Incorporating the Applications of Building Information Modeling (BIM) Technology in the Sustainable Retrofitting of Heritage Buildings: A Systematic Review

Aawag Mohsen Alawag
Civil and Environmental Engineering
Universiti Teknologi PETRONAS
Seri Iskandar, Perak, Malaysia
aawag_17006581@utp.edu.my

Wesam Salah Alaloul
Civil and Environmental Engineering
Universiti Teknologi PETRONAS
Seri Iskandar, Perak, Malaysia
wesam.alaloul@utp.edu.my

M.S. Liew
Civil and Environmental Engineering
Universiti Teknologi PETRONAS
Seri Iskandar, Perak, Malaysia
shahir_liew@utp.edu.my

Eman Ali Al-awag
Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia,
86400 Batu Pahat, Johor, Malaysia
eman12ali@gmail.com

Abdullah O. Baarimah
Civil and Environmental Engineering
Universiti Teknologi PETRONAS
Seri Iskandar, Perak, Malaysia
abdullah_20000260@utp.edu.my

Mazen M. Omer
Civil Engineering Technology
Universiti Malaysia Pahang,
Gambang 26300, Malaysia
mazentri@gmail.com

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***Abstract*— The sustainable retrofitting of heritage constructions presents a unique set of challenges that require a comprehensive approach to address the historical and cultural significance, as well as energy efficiency, functionality, and safety. Building Information Modeling (BIM) technology has emerged as a promising tool for addressing these challenges. Thus, the purpose of this paper is to highlight the literature on the applications of BIM technology in the sustainable retrofitting of heritage constructions, with a focus on the advantages and challenges of this approach. To achieve this study's aim, the relevant literature was extracted from the Scopus database. Therefore, 41 papers were extracted from Scopus using a keyword search approach. Throughout the year 2013 to April 2023, the keyword search criteria contained the phrases "BIM" AND "HERITAGE" "Retrofitting" AND "CONSTRUCTION" OR "REPAIR.". In addition, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used, and 14 out of 41 papers were chosen for comprehensive evaluation. A thorough examination of the selected articles highlighted the influence of BIM technology in the Sustainable Retrofitting of Heritage Constructions. Overall, incorporating the applications of BIM technology in the sustainable retrofitting of heritage constructions can help ensure that the retrofitting process is efficient, effective, and environmentally responsible.**

Keywords*— BIM, Application of BIM, Heritage, Sustainable Retrofitting, Heritage Construction, Cultural Heritage, Database, HBIM, Systematic Review.

I. INTRODUCTION

Rapid construction has led to an increase in building, which has significantly increased resource development in many areas [1]. Building Information Modelling (BIM) is an innovative approach to the design, construction, and maintenance of buildings [2]. It is a digital representation of a building that enables architects, engineers, and construction professionals to collaborate and share information throughout the building lifecycle [3]. BIM has grown in popularity as a technology for designing sustainable buildings in recent years, as it can improve energy efficiency, reduce waste, and carbon emissions, and enhance the overall sustainability of a building [4], [5]. Sustainable development seeks to use natural resources in a way that is sensible and has neither immediate nor long-term negative effects on the environment [6]. The basic conception of sustainable development is to undertake initiatives to preserve energy and natural resources, motivate substance reuse, reduce toxic material carbon dioxide emissions, and enhance internal standards of living while maintaining and improving the environment's potential at both local and global levels throughout its existence [7]. When it comes to heritage buildings, the use of BIM presents unique challenges and opportunities [8]. The use of BIM technology is becoming increasingly popular in the construction industry due to its ability to enhance the design, construction, and maintenance phases of a building [9], [10]. BIM can be used to capture and model the unique characteristics of heritage buildings, enabling architects and engineers to plan and implement appropriate conservation and restoration measures [11]. One of the key benefits of BIM for heritage buildings is its ability to facilitate the integration of sustainability considerations into the design and construction process [12]. BIM can help identify areas where energy efficiency can be enhanced and enable the use of sustainable materials and construction techniques [13]. This can help reduce the environmental impact of heritage building projects while preserving their historic and cultural significance.

Several studies have been conducted on the use of BIM technology in retrofitting heritage buildings, and they have highlighted the benefits of this technology. For instance, Zhou et al [14] investigated the application of BIM in the sustainable retrofitting of heritage buildings in China. They concluded that BIM technology improves the accuracy of design, reduces construction errors, and enhances project collaboration, resulting in a more efficient and sustainable retrofitting process. In another study, Liao et al [15] investigated the use of BIM in the retrofitting of historic timber structures. They found that BIM technology enabled the identification of the most suitable retrofitting strategies and helped to overcome design and construction challenges, resulting in a successful retrofitting project. Similarly, Mahmoudi et al [16] explored the practice of BIM technology in the retrofitting of a historic building in Iran. They found that BIM technology helped to identify potential structural problems, enabled the visualization of different retrofitting options, and provided an efficient platform for collaboration between stakeholders. In a study by Delgado et al [17], the authors investigated the usage of BIM technology in the retrofitting of a historic building in Spain. They found that BIM technology enabled the identification of potential energy-saving measures, resulting in significant energy savings and improved environmental performance. Moreover, the study by Wang et al [18] explored the use of BIM technology in the retrofitting of a heritage building in Singapore. The authors found that BIM technology enabled the visualization of different retrofitting options, helped to overcome design and construction challenges, and improved project