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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

ADOPTION OF BACTERIA BASED SELF-HEALING CONCRETE (BSHC) IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Concrete is a commonly used building material in the construction industry. The massive use of concrete in the construction industry has caused the increase of carbon dioxide (CO2) emissions and resulted in air pollution. It is imperative to develop an environmentally friendly alternative to conventional concrete. This paper aims to propose a conceptual framework to explore an alternative material that is more cost effective and environmentally friendly than the conventional concrete in the context of the construction industry in Malaysia. To achieve the aim of the research, the specific research objectives are formulated as follows: 1) To identify the requirements in adopting Bacteria Based Self-Healing Concrete (BSHC) in the construction industry and 2) To assess whether the Malaysian construction industry meets those requirements to adopt BSHC. The research methodology used for data collection for this research is the combination of literature review and semi-structured interviews with five (5) interviewees, i.e. one (1) person from SIRIM QAS, one (1) person from CIDB, one (1) person from CREAM and two (2) microbiologists.

Keywords: Bacteria, self-healing concrete, requirement, capability, sustainability

I. INTRODUCTION

Concrete is one of the most widely used materials in the construction industry, but its high production contributes to CO_2 emissions and environmental concerns. To address this issue, Bacteria-Based Self-Healing Concrete (BSHC) offers an innovative, sustainable alternative. This paper provides a conceptual framework as Figure 1.0 to the adoption of BSHC in Malaysia's construction industry by identifying key requirements and assessing the industry's readiness.

Previous study highlights the benefits of BSHC, including reduced maintenance costs, improved durability, and lower carbon emissions (Ferreira Brasilero et al, 2021). However, factors such as climate suitability, cost-effectiveness, and resource availability must be considered. The research aims to determine whether Malaysia meets the necessary conditions for BSHC adoption.

A qualitative approach is used, involving literature reviews and expert interviews with engineers, microbiologists, and industry professionals. Data from these sources will be analysed to evaluate the feasibility of implementing BSHC in Malaysia. If successful, BSHC could revolutionize the construction industry by reducing concrete production, minimizing environmental impact, and supporting sustainable development goals

II. LITERATURE REVIEW

2.1 Self-Healing Concrete

Self-Healing Concrete is a type of concrete that can repair its own cracks without human intervention (Talaiekhozan et al., 2014). According to Ferreira Brasileiro et al. (2021), research confirmed that self-healing concrete provided multiple benefits towards the structure such as: -

1. *Effective in sealing cracks*; Cracks are sealed autonomously and reduce the risk of structural failure.
2. *Enhancing durability*; When cracks are sealed, it prevents water penetration thus protects the steel

reinforcement within the concrete from eroding and improves the structural integrity of the building.
3. *Extends the structures life span*; Self-healing concrete decreases the need for maintenance and extends the service life of the building.
4. *Strengthening the concrete matrix*; Self-healing concrete seals micro cracks and fills in void within the concrete matrix thus improves the compressive strength and tensile strength of the building.
5. *Promote sustainability*; Self-healing concrete reduces the need for cement-based repairs which leads to a decrease in carbon emission originating from the production of cement thus reducing environmental impact.

There are many types of self-healing strategies. According to Talaiekhozan et al. (2014) and Luo et al. (2018), self-healing concrete can be achieved through three strategies: (1) autogenous healing, (2) chemical methods, and (3) biological methods.

1. *Autogenous Healing*: This natural process occurs when calcium hydroxide ($Ca(OH)_2$) reacts with water and carbon dioxide (CO_2), forming compounds that seal cracks. While cost-effective, it requires water, takes a long time, and is only effective for cracks smaller than 0.2 mm (Luo et al., 2018; Mahmoodi & Sadeghian, 2019).
2. *Chemical Healing*: This involves encapsulated polymeric materials that react with fluids to form a foam, sealing cracks. However, it carries risks, such as toxic gas emissions and potential crack expansion (Luo et al., 2018).
3. *Biological Healing*: This method uses bacteria to enhance autogenous healing, making it the most effective and eco-friendly approach (Talaiekhozan et al., 2014; Bagga et al., 2022). Due to its advantages, this study focuses on the biological approach.

2.2 Bacteria Based Self-Healing Concrete (BSHC)

According to Graham (2019), bacteria are single-celled organisms that can survive in almost any environment. With over a billion species estimated, current technology cannot identify them all (Dykhuizen, 2005). Most bacteria are harmless, and some, like *Lactobacillus*, aid digestion. However, some, such as *Escherichia coli* (E. coli), can be harmful to humans (Dykhuizen, 2005).

2.2.1 Microbially Induced Calcium Carbonate Precipitation (MICP)

Not all bacteria are suitable for self-healing concrete. According to Talaiekhozan et al. (2014), bacteria strains that can precipitate calcium carbonate are essential. Precipitation refers to liquid formation in the atmosphere. Microbially Induced Calcium Carbonate Precipitation ("MICP") uses bacteria to produce calcium carbonate through ureolysis (Lee & Park, 2018). Chen et al. (2019) explain the process with this reaction:

$$NH_2(CO)NH_2 + 3H_2O \rightarrow 2NH_4^+ + 2OH^- + CO_2$$

This reaction releases ammonia (NH_4^+), hydroxide ions (OH^-), and carbon dioxide (CO_2). The carbonate ions then bond with calcium in the concrete, forming calcium carbonate crystals, which seal cracks.

2.2.2 BSHC Rate of Healing

MICP production is influenced by factors such as pH levels, temperature, water exposure, oxygen presence, and calcium ion concentration (Bagga et al., 2022). To test bacterial efficiency, researchers expose bacteria to different conditions, like high pH or temperature variations. According to Tziviloglou et al. (2016), submerging bacteria-based healing agents in water increases the healing rate, indicating water plays a key role. Wang et al. (2017) found that higher pH levels slow bacterial germination, reducing crack healing speed. While oxygen affects bacterial growth, it does not directly impact healing. Lower temperatures also slow germination, meaning optimal conditions lead to faster crack sealing. Metwally et al. (2020) tested bacterial healing in concrete over 90 days. Cracks of 0.1–0.3 mm showed an 85% healing rate in 20 days, while larger cracks (0.3–0.5 mm) healed only 50–70%. This suggests smaller cracks heal more effectively than larger ones.

2.2.3 Bacterial Agent Selection

Choosing the right bacteria for BSHC depends on its ability to precipitate calcium carbonate (Talaiekhozan et al., 2014). The bacteria must also tolerate high alkalinity (pH ~12) and withstand temperature changes (Bagga et al., 2022). Some of the suggested bacteria that can be implemented in BSHC can be seen in **Table 1.0**.

Table 1.0 Type of Bacteria

TYPE OF BACTERIA	CHARACTERISTIC	REFERENCES
Bacillus Sphaericus	- Can undergo MICP - High comprehensive strength - Improve cement hydration - High pH tolerance, however, the rate of healing decreases as the pH level increases	Lee & Park (2018), Wang et al. (2017), Luo et al. (2018), Metwally et al. (2020)
Bacillus Pasteurii	- Can undergo MICP - Able to withstand changes in temperature - Safe for usage	Luo et al. (2018), Chen et al. (2019)
Trichoderma Reesei	- Can undergo MICP - High pH tolerance - Can withstand changes in temperature	Luo et al. (2018)

While *B. Sphaericus* and *B. Pasteurii* are effective, excessive bacterial precipitation may increase nitrogen levels in the environment (Luo et al., 2018). As an alternative, *T. Reesei* provides similar benefits and is considered safer for humans, though long-term monitoring is needed.

2.3 Requirement in Adopting Bacteria Based Self-Healing Concrete (BSHC)

Adopting BSHC in construction requires several key considerations to ensure successful integration. These include certification, training, research and development, material costs, and resource accessibility.

2.3.1 Certification

Certification ensures that BSHC meets industry standards, providing safety, quality assurance, and liability protection (Beznosikova, 2017). While not legally required, certified products tend to be of higher quality and gain market trust. Different countries have their own certification standards, such as the EU's Environmental Impact Analysis and China's Green Building Standard (Schumacher, 2019; Geng et al., 2012).

The certification process typically involves:

1. Product proposal
2. Certification acceptance
3. Document audit
4. Product testing
5. On-site inspection
6. Certification approval
7. Post-certification supervision (Fan et al., 2022).

2.3.2 Training and Skill Development

Training equips workers with the necessary skills to handle new materials like BSHC, improving productivity, safety, and work efficiency (IBM, 2019). In construction, specialized training is essential for handling new technologies, ensuring consistency, and enhancing project outcomes (Nallathiga & Ramana, 2013).

2.3.3 Research and Development ("R&D")

R&D drives innovation by improving materials, reducing costs, and identifying potential risks (Kenton, 2024). In construction, R&D focuses on analysing material properties, cost implications, and efficiency. Feasibility studies help identify risks and market demand (Shen et al., 2010), while pilot studies assess real-world performance and potential improvements (Turner, 2005).

2.3.4 Material Costing

Material costs impact BSHC's feasibility. BSHC contains calcium lactate and bacteria, making it 81% more expensive than conventional concrete (Andrade et al., 2022). While costly upfront, BSHC's durability and self-healing properties can lead to long-term savings (Ferreira Brasileiro et al., 2021).

2.3.5 Resource Accessibility

Easy access to raw materials ensures production stability and product quality (Chang et al., 2011). Studies show that bacteria used in BSHC can be sourced locally, eliminating the need for imports (Andrade et al., 2022; Metwally et al., 2020). However, establishing a reliable supply chain is essential for consistent production.

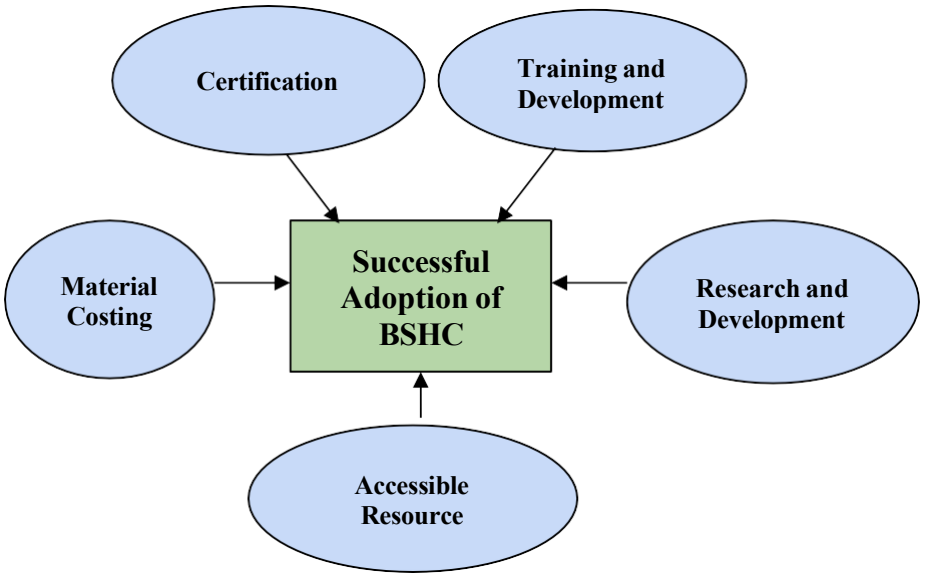

Figure 1.0 BSHC Adoption Framework

III. METHODOLOGY

The proposed research will use a qualitative approach to understand the industry professionals' views on adopting Bacteria-Based Self-Healing Concrete ("BSHC") and Malaysia's ability to support its implementation. This method helps gather insights on the challenges, benefits, and feasibility of using BSHC in the local construction industry.

The interview questions are based on findings from the literature review and are tailored to each interviewee's area of expertise. Since different professionals contribute to various aspects of BSHC adoption—certification, training and development, research and development, material cost, and resource availability—the questions will focus on these areas. The interviews will have two sections: the first section will include general questions for all interviewees to understand their background and role, while the second section will have specific questions related to their area of expertise. This section is further divided into two parts: (1) requirements for adopting BSHC and (2) Malaysia's capability to adopt BSHC.

For this study, the researcher will interview five industry professionals. A Standard and Industrial Research Institute of Malaysia Quality Assurance Services ("SIRIM QAS") representative will explain the certification process for BSHC. A Construction Industry Development Board ("CIDB") representative will discuss training and development needs. A Construction Research Institute of Malaysia ("CREAM") representative will provide insights into research and development efforts. Additionally, two microbiologists will be consulted to assess the cost and availability of bacteria used in BSHC.

The collected data will be analysed using *narrative analysis*, a method that helps interpret qualitative data by identifying themes and insights from interviews. According to Warren (2023), this method is useful for understanding challenges, industry readiness, and policy implications related to BSHC adoption.

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