ENHANCED KNOWLEDGE IN SCIENCES AND TECHNOLOGY
e-ISSN: 2773-6385

EKST

Vol. 4 No. 2 (2024) 680-686
https://publisher.uthm.edu.my/periodicals/index.php/ekst

A Review: Monitoring Historical and Heritage Buildings Using Terrestrial Laser Scanning

Nurhidayah Nasir[1], Nazirah Mohamad Abdullah[1*], Nurmasitah Mohd Amran[1], Noor Azlin Harun[1], Azmal Sabil[2]

[1] *Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh, Muar, 84500, MALAYSIA*
[2] *Faculty Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia (UTHM) Parit Raja, Batu Pahat, 86400, MALAYSIA*

*Corresponding Author: nazirah@uthm.edu.my
DOI: https://doi.org/10.30880/ekst.2024.04.02.073

Article Info

Received: 27 December 2023
Accepted: 13 January 2024
Available online: 12 December 2024

Keywords

Sultan Ibrahim Jamek Mosque 1, Leica BLK360 2, 3D laser scanning 3, mixed-methods approach 4, technology 5

Abstract

This study aims to investigate the effectiveness of using terrestrial laser scanning (TLS) technology to assess early signs of building destruction and protect the architecture of historic buildings, with a specific focus on the Sultan Ibrahim Jamek Mosque in Muar, Johor. The traditional method of conservation has limitations in terms of accuracy and efficiency, which can compromise the preservation of these valuable structures. The study focuses on the use of Leica BLK360, a 3-Dimensional (3D) laser scanning, as a technology method for conservation. The objective of this study is to assess early signs of building destruction and also protect the architecture of historic buildings by using terrestrial laser scanning tools. The study employs a mixed-methods approach, including site surveys, interviews, and observations, to collect data on the conservation of the Sultan Ibrahim Jamek Mosque. The study included an interview with the Imam of the mosque, revealing challenges with the traditional observation-based method, such as irregular monitoring, lack of consistent reporting, and delayed responses to conservation needs. This method lacked accuracy and comprehensive documentation, hindering effective preservation. In contrast, modern approaches offer greater accuracy, efficient data collection, and comprehensive documentation crucial for guiding conservation efforts and monitoring the building's condition over time. The significant result of this study lies in the potential of TLS to substantially aid in the conservation and documentation of cultural treasures. TLS can create accurate 3D representations of historic structures, archaeological sites, and other cultural artifacts, providing essential data for research and analysis, and assisting with conservation and restoration initiatives. The study utilized advanced technologies, such as 3D laser scanning along with specialized software, to create a highly accurate 3D model of the Sultan Ibrahim Jamek Mosque, emphasizing the importance of accurate data collection and the use of advanced technologies to guide preservation efforts. The findings of the study contribute to the body of knowledge on the use of technology in conservation and provide insights for future conservation projects. The

study's emphasis on accurate data collection, comprehensive documentation, and the use of advanced technologies aligns with modern methods of heritage conservation, underscoring the significance of these approaches in guiding preservation efforts. The study sets a valuable precedent for the conservation of other heritage buildings, securing their legacy for the benefit of future generations.

1. Introduction

Historic and heritage buildings (HHB) are important cultural and historical assets that require careful conservation and preservation. These buildings are often of great significance to local communities and the wider public, and their loss can result in the erasure of important cultural and historical heritage. However, the traditional methods of conservation have limitations in terms of accuracy and efficiency, which can compromise the preservation of these valuable structures. Therefore, the use of technology in conserving HHB has become increasingly important in recent years.

The Sultan Ibrahim Jamek Mosque in Muar, as shown in Fig. 1, has been chosen as the site for this study. The Sultan Ibrahim Jamek Mosque in Muar, Johor, is a historic and heritage building that is of great cultural and historical significance. The mosque was built in 1927 and is an excellent example of the traditional Malay architecture that was prevalent during that period [1]. The mosque's unique design features, such as its distinctive minarets and intricate carvings, make it a valuable architectural heritage that embodies the cultural and historical legacy of the region. The mosque's historical and cultural significance has led to its classification as a heritage building, which requires careful conservation and preservation.

Fig. 1 *Sultan Ibrahim Jamek Mosque*

(Source: Ghazali, 2023)

When discussing the tool, Leica BLK360, according to [2], it should be a fast and accurate tool that can capture detailed measurements of the building's structure, which can help identify areas of damage or decay and inform conservation efforts. This tool also is easy to use and has a long-range scanning capability, making it ideal for documenting large-scale structures. Compared to other 3D laser scanning tools, the Leica BLK360 is known for its speed, accuracy, and ease of use, making it a valuable asset for the conservation of historic and heritage buildings.

One of the most significant advantages of using technology in the conservation of HHB is the ability to achieve greater accuracy and precision in the documentation of these structures. For example, the use of 3D laser scanning technology, such as the Leica BLK360, can provide detailed and precise measurements of the building's structure, which can help identify areas of damage or decay and inform conservation efforts [3]. This technology can also significantly reduce the time and effort required for documentation, allowing experts to focus on the most critical aspects of conservation [4].

Despite the advantages of using technology in conservation efforts, there are still common issues facing the maintenance department in order to maintain HHB. [5] stated that one of the most common problems is the lack of appropriate documentation tools to help with sustainable heritage preservation. This can make it difficult to develop appropriate conservation strategies and policies to ensure the survival of these buildings for future generations. Another common issue is the lack of attention and importance given to industrial structures with historical value, most of which have lost their original function [4]. This can result in the neglect and deterioration of these structures, which are important architectural heritage that includes the historical, technological, social, architectural, and scientific values of the industrial culture of the period.

Enhanced Knowledge in Sciences and Technology Vol. 4 No. 2 (2024) p. 680-686

Therefore, this study aims to investigate the effectiveness of using technology, specifically the Leica BLK360, in conserving HHB, specifically the Sultan Ibrahim Jamek Mosque in Muar, Johor. The study will compare the accuracy and efficiency of the Leica BLK360 with traditional methods, identify the benefits and challenges of using the technology, and evaluate the impact of the technology on the conservation process. The study employs a mixed-methods approach, including site surveys, interviews, and observations, to collect data of conservation of the Sultan Ibrahim Jamek Mosque.

2. Methods

The following flowchart, Figure 2 illustrates the sequential steps involved in the process of conducting this research. Each step is outlined to provide a clear and comprehensive understanding of the surveying process, from initial setup to data processing and analysis.

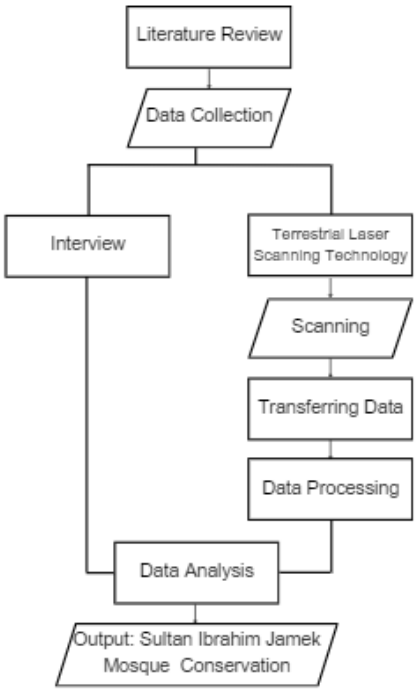

Fig. 2 *Flowchart*

2.1 Site Survey

The conservation process for the mosque began with a thorough visual inspection of its surroundings to identify potential threats or hazards that could impact the structure. This initial step helped to establish the scope of the conservation project and informed the subsequent site examination. The site examination focused on the mosque's architectural features and any signs of damage, and was conducted by a team from field conservation experts. This detailed examination enabled the identification of areas of concern and the recommendation of appropriate conservation strategies. These steps were essential in gathering the necessary data and information for the conservation process and facilitated the development of a detailed digital model of the mosque. This digital model serves as a valuable tool to inform and guide the conservation process, ultimately ensuring the preservation of the structure for future generations.

2.2 Interview

The interview method involved open-ended questions via phone call with the Imam of the Sultan Ibrahim Jamek Mosque to gather insights on the traditional observation-based method used for monitoring and maintaining the conservation of the mosque. The questions focused on how the conservation of the mosque was traditionally monitored and maintained, the challenges faced with the traditional observation-based method, and the limitations of this method in monitoring and maintaining the conservation of the mosque using the traditional method.

The interviews revealed that the observation-based method presented several challenges, including irregular observation of new damages, lack of a consistent reporting schedule, and delayed responses in addressing the conservation needs of the mosque. The weaknesses of the traditional method included limited

accuracy and a lack of comprehensive documentation, as the maintenance work done by the building's expert is short-term, which results in inefficient data collection and hinders effective preservation strategies. In contrast, modern approaches to the assessment of historic structures involve multidisciplinary research, data merging, and the use of Building Information Modelling (BIM) technology, offering greater accuracy, efficient data collection, and comprehensive documentation crucial for guiding conservation efforts and monitoring the building's condition over time. These modern methods address the need for a method to conserve and monitor architectural transformations during the operational period of historical objects, minimizing the costs and timing of structural assessment.

2.3 Terrestrial Laser Scanner Technology

The Leica BLK360 scanner, known for its compact and lightweight design, offers exceptional portability, allowing for easy transportation. When in use, the scanner, along with its accompanying tripod and remote controller operated via smartphone, can be conveniently packed into a single compact case. During the scanning process, this tool employs a combination of laser scanning and panoramic photography to meticulously capture detailed data of the selected building. The Leica BLK360 offers a resolution that can be set as low as 2 cm at 10 m, a choice made to optimize the speed of laser scanning. This resolution is particularly suitable for interior mapping, where distances are typically around 5 m or less, making it well-suited for both 2D and 3D modeling purposes [3].

In practice, the device is mounted on a tripod and positioned to collect data within a specific area designated for scanning. Once the scan is initiated, the device captures and transmits the data in real time. Image and point cloud data are streamed to a smartphone or tablet or final project data to Leica Cyclone REGISTER 360 PLUS or Cyclone REGISTER 360 PLUS via Wireless Fidelity (Wi-Fi) as shown in Figure 3, with full data synchronization between devices [12]. Subsequently, the collected data is processed to generate a detailed 3D resolution by point cloud. Finally, the processed data is transferred from the device's memory card to a computer for further analysis and application.

Fig. 3 *Application used*

In the conservation of tall historical buildings, such as the mosque, the Leica BLK360 3D laser scanning technology is often used to capture detailed information. However, due to the height of the building, it can be challenging for the tool to capture all the necessary data. To address this, drones are used to take aerial photographs of the building. These photographs provide a complete overview of the building as shown in Figure 4, including areas that are difficult to access from the ground [6]. By combining the data from the BLK360 with the aerial photographs, conservation experts can create a more accurate 3D model of the building. This approach is cost-effective, saves time, and ensures that all the required data for the conservation effort is captured. Therefore, the use of drones for aerial photography complements the Leica BLK360 technology, making the conservation process more effective and efficient.

Enhanced Knowledge in Sciences and Technology Vol. 4 No. 2 (2024) p. 680-686

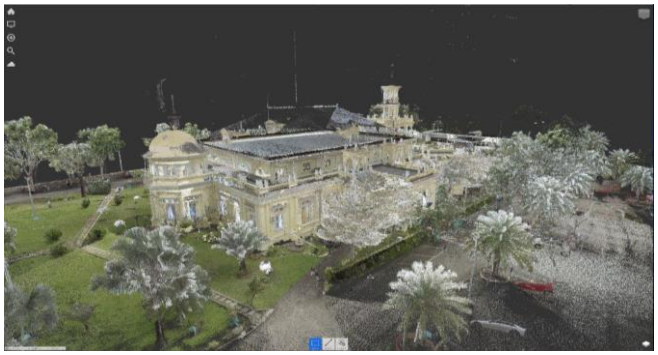

Fig. 4 *Overview of the building using drone*

Leica BLK360, is used to protect the architecture of historic buildings by providing a fast, non-invasive, and precise method for capturing comprehensive information about the building's condition [7]. This technology method is used to produce a 3D model of the building, which can be used to detect early signs of destruction or damage. By comparing the 3D model with the building's current state, conservation experts can identify areas that require attention and plan appropriate interventions. This approach also a cost-effective, saves time, and ensures that all the required data for the conservation effort is captured. Therefore, the use of TLS technology, including the Leica BLK360, plays a crucial role in the conservation of historic buildings by providing the necessary data for assessment, documentation, and preservation efforts.

3. Result and Discussion

The study utilized advanced technologies, including 3D laser scanning and specialized software, to create a highly accurate 3D model of the Sultan Ibrahim Jamek Mosque, as shown in Figure 5. The 3D model was generated using the Leica BLK360 scanner, which is known for its compact and lightweight design, making it highly portable and mobile. The scanner employs a combination of laser scanning and panoramic photography to capture detailed data of the building, with a resolution that can be set as low as 2 cm at 10 m, making it well-suited for both 2D and 3D modeling purposes [8].

The interview session with the Imam revealed the limitations of the traditional observation-based method used for monitoring and maintaining the conservation of the mosque. The traditional method presented several challenges, including irregular observation of new damages, lack of a consistent reporting schedule, and delayed responses in addressing the conservation needs of the mosque. The weaknesses of the traditional method included limited accuracy and a lack of comprehensive documentation, as the maintenance work done by the building's expert is short-term, which results in inefficient data collection and hinders effective preservation strategies [9].

The study highlights the potential of advanced technologies, such as 3D laser scanning, in heritage conservation. These technologies offer numerous advantages, including enhanced accuracy and detail, efficient data processing, and collaborative efforts. The use of advanced technologies in heritage conservation emphasizes the importance of precise data collection, comprehensive documentation, and the use of advanced technologies to steer preservation endeavors [10]. The collaborative approach facilitated by these technologies brings together various stakeholders to work towards the common goal of preserving our cultural heritage [11].

In conclusion, the study demonstrates the potential of advanced technologies, such as 3D laser scanning along with specialized software, in heritage conservation. The use of these technologies offers numerous advantages over traditional-based methods, including enhanced accuracy and detail, efficient data processing, and collaborative efforts. The study highlights the importance of precise data collection, comprehensive documentation, and the use of advanced technologies to guide preservation efforts. The collaborative approach facilitated by these technologies brings together various stakeholders to work towards the common goal of preserving our historic and heritage building.

(a) **(b)**

Fig. 5 *3D model of Sultan Ibrahim Jamek Mosque using TLS (a)exterior; (b) interior*

4. Conclusion

The study at the Sultan Ibrahim Jamek Mosque in Muar, emphasizes the importance of accurate data collection, comprehensive documentation, and the use of advanced technologies in heritage conservation. The 3D laser scanning technology employed in the study created a highly precise model of the mosque, underlining the necessity of exact data collection and advanced technologies in preservation efforts. However, it is important to acknowledge that the study's limitation lies in the fact that the 3D model is the first of its kind, making it challenging to compare to other models, emphasizing the need for further research and data collection to fully understand the mosque's historical significance. The interview highlighted the drawbacks of traditional methods and the need for a more comprehensive and accurate approach to heritage conservation, achievable through advanced technologies such as 3D laser scanning and specialized software. The study's emphasis on accurate data collection and advanced technologies aligns with modern heritage conservation methods, setting a valuable precedent for the preservation of other heritage buildings, ensuring their legacy for future generations.

Acknowledgement

We would like to express our sincere gratitude to the Faculty of Applied Sciences and Technology (FAST) at Universiti Tun Hussein Onn Malaysia (UTHM) for providing us with the invaluable opportunity to conduct this study. We extend our heartfelt appreciation to all those who have provided us with direct and indirect assistance, for their unwavering guidance and support throughout the research process. We would also like to express our gratitude to the Imam of the Sultan Ibrahim Jamek Mosque for his cooperation and valuable insights during the interview session. Their contributions have been instrumental in the successful completion of this paper, and we are honored to have had the opportunity to work with such an exceptional group of individuals.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design, data collection, methodology, analysis and interpretation of results:*** *Nurhidayah Nasir, Nazirah Mohamad Abdullah, Nurmasitah Mohd Amran, Noor Azlin Harun and Azmal Sabil*. *All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Asif, N., Utaberta, N., & Sarram, A. (2019). Architectural Styles of Malaysian Mosque: Suitability in Compact Urban Settings. MATEC Web of Conferences.

[2] Hess, M., & Ferreyra, C. (2021). Recording and comparing historic garden architecture. Value Of Slam-Based Recording for Research on Cultural Landscapes in Connection with Heritage Conservation. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 46, 301-308.

[3] Dlesk, A., Vach, K., Šedina, J., & Pavelka, K. (2022). Comparison Of Leica BLK360 and Leica BLK2go On Chosen Test Objects. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences

[4] Yenel, A. (2023). Conceptual Suggestions for Re-functioned Industrial Heritage Buildings. Kocaeli Üniversitesi Mimarlık ve Yaşam Dergisi

[5] Elkwisni, Y.M., & ElMaidawy, A.E. (2023). Historical building information modelling (HBIM) integration with environmental analysis for green rating systems. Mansoura Engineering Journal
[6] Małyszek, H.A., Stachula, S., & Kępowicz, B. (2023). The Case Study of Using Photogrammetric Systems and Laser Scanning for Three-Dimensional Modeling of Cultural Heritage Sites. Advances in Science and Technology Research Journal.
[7] Damięcka-Suchocka, M., Katzer, J., & Suchocki, C. (2022). Application of TLS Technology for Documentation of Brickwork Heritage Buildings and Structures. Coatings.
[8] Tucci, G., Bartoli, G., & Betti, M. (2018). TLS Survey and FE Modelling of the Vasari's Cupola of the Basilica dell'Umiltà (Italy). An Interdisciplinary Approach for Preservation of CH. Transdisciplinary Multispectral Modelling and Cooperation for Preservation Cultural Heritage.
[9] Turco, M.L., Mattone, M., & Rinaudo, F. (2017). Metric Survey and BIM Technologies To Record Decay Conditions. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 261-268.
[10] Gardzińska, A. (2021). Application of Terrestrial Laser Scanning for the Inventory of Historical Buildings on the Example of Measuring the Elevations of the Buildings in the Old Market Square in Jarosław. Civil and Environmental Engineering Reports, 31, 293 - 309.
[11] Nieto-Julián, J.E., Farratell, J., Bouzas Cavada, M., & Moyano, J. (2022). Collaborative Workflow in an HBIM Project for the Restoration and Conservation of Cultural Heritage. International Journal of Architectural Heritage, 17, 1813 - 1832.
[12] Leica Geosystems. (2023) Leica BLK360 Imaging Laser Scanner. Retrieved from https://leica-geosystems.com/products/laser-scanners/scanners/blk360
[13] Ghazali, H. (2023). 10 Tempat Menarik Di Muar Johor [2023]. Melancong.my. Retrieved June 4, 2023, from https://www.melancong.com.my/tempat-menarik-di-muar/.