



UNIVERSITI
TEKNOLOGI
MARA

Cawangan Perak

ISCU 2025

17TH RISM INTERNATIONAL SURVEYING CONFERENCE FOR UNDERGRADUATES

Embracing Construction Revolution 4.0 (CR4.0): Transforming Malaysia's Built Environment

16th - 17th May 2025 | Friday - Saturday

E-ISBN PROCEEDING VOLUME I



©Royal Institution of Surveyors Malaysia

Published by
Royal Institution of Surveyors Malaysia
3rd Floor, Bangunan Juurukur
64 & 66, Jalan 52/4
46200 Petaling Jaya
Selangor

E- PROCEEDING 17th RISM ISCU 2025 Volume 1

Editors: Lizawati Abdullah, Nor Suzila Lop, Nor Nazihah Chuweni, Suriani Ngah Abdul Wahab,
Hasnan Hashim

All Rights Reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher, except in the case of brief quotations embodied in critical reviews and certain other non-commercial uses permitted by copyright law.

eISBN 978-629-94789-0-4



(online)

WELCOME SPEECH FROM THE CHAIRMAN

RISM 17th International Surveying Conference for Undergraduates (ISCU 2025)

بسم الله الرحمن الرحيم السلام

عليكم ورحمة الله وبركاته

Greetings to all,

It is with great pleasure that I welcome you to the 17th RISM International Surveying Conference for Undergraduates (ISCU 2025), themed “*Embracing Construction Revolution 4.0: Transforming Malaysia’s Built Environment*.” On behalf of the Royal Institution of Surveyors Malaysia (RISM), I also wish to express our sincere appreciation to Universiti Teknologi MARA (UiTM), Perak Campus, for graciously hosting this significant event.

As we navigate the era of the Fourth Industrial Revolution (IR4.0)—or in our context, Construction Revolution 4.0 (CR4.0)—we are witnessing transformative advancements across the global construction sector. Technologies such as Building Information Modelling (BIM), the Internet of Things (IoT), artificial intelligence (AI), robotics, big data analytics, and cloud computing are redefining the way we build, manage, and interact with our built environment. For Malaysia, embracing CR4.0 is a strategic imperative to achieve our socio-economic and environmental goals.

This conference serves as a vital platform to unite surveying undergraduates from various disciplines, fostering critical dialogue on industry challenges, enhancing professional networking, and preparing a new generation of talent for the rapidly evolving construction landscape. It is also an opportunity for employers to engage with and inspire our future professionals.

I would like to extend my heartfelt thanks to all industry speakers, paper presenters, judges, and participants for their time, contributions, and support in making ISCU 2025 a success. I also commend the organising committee for curating a meaningful and dynamic conference experience.

May the knowledge gained, connections formed, and ideas exchanged during this event inspire all participants to lead and innovate in their future endeavours.

Wishing everyone a productive and memorable conference.

Prof. Ts Sr Dr. Adi Irfan Bin Che Ani'

Chairman, Universities' Partnering Committee

RISM Session 2024/2025

May 2025

WELCOME SPEECH FROM CO-CHAIRMAN

RISM 17th International Surveying Conference for Undergraduates (ISCU 2025)

Bismillahirrahmanirrahim.

السلام عليكم ورحمة الله وبركاته and greetings to all.

It is my great pleasure to welcome everyone to the 17th International Surveyor Conference for Undergraduates (ISCU 2025), proudly hosted by Universiti Teknologi MARA (UiTM) Perak Branch in collaboration with the Royal Institution of Surveyors Malaysia (RISM). This event is a meaningful platform for students in the built environment to share ideas, showcase innovations, and build professional networks. We are honoured by your presence and enthusiastic participation, with 135 accepted papers and 78 poster presentations this year.

UiTM Perak, home to the College of Built Environment, has long been a hub for academic excellence in architecture, planning, and surveying. Our commitment remains strong in nurturing competent graduates who meet industry demands and contribute to nation-building.

While you're here, we invite you to experience the heritage and culture of Perak Tengah from the architectural richness of Rumah Kutai to the historical towns of Pasir Salak, Bota, and Kampung Gajah.

To all presenters and winners, congratulations on your achievements. Let your work today be a catalyst for future success and academic growth. We hope this conference will inspire you to explore new ideas, foster collaboration, and make lasting memories.

My deepest thanks to the Royal Institution of Surveyors Malaysia (RISM) and the organising committee for making this event a success.

We hope your experience here will be rewarding and unforgettable.

Thank you. Selamat datang dan selamat berjaya.

Associates Professor Dr. Nur Hisham Ibrahim, *PMP*

Co-Chairman, Universities' Partnering Committee

RISM Session 2024/2025

May 2025

WELCOME SPEECH FROM THE PROJECT DIRECTOR

RISM 17th International Surveying Conference for Undergraduates 2025

Alhamdulillah, all praise to Allah S.W.T. for His guidance and blessings in making the RISM 17th International Surveying Conference for Undergraduates (ISCU) 2025 a reality.

It is with great honour and gratitude that I welcome all participants, guests, academicians, and industry professionals to this prestigious event, proudly organized under the Royal Institution of Surveyors Malaysia (RISM). This 17th edition of ISCU stands as a proud testament to our collective dedication toward academic excellence, professional collaboration, and youth empowerment in the field of surveying.

I extend my heartfelt appreciation to RISM for its unwavering support, to the hardworking ISCU 2025 Organising Committee, and to all 16 partnering universities across Malaysia for their commitment and contributions. Your efforts have shaped this conference into a dynamic platform for knowledge exchange, innovation, and professional growth.

To the academicians and practitioners present, your insights are invaluable in bridging the gap between academic theory and real-world practice. To our undergraduate participants, your passion, curiosity, and commitment are the very foundation of our future. May this conference not only deepen your academic journey but also ignite a spirit of leadership, integrity, and sustainable thinking.

Let this gathering serve as more than an academic milestone. May it foster lifelong networks, inspire transformative ideas, and chart new directions in our shared professional journey.

Wishing everyone a rewarding and inspiring conference experience.

Sr Dr. Nurul Fadzila Zahari

Project Director

RISM 17th ISCU 2025

GREEN WALL MAINTENANCE PRACTICES ATTAINMENT IN MALAYSIA

Lee Yung Seng¹, Siti Hamidah Husain^{2*}

^{1,2*} Building Surveying Programme, School of Housing, Building and Planning,
Universiti Sains Malaysia, Penang, MALAYSIA.
Email: sitihamidahhusain@usm.my

*Corresponding Author

ABSTRACT

Green building and sustainability are current social concerns. The global construction industry is actively promoting the implementation of sustainable green development, as the green walls are a crucial building component that closely aligns with sustainability and energy efficiency. Buildings in Malaysia have recently begun to adopt these well-known green walls. However, despite Malaysia's adoption of this technology in buildings, the Malaysian construction industry still considers it a novel approach. Therefore, this study aims to figure out the policies and regulation frameworks that govern the maintenance practices of green wall, and outline the key factors influencing the maintenance of green walls in Malaysia. To answer the question, the qualitative research methods were employed, namely document analysis and Systematic Literature Review (SLR). The study findings reveal that plant selection, irrigation and water management, structural and system integrity, environmental factors, cost and budget management, and human factors and expertise are the main factors that influenced green wall maintenance in Malaysia. This study contributes valuable insights for architects, urban planners, and building managers looking to implement efficient green wall systems with reduced maintenance requirements and inspires professionals to create better maintenance plans by referring to factors that are mentioned in this study in the Malaysian condition. A future study is suggested to be conducted to figure out the standard of procedure for maintaining a green wall, especially for Malaysia's country conditions and practices.

Keywords: Green Wall; Long-Term Sustainability; Maintenance; Green Wall Maintenance; Malaysia

I. INTRODUCTION

Environmental sustainability has become the most focused area globally. The rise of natural hazards, climate change, and environmental degradation makes environmental sustainability important and popular in every industry. To support and address the environmental issue and achieve sustainability, green walls are developed and applied in the cities. Green walls refer to all systems that enable greening a vertical surface, such as facades, walls, blind walls, partition walls, and others, with a selection of plant species, including all the solutions with the purpose of growing plants on, up, or within the wall of a building (Manso & Castro-Gomes, 2014). At a building scale, green wall systems can be used as a passive design solution contributing to buildings sustainability performance (Manso & Castro-Gomes, 2014). Green walls play a significant role in air quality improvement, reducing energy consumption, and enhancing aesthetics (Yungstein & Helman, 2023). Malaysia is in an urbanization period; rapid urbanization increases the application of green walls in the city.

The rise in the adoption of green walls in Malaysia makes the maintenance of green walls a critical challenge due to the tropical climate of Malaysia. Tropical climates can't match the existing maintenance procedures and plans from temperate climates such as Europe and America. Applying unsuitable maintenance plans for the green walls in Malaysia will cause resource waste and bring side effects. Good and effective maintenance can ensure the long-term functionality and sustainability of green walls and increase their performance. However, long-term sustainability green walls maintenance can be affected by numerous internal and external factors. The maintenance process for green walls is more complex than the conventional walls and is depends on the specific case situation and environmental factors. Therefore, this study aims to identify the key factors that influence the long-term sustainability of green walls maintenance in Malaysia through a literature search and critical literature review approach.

II. LITERATURE REVIEW

Green walls, as one of the components of green infrastructure, play an important role in fighting climate change and environmental issues. Green walls, also known as vertical gardens, green facades, and living walls, are vertically established greening systems in buildings (Nevárez-Favela et al., 2023). Manso and Castro-Gomes (2014) have identified several nomenclatures used to refer to various types of green wall systems. Some use the term “vertical garden,” others call them “vertical greening systems,” “green vertical systems,” or “vertical greenery systems (VGSs).”

In fact, the concept of green walls refers to all systems that enable greening a vertical surface (e.g., facades, walls, blind walls, partition walls, etc.) with a selection of plant species, including all the solutions with the purpose of growing plants on, up, or within the wall of a building (Manso & Castro-Gomes, 2014). The green wall has a more complex design compared to the concrete wall due to the components and system. The essential components for a green wall are vegetation, a substrate, an irrigation system, a waterproof membrane, and a support system (Nevárez-Favela et al., 2023; Medl et al., 2017). Abdeen and Rafaat (2024) divide green walls into two main systems: living walls (LWS) and green facades. The distinction between green facades and living walls is that green facades have climbing plants growing along the wall, covering it; living walls need materials and technology to support more plants for growth along the surface (Manso & Castro-Gomes, 2014).

Green wall maintenance plays a significant role in ensuring long-term sustainability and efficiency. To achieve efficient maintenance for green walls, some maintenance approaches can be applied. First is preventive maintenance, as it is a proactive approach that includes routinely planned maintenance to stop facilities and equipment from malfunctioning. People can define preventive maintenance as the maintenance of devices, machines, or systems before a failure occurs (Grabski, 2014). It prevents breakdowns and ensures the continuous performance of buildings and green technologies, like green walls. As opposed to preventive maintenance, predictive maintenance uses data analytics, sensor technology, and machine learning algorithms to guess when equipment will break down and allow companies to plan maintenance activities ahead of time (Patel et al., 2023). The use of computerised systems such as CMMS and BMS can support predictive maintenance by providing data on the current condition of equipment and building elements like green walls. In addition, green wall maintenance commonly employs Reliability-Centered Maintenance (RCM). It is a systematic approach to evaluating and optimizing maintenance strategies for physical assets that implemented to optimize the maintenance program of a company or facility.

According to Chew and Conejos (2016), there are three categories of key issues concerning the maintainability of green walls which are technical issues, cost issues, and client expectation for the green wall. Each category of key issues can affect the maintenance of green wall directly and indirectly. Besides that, Chew and Conejos (2016) also mentions that there are lack of industry technical standard and information on maintenance requirement cause costly maintenance. Client will lack of confident to the green wall technology due to lack of standard for green wall. Green wall in Malaysia faced the same problem which lack of standard, policies and regulation for maintaining the green wall and lack of knowledge on the factors that influencing green wall maintenance. In Malaysia, there are limited context-specific studies for the green wall long-term sustainability maintenance, which causes a lack of understanding and knowledge of green wall maintenance and its key factors. This led to inefficient and unstable quality green wall maintenance and causing resource waste and costly. This brings losses to the owner or client and influences their confidence in this technology. Therefore, proposing and performing effective and efficient maintenance is crucial and inescapable. Through document review and SLR, this study was outlined to answer the two (2) research questions, which are 1. What are the policies and regulation frameworks that govern the maintenance practices of green walls? and 2. What are the key factors influencing the maintenance of green walls?

III. RESEARCH METHODOLOGY

A. Document Review and Analysis

The first research question, "What are the policies and regulatory frameworks that govern the maintenance practices of green walls?" is answered by the qualitative research method, which involves document review and analysis from related fields across the country and around the world. This is also supported by the literature review findings from academic papers, conference papers, books, journals, and authoritative industry reports in related fields from relevant platforms.

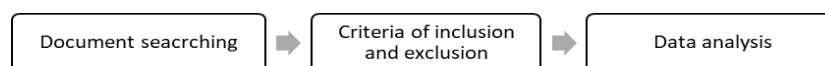


Figure 1.0 Process of document review and analysis

Figure 1.0 shows the process of document review and analysis. There are three steps available, which are document searching, criteria of inclusion and exclusion, and data analysis. For the first step, the document analysis begins with searching documents from online databases such as Google Scholar, Science Direct, and others with the keywords “green wall,” “maintenance,” “green infrastructural,” “policy,” and “regulation”. Not only from these databases but also the documents collected from government websites and organisation websites. After document searching, the criteria of inclusion and exclusion will be developed. Table 1.0 shows the criteria of inclusion and exclusion for the document analysis. The final step involves the analysis of data. The collected document has been reviewed, and the data needed has been extracted and made into a table.

Table 1.0 The criteria for inclusion and exclusion

Criteria	Includes	Excludes
Publication Date	2009-2025	<2009
Document Type	Government regulations, policy frameworks, organization guidelines, research paper, book	Studies, report, regulations, policy framework, guidelines that not focusing on green wall maintenance
Credibility & Authorship	Published by governmental bodies, international organizations, or reputable academic journals.	Blog posts, opinion articles, or unverified online sources without academic or governmental backing.
Language	English	Non-English

B. Systematic Literature Review (SLR)

This paper adopts the research method of Systematic Literature Review (SLR) and collects academic papers, conference papers, books, journals, and authoritative industry reports in related fields from relevant platforms such as Scopus, Web of Science, Springer, and Google Scholar. The time limit is set between 2015 and 2024 and uses keywords such as "green wall," "maintenance," "long-term sustainability," and "green wall maintenance" for comprehensive retrieval. In the retrieval, researchers focus on the cases and the actual implementation. This paper selects green walls as the research object of the literature review to explore the key factors influencing the long-term sustainability of green walls. This SLR approach was employed to answer the question in “What are the key factors influencing the maintenance of green walls”?

In Figure 2.0, there are four (4) steps available for the PRISMA process. First is identification. Four (4) main databases were used to review, which are Scopus, Google Scholar, Springer Link, and Web of Science. The second step of PRISMA is screening. This process involved the inclusion or exclusion of articles according to the criteria determined by the authors with the assistance of databases, such as the publication is between 2015 until 2024, and subject area is in Engineering and Built Environment. Next is "eligibility," which is a process that includes or excludes articles manually according to the authors' specific criteria. The process thoroughly reviewed the retrieved articles, excluding any that did not meet these criteria. The final step is data abstraction and analysis. The total number of 20 articles that were evaluated, reviewed, and checked were selected. From 20 articles, 8 articles are from Q1 journal, 6 from Q2 journal, 2 from Q3 journal and the rest are from Q 4 journal.

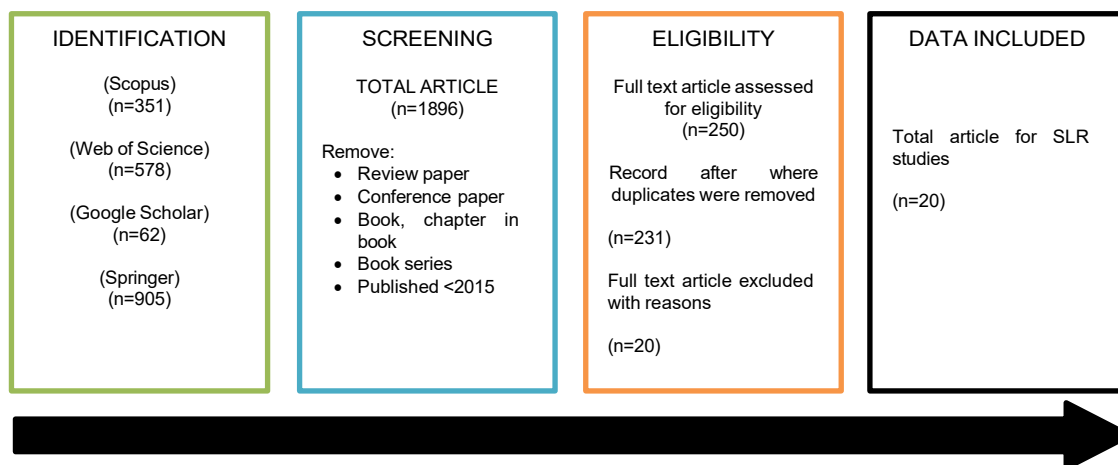


Figure 2.0: The steps of PRISMA for SLR studies

V. RESULTS

A. *The policies and regulatory frameworks that govern the maintenance practices of green walls*

Table 2.0 shows the policy and regulation framework, organisation guidelines, books, and research articles that govern the maintenance practice of green walls. The total number of 10 documents is collected from different nations, which are Malaysia, the United States, the United Kingdom, Singapore, and Viet Nam. Green wall maintenance is important in sustainability and climate adaptation. Green building ranking tools like MYCREST, BCA Green Mark Certification, and LAPT highlight green walls as a solution for heat island mitigation and also mention some maintenance approaches for green elements like green walls. Besides that, some guidelines are available for green wall and green wall maintenance such as Living Wall Guide UK and A Handbook on Developing Sustainable Skyrise Gardens. These guidelines provide the best practice for green wall maintenance with case studies and list down some maintenance considerations. Green wall maintenance is a critical but often overlooked aspect of green infrastructure policy. Therefore, the research question is developed and aims to achieve long-term sustainability green wall maintenance from the policy and regulation framework aspect.

Table 2.0 The policies and regulatory framework that govern the maintenance practices of green walls

Document selected	Data Analysed
Malaysian Carbon Reduction and Environmental Sustainability Tool (MYCREST) (Operation and maintenance) - (CIDB Malaysia (Govt))	Encourage the use of green wall for the heat island mitigation, guide to produce building user manual for operation and maintenance. maintenance plan and schedule will be documented for the irrigation of green wall
Green Roof & Wall Policy in North America - Green Roofs for Healthy Cities (GRHC)	Emphasizes the need for maintenance funding & regulations and recommends performance-based incentives for long-term upkeep. List the policy available in US related to green wall and green wall maintenance.
BCA Green Mark Certification - Building and Construction Authority (Singapore)	A ranking system and tools that guide to green wall maintenance for better ranking. Focus on sustainability and encourage monitoring plant health, irrigation and safety of green elements.
Implementation Guideline Green walls and green roofs: Urban Ecosystem-Based Adaptation to Climate Change in Vietnam	Recommends regular maintenance protocols, describing the importance of green wall maintenance and the cost of maintenance.
A Review of Policies and Regulations of Green Infrastructure Establishment in Kuala Lumpur, Malaysia (Yeo et al., 2023)	Study on regulation and policy, guidelines, Acts, NGO plans and report that related to Green Infrastructure (green wall) in Malaysia.
Living Architecture Performance Tool (LAPT) - Green Infrastructure Foundation (GIF)	Provide a detail maintenance checklist and guide to create a maintenance plan for at least five years.
Living Wall Guide UK – Urban Greening	Offers best practices for long-term care, emphasizes seasonal maintenance strategies. Focus on the maintenance of irrigation.
Living Walls & Fire Safety Best Practices (UK) -Fire Protection Association (FPA) and the UK government	Provide best practices guide on the maintenance of green wall to achieve fire safety.
Living Wall Systems: a technical standard proposal- (Giordano et al., 2017)	Mainly study on the policy in European of green wall. Recommend to provide maintenance manual and more focus on the irrigation maintenance.
A Handbook on Developing Sustainable Skyrise Gardens - National Parks Board	Provides case studies on green wall maintenance and list the maintenance considerations.

B. *Systematic Literature Review (SLR)*

Figure 3.0 shows the critical literature review results on factors influencing green wall maintenance from 2015 until 2024. Via the PRISMA process, a total number of 20 articles was selected and analysed. The application of thematic analysis led to the creation of six main themes and seven sub-themes. The six main themes are plant selection, irrigation and water management, structural and system integrity, environmental factors, cost and budget management, and Human Factors and Expertise. The sub-themes are Component and Materials (CM) and Design Consideration (DC), Climate Adaptation (CA), Microclimate Management (MM), Training and

Knowledge (TK), and Monitoring System (MS). CM and DC are under structural and system integrity, CA and MM are under Environmental Factors and TK and MS are under Human Factors and Expertise.

Authors	Plant Selection	Irrigation and Water Management	Structural and System Integrity		Environmental Factors		Cost and budget management	Human Factors and Expertise	
			CM	DC	CA	MM		TK	MS
Chew and Conejos (2016)	/	/	/	/	/		/		
Conejos et al. (2019)		/					/		
Huang et al. (2019)	/						/		
Rivas-Sánchez et al. (2019)									/
Al, T. E. (2020)	/	/							
Yeo et al. (2021)								/	
Dominici et al. (2021)						/			
Tabatabaee et al. (2021)							/		
Ogut et al. (2022)		/					/		
Stollberg et al. (2022)					/				
Reyhani et al. (2023)			/						
Carlucci et al. (2023)	/								
Jayakody et al. (2023)							/		
Nicolini et al. (2023)						/			
Irga et al. (2023)				/					
Raynham et al. (2024)						/			
Madushika and Ramachandra (2024)	/						/		
Zhong et al. (2024)				/					
Maricruz et al. (2024)							/		
Refaat and El-Zoklah (2024)		/		/			/		
Structural and System Integrity CM- Component and Material DC- Design Consideration Environmental Factors CA- Climate Adaptation MM- Microclimate Management Human Factors and Expertise TK- Training and Knowledge MS- Monitoring system									

Figure 3.0 SLR results on factors of green wall maintenance from 2015 until 2024

Selection of Plants

Plant selection is the first step in installing a green wall on a building, and as such, it plays a critical role in influencing the maintenance of the wall. The selection of plants for green walls has to be according to the local conditions, such as weather, climate, and temperature; it is important, especially for tropical countries like Malaysia, which have high humidity, frequent rainfall, strong sunlight, and high temperatures (Huang et al., 2019). The selection of plants can significantly impact maintenance conditions, particularly in terms of cost.

Irrigation and Water Management

Efficient water management is essential for green wall sustainability. In Malaysia's tropical climate, excessive watering can result in root rot and other plant diseases, while insufficient watering can also lead to plant death in green walls. However, compared to other green infrastructures like green roofs, green walls require frequent irrigation and nutrient supply (Manso et al., 2020).

Structural and System Integrity

Structural and system integrity will relate to the design of the green wall, components, and materials, as well as the supporting system. The most common construction materials used were metal, which is aluminum and steel,

and plastic (Medl et al., 2017). Due to the high humidity and heavy rainfall in Malaysia, materials that are durable and weather-resistant are recommended to use. Design consideration is also a significant factor that will influence green wall maintenance. The green wall designer, landscape architect or person responsible for designing green walls has to create a proper design while considering all factors and future planning.

Environmental Factors

Malaysia, well known as a tropical climate country, presents challenges for green wall maintenance. This is because Malaysia's high humidity can promote rapid plant growth, requiring more frequent pruning to maintain the wall's appearance and prevent overcrowding. Due to the Malaysia climate issue, flexible maintenance strategies that can adapt to changing weather conditions throughout the year are necessary. For now, most of the current systems originate from temperate climate countries, which are countries that have four seasons and may not perform as well in a tropical climate, leading to the future maintenance of green walls (Chew & Conejos, 2016).

Cost and Budget Management

Cost and budget are the most influential factors that influence green wall maintenance. This is because any maintenance work on the green wall is supported by an allocation budget for that purpose. Proper cost and budget management enable the whole maintenance to go successfully. Typically, green wall installation and maintenance services are bundled together and performed by the same company. According to Chew & Conejos, 2016, the high maintenance cost incurred is a barrier to vertical greenery development since there is a perceived unwillingness among developers to implement systems as the high maintenance costs and prolonged maintenance issues will eventually be borne by them.

Human Factors and Expertise

Human factors and expertise are significant factors that can influence green wall maintenance. In maintenance, human factors and expertise refer to the maintenance staff or labour and knowledge of maintenance and green walls. Expertise and knowledge in sustainable landscape or maintenance management is important for effective maintenance. Maintenance of green walls is complex and requires specific knowledge that unskilled workers may not have developed, which can affect their ability to identify, understand, and avoid the risks associated with specific maintenance tasks (Han & Abidin, 2021).

CONCLUSION

In conclusion, this paper answers two (2) research questions by document review and SLR. Through document review, 10 documents are recorded. These documents outline the guidelines, standards, policy and regulations that related to green wall maintenance. These documents can be referenced and refined to produce a standard or policy that can applied in Malaysia content. From SLR, six (6) main themes and six (6) sub-themes are successfully created and developed. The findings collected provide a better understanding of factors that could influence the maintenance activities of green walls and help to promote the use of green wall in Malaysia's building. The contribution enables professionals and experts in the green wall industry to consider the factors and propose a more suitable and comprehensive green wall maintenance plan that leads to cost savings in operation and maintenance.

ACKNOWLEDGMENT

The main author would like to express his gratitude to Building Surveying Program, School of Housing, Building and Planning, USM for funding this publication.

REFERENCES

- Abdeen, N., & Rafaat, T. (2024). Assessing vertical green walls for indoor corridors in educational buildings and its impact outdoor: A field study at the universities of Canada in Egypt. *Results in Engineering*, 21, 101838.
- Al, T. E. (2020). Evaluation of perception with regards to green wall systems application in Nicosia, N. Cyprus. *International Journal of Advanced and Applied Sciences*, 7(3), 24–36.
- Carlucci, S., Charalambous, M., & Julia Nerantzia Tzortzi. (2023). Monitoring and performance evaluation of a green wall in a semi-arid Mediterranean climate. *Journal of Building Engineering*, 77, 107421–107421.
- Chew, M. Y., & Conejos, S. (2016). Developing a green maintainability framework for green walls in Singapore. *Structural Survey*, 34(4/5), 379–406.

- Conejos, S., Chew, M. Y. L., & Azril, F. H. B. (2019a). Green maintainability assessment of high-rise vertical greenery systems. *Facilities*, 37(13/14), 1008–1047.
- Dominici, L., Fleck, R., Gill, R. L., Pettit, T. J., Irga, P. J., Comino, E., & Torpy, F. R. (2021a). Analysis of lighting conditions of indoor living walls: Effects on CO₂ removal. *Journal of Building Engineering*, 44, 102961.
- Giordano, R., Montacchini, E., Tedesco, S., & Perone, A. (2017). Living Wall Systems: A Technical Standard proposal. *Energy Procedia*, 111, 298–307.
- Grabski, F. (2014). Simple model of maintenance. In *Elsevier eBooks* (pp. 177–186).
- Han, L. J., & Abidin, N. Z. (2021). Integration of safety aspects in the maintenance work of a living Wall: An Overview of practice and challenges. *Built Environment Journal*, 18(2), 23.
- Huang, Z., Lu, Y., Wong, N. H., & Poh, C. H. (2019). The true cost of “greening” a building: Life cycle cost analysis of vertical greenery systems (VGS) in tropical climate. *Journal of Cleaner Production*, 228, 437–454.
- Irga, P. J., Torpy, F. R., Griffin, D., & Wilkinson, S. J. (2023). Vertical Greening Systems: A perspective on Existing technologies and new design recommendation. *Sustainability*, 15(7), 6014.
- Jayakody, G., Weerasinghe, K., Jayasinghe, G., & Halwatura, R. (2023). Economical sustainability of vertical greeneries in tropical climate. *Energy and Buildings*, 299, 113580.
- M. Reyhani, Enrica Santolini, Tassinari, P., & Torreggiani, D. (2023). Environmental assessment of design choices of green walls based for materials combination and plants. *International Journal of Life Cycle Assessment*, 28(9), 1078–1091.
- Manso, M., & Castro-Gomes, J. (2014). Green wall systems: A review of their characteristics. *Renewable and Sustainable Energy Reviews*, 41, 863–871.
- Manso, M., Teotónio, I., Silva, C. M., & Cruz, C. O. (2020). Green roof and green wall benefits and costs: A review of the quantitative evidence. *Renewable and Sustainable Energy Reviews*, 135, 110111.
- Maracruz Solera Jimenez, João Cortesão, Lenzholzer, S., & Walker, R. (2024). Plant Pixel: an optimized bio-inspired living wall system. *Developments in the Built Environment*, 100438–100438.
- Medl, A., Stangl, R., & Florineth, F. (2017). Vertical greening systems – A review on recent technologies and research advancement. *Building and Environment*, 125, 227–239.
- Neárez-Favela, M. M., García-Albarado, J. C., Quevedo-Nolasco, A., López-Pérez, A., & Bolaños-González, M. A. (2023). Perception Of Green Infrastructure Systems: Green Walls and Green Roofs. *Agrociencia*.
- Nicolini, E., Olivieri, F., Germanà, M. L., Marcon, G., Chiodi, M., & Olivieri, L. (2023). Comparative analysis of the thermal insulation performance of a façade enclosure integrated by vegetation under simultaneous windy and rainy climatic conditions. *Building and Environment*, 239, 110386.
- Ogut, O., Tzortzi, N. J., & Bertolin, C. (2022). Vertical Green Structures to Establish Sustainable Built Environment: A Systematic Market Review. *Sustainability*, 14(19), 12349.
- Patel, M., Vasa, J., & Patel, B. (2023). Predictive Maintenance: A Comprehensive Analysis and Future Outlook. *Research Gate*, 1–7.
- Raynham, P., & Dugar, A. M. (2024). Lighting for green walls. *Light & Engineering*, 03–2024, 95–100.
- Refaat, T., & El-Zoklah, M. (2024a). Trans-functional green wall's developed predesign model as a first stage to designers to understand the design and potential performance aspects of green walls. *Open House International*, 49(4), 752–772.
- Rivas-Sánchez, Y. A., Moreno-Pérez, M. F., & Roldán-Cañas, J. (2019). Environment Control with Low-Cost Microcontrollers and Microprocessors: Application for Green Walls. *Sustainability*, 11(3), 782.
- Stollberg, M., Moser, G., Müller, C., & von Birgelen, A. (2022). Meadow-living walls: Creating attractive vertical greenery with meadow seed mixtures – Experiences and recommendations from a three-year field trial. *Ecological Engineering*, 185, 106817.
- Tabatabaee, S., Ashour, M., Mohandes, S. R., Sadeghi, H., Mahdiyar, A., Hosseini, M. R., & Ismail, S. (2021). Deterrents to the adoption of green walls: a hybrid fuzzy-based approach. *Engineering, Construction and Architectural Management*, 29(9), 3460–3479.
- U.G.D. Madushika, & Ramachandra, T. (2024). A comparative assessment of indirect green façade and conventional walls: perspective of life cycle cost. *Built Environment Project and Asset Management*.
- Yeo, M. S. K., Samarakoon, S. M. B. P., Ng, Q. B., Muthugala, M. A. V. J., & Elara, M. R. (2021). Design of Robot-Inclusive Vertical Green Landscape. *Buildings*, 11(5), 203.
- Yeo, O. T. S., Yusof, M. J. M., Maruthaveeran, S., Saito, K., & Kasim, J. A. (2023). A review of policies and regulations of green infrastructure establishment in Kuala Lumpur, Malaysia. *Pertanika Journal of Social Science & Humanities*, 31(2), 561–584.
- Yungstein, Y., & Helman, D. (2023). Cooling, CO₂ reduction, and energy-saving benefits of a green-living wall in an actual workplace. *Building and Environment*, 236, 110220.
- Zhong, W., Torsten Schröder, & Bekkering, J. (2024). Implementing biophilic design in architecture through three-dimensional green spaces: Guidelines for building technologies, plant selection, and maintenance. *Journal of Building Engineering*, 92, 109648–109648.



UNIVERSITI
TEKNOLOGI
MARA

Cawangan Perak

eISBN 978-629-94789-0-4



(online)