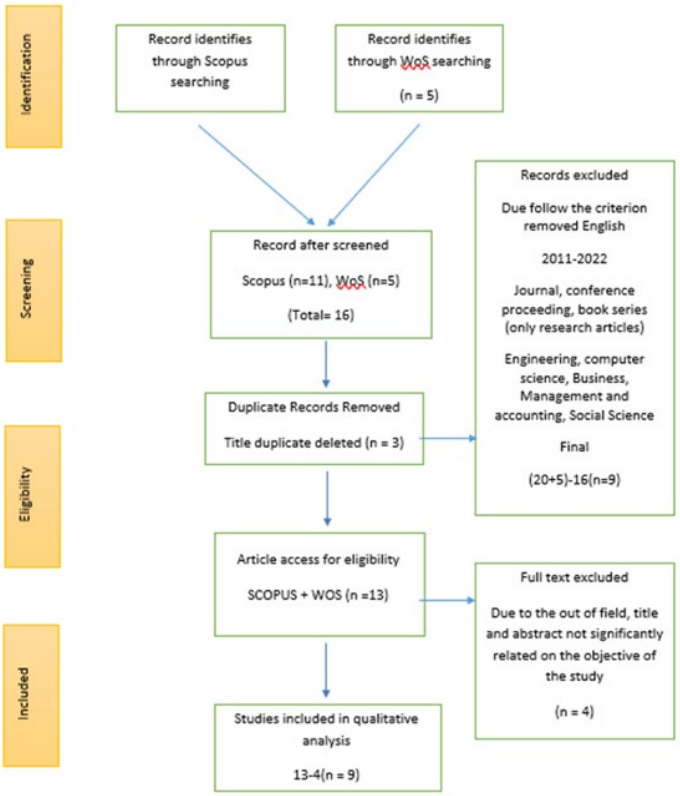

Figure 1. Flow diagram of the proposed searching study [9].

3. RESULTS

Based on the search technique, nine articles were extracted and evaluated. Three main themes-defect inspection (three articles), building maintenance knowledge (three articles), and problem solving (three articles)-were used to categorize all articles. Table 1 shows the results of the research articles based on the proposed search criteria.

Table 1 The research article finding based on the proposed searching criterion

No.	Authors	Title	Year	Source title	Themes
1	Chow, J.K., Liu, K.-F., Tan, P.S., Su, Z., Wu, J., Li, Z., Wang, Y.-H.	Automated defect inspection of concrete structures	2021	Automation in Construction	Defect inspection
2	Eskandari, N., Noorzai, E.	Offering a preventive solution to defects in commercial building facility system using BIM	2021	Facilities	Defect inspection
3	Ismail, Z.-A.	How BIM systems affect maintaining IBS building	2020	Facilities	Building maintenance Knowledge
4	Ismail, Z.-A.	Implementation of BIM technology for knowledge transfer in IBS building maintenance projects	2020	International Journal of Building Pathology and Adaptation	Building maintenance Knowledge
5	Ismail, Z.-A.	Lesson learned in maintaining the precast concrete buildings	2020	Journal of Facilities Management	Building maintenance Knowledge
6	Xu, Z., Li, S., Li, H., Li, Q.	Modeling and problem solving of building defects using point clouds and enhanced case-based reasoning	2018	Automation in Construction	Problem solving
7	Ismail, Z.-A.	Improving conventional method on precast concrete building maintenance Towards BIM implementation	2017	Industrial Management and Data Systems	Problem solving
8	Chen, JJ; Lu, WS; Lou, JF	Automatic concrete defect detection and reconstruction by aligning aerial images onto semantic-rich building information model	2022	Computer-Aided Civil and Infrastructure Engineering	Defect inspection
9	Hamledari, H; Azar, ER; McCabe, B	IFC-Based Development of As-Built and As-Is BIMs Using Construction and Facility Inspection Data: Site-to-BIM Data Transfer Automation	2018	Journal of Computing in Civil Engineering	Problem solving

4. CONCLUSION

This study presents a systematic review of the applications of BIM in maintenance management monitoring and structural maintenance. In general, 25 papers published between 2011 and 2022 were selected. Limitations and improvements are presented, with a focus on maintenance and monitoring performance. Key topic areas and resources used by BIM to improve project results are indicated through data summaries and article content. In addition, this publication has attempted to define future research perspectives to advance this area of research. However, the design-build drawing process and its relationship to the BIM model of the entire management life cycle need further research or investigation. Data analysis revealed that most of the relevant publications have appeared in the Journal of Automation in Construction and Infrastructure. The benefits of using BIM for cost and time management are discussed in this paper. About 92% of the analyzed publications were published in the last 11 years indicating a large number of research papers on the use of BIM for monitoring and maintenance.

i. When analysing the content based on keywords and reviews, the articles can be divided into three groups. Some articles stand out for their ideas and goals, while others are highlighted for their unique case studies. Inspecting for defects, understanding building maintenance and troubleshooting are considered key topics in building maintenance. In general, there are problems in determining the location of building deficiencies, causes, data and documentation issues, challenges that often make maintenance management ineffective and cause problems with time and money. The main challenge researchers face in building maintenance studies especially in addressing building defects in different studies is the need for additional analysis and experimental efforts.

ii. Several methods are used to identify building defects are various technologies including 360° cameras, digital LiDAR and aerial photography can be used to improve the monitoring process and decision accuracy. However, obtaining sophisticated component information with affordable sensors, investigating different sensor technologies for non-destructive testing (NDT) such as spectroradiometers for defect detection and improving the system's intelligent functions to obtain the best algorithms for all conditions remain challenges for researchers and must continue in the future.

iii. Monitoring and assessing risk or damage is facilitated by integrating the processes of BIM with additional platforms such as Computerized Maintenance Management Systems

(CMMS), multi-attribute selection, and scanning technologies. The accuracy of this process is further enhanced through the use of higher dimensional BIM technologies such as 6D modeling that incorporates data from 3D models as well as time, cost, and carbon footprint analyze. However, in addition to the aforementioned program studies, long-term monitoring, load monitoring, watertightness, fatigue, steel corrosion, concrete creep and other environmental effects are also important and need to be given greater consideration.

iv. TPM successfully prevents system outages during operation and maintenance hours. As a result, building managers can take TPM based action to prevent outages by evaluating results through an integrated platform BIM.

v. In order to demonstrate the evolution of building maintenance monitoring and decision making during the building life cycle, the effectiveness of combining BIM technology with real-time remote sensing tools in the building maintenance process is examined. Key advances in this area include consideration of risk measures in building maintenance management, time and energy savings through simulation in building management, and consideration of FM throughout the design process. Disadvantages of using BIM for FM include limited energy savings in mechanical, electrical and plumbing systems. Communicating and documenting data or parameters in the building maintenance process and minimizing the environmental impact of building maintenance activities.

vi. Due to the lack of standards for all modeling techniques, researchers have only examined the use of BIM in monitoring under various assumptions, as there are significant research gaps in all current studies. In addition to considering how the environment may affect the monitoring of recurrent construction hazards and defects, other important gaps include the expansion of BIM model data and the management of large data sets.

Consequently, a BIM model was developed for the owner during the operation phase to ensure the effective implementation of building maintenance management. Apart from that, this review study can be a useful reference for those interested in using BIM for building maintenance management.

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