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

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WELCOME SPEECH FROM THE CHAIRMAN

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

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ السَّلَام

عَلَيْكُمْ وَرَحْمَةُ اللَّهِ وَبَرَكَاتُهُ

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

CHALLENGES AND CONSIDERATION IN FIRE SAFETY FOR HERITAGE BUILDINGS: A LITERATURE REVIEW

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ABSTRACT

Heritage building serve as significant historical and cultural landmarks, necessitating preservation while ensuring fire safety. Older buildings, antiquated fire safety techniques, and restrictions on structural integrity make fire safety a serious concern. In Malaysia, the risk of fire incidents is heightened due to inadequate fire safety management in many heritage buildings. The purpose of this research is to analyse the fire safety management put at heritage building in Malaysia. The study aims to accomplish objective, to determine the present condition of fire safety management in heritage buildings. A quantitative research approach was applied, consisting of a questionnaire. This strategy allows for a complete knowledge of the fire safety practices used and their efficiency in decreasing fire dangers. The findings show that, while some historic buildings have implemented fire safety measures, significant obstacles remain, including aged electrical systems, insufficient fire suppression technology, and limited access to emergency services. Compliance to fire safety requirements is sometimes variable owing to preservation issues. According to the research, a strong fire safety framework is essential for balancing historical conservation with fire protection. Its supporter for the incorporation of modern fire-resistant materials, the advancement of fire detection technologies, and the increase of fire safety education among relevant parties. The findings of this study emphasize the necessity for policymakers, building managers, and conservationists to work together in creating sustainable fire safety measures for heritage structures. Implementing efficient fire safety management will aid in the ongoing preservation of Penang's cultural heritage.

Keywords: Heritage Building, fire safety, conservation, risk management, fire prevention

I. INTRODUCTION

The danger is further increased by antiquated electrical systems and a lack of contemporary fire suppression equipment (Idrus et al., 2010). Fire safety in heritage buildings is a special problem because of its historical and architectural value. Unlike modern buildings, heritage structures were often constructed using materials and practices that were not planned with fire safety in mind. The preservation of architectural originality and cultural value frequently conflicts with the need for contemporary fire safety measures, posing a difficult balancing act for building managers and legislators (Torero, 2019). Fires in heritage buildings can cause permanent harm to both the physical structure and the historical and cultural character that is established within them (Watts & Solomon, 2002). Fire safety management is further complicated by restricted access to emergency services because of congested streets and intricate building layouts (Idrus et al., 2010).

In addition to lowering the probability of fires, efficient fire safety management guarantees occupant protection and minimizes structural damage in the case of a fire (Ishmah et al., 2021). Heritage building preservation holds national and cultural significance in Malaysia, especially in Penang. It is still very difficult to strike a balance between historical preservation and fire safety regulations (Idrus et al., 2010). Due to budgetary limits, legal restrictions, and conservation-related restrictions, many heritage buildings still lack complete fire safety plans, even if some have integrated contemporary fire detection and suppression equipment (Fatiha et al., 2021). The purpose of this essay is to examine the difficulties and factors to be considered while putting fire safety management into place in historic structures. This study aims to identify important obstacles and offer suggestions to improve fire safety awareness and management in heritage structures by examining the body of current literature and examining fire safety procedures (Ishmah et al., 2021).

Several fundamental elements contribute to heritage buildings' higher vulnerability to fire. These include the use of materials that can be ignite like lumber, insufficient compartmentation, and a lack of current fire protection infrastructure. Furthermore, the intricate designs of heritage sites might impede firefighting attempts and occupant

evacuation (Salleh, 2012). The disastrous fires at Notre-Dame Cathedral in 2019 and Windsor Castle in 1992 highlight the critical importance of comprehensive fire safety management in historic buildings (Torero, 2019).

II. LITERATURE REVIEW

A. Fire And Heritage Buildings

Heritage of culture and architectural originality are severely harmed by fire accidents in historic structures. Heritage buildings are extremely exposed to fire damage since they frequently lack contemporary fire protection systems and fire-resistant materials, in contrast to modern constructions. According to Torero (2019), the incompatibility of contemporary fire suppression technologies with ancient building materials and design creates special fire safety issues for heritage structures. The difference results from the fact that many heritage buildings were built using extremely burning and structurally weak materials including wood, plaster, and lime mortar before the creation modern fire safety regulations. Moreover, the older structural components, antiquated electrical systems, and lack of modern fire suppression technologies make them vulnerable to fire incidents (Idrus et al., 2010). The majority of Malaysia's heritage buildings lack appropriate division, fire-resistant doors, and sufficient emergency escape routes, according to research by Salleh (2012) on fire safety at Malaysian museums. This increases the possibility that the fire may spread quickly, putting the building's structural integrity and its residents at danger. Salleh (2012) further highlights that because of financing constraints and preservation considerations, many historic buildings lack automatic fire detection and suppression systems.

The damaging effect of fire on historic buildings is best illustrated by the 2019 Notre-Dame Cathedral fire. Kincaid (2022) claims that the heavy use of timber in the roof structure, in addition to the lack of fire breaks and contemporary fire suppression equipment, contributed to the fire's quick spread. Similar to this, the 1992 Windsor Castle fire revealed flaws in the fire response procedures for historic structures and seriously damaged the inside of the structure (Torero, 2019). These accidents highlight how crucial it is to put in place customized fire safety plans that take into consideration the special qualities of historic structures. According to a review of fire risk assessment in heritage buildings by Meacham (2020), complete fire safety policies must include three essential components:

Table 1.0 Key Elements of Fire Safety Strategies
(Source: Meacham 2020)

Key Elements	Description
Risk identification	The process of evaluating the fire risks that heritage buildings have, such as flammable materials and outdated electrical systems.
Emergency preparedness	Includes creating personalized evacuation plans and making sure building personnel are instructed on fire safety procedures.
Conservation-Compatible Solutions	Using fire prevention techniques like hidden sprinkler heads and fire-resistant coatings that resemble traditional finishes without affecting the building's historic character.

According to Table 1.0 Key Elements of Fire Safety Strategies, risk identification, emergency planning, and conservation-compatible solutions are critical components of fire safety management in heritage structures. To reduce possible dangers, risk identification entails assessing fire threats such as combustible materials and outmoded electrical equipment. Moreover, Emergency preparedness includes developing tailored evacuation plans and ensuring that building workers are trained in fire safety practices. In addition, Conservation-compatible solutions rely on fire protection measures such as buried sprinkler heads and fire-resistant coatings that mimic traditional finishes while preserving the building's historical character.

B. Challenges In Fire Safety for Heritage Buildings

Ensuring fire safety in heritage buildings involves dealing with a complex set of issues arising from their historical architecture, preservation commitments, and regulatory settings. These issues are difficult and need for a careful strategy to strike a balance between conservation and safety.

a) Structural and Materials Limitations

Wood, thatch, and plaster are combustible materials that are not fire resistant and were used in the construction of many historical buildings. These materials not only raise the possibility of a fire spreading, but they also make it more challenging to apply fire-retardant treatments without sacrificing the building's historic integrity (Watts and Solomon, 2002). Additionally, fire suppression and evacuation attempts are made more difficult by the structural

complicated of heritage buildings, which include hidden compartments, limited staircases, and concealed voids (Salleh, 2012).

According to Kincaid (2022) research on fire safety in historical buildings, building preservation rules and conservation legislation frequently restrict structural modifications. For example, modifying historic features to add contemporary fire doors or sprinkler systems may encounter opposition from heritage preservation authorities. This leads to a dilemma between preserving historical integrity and making sure that fires are safe.

b) Inadequate Fire Safety Infrastructure

Modern fire detection and suppression systems are missing from many historic structures. According to Roslan and Said (2017), many Malaysian heritage buildings have little to no fire protection features. Concerns about aesthetic disturbance and possible harm to historic elements frequently prevent the incorporation of advanced technology like automatic sprinklers (Figure 1.0). Furthermore, the risk is increased by the lack of division, which is a current building requirement to limit flames. This allows fires to spread unchecked through broad, open spaces.



Figure 1.0 Automatic Sprinklers
(Source: PSB Fire Engineers 2021)

c) Regulatory and Compliance Issues

The straight application of standard fire safety requirements to heritage sites presents challenges because they are usually created with modern buildings in mind. According to Torero (2019), historic buildings may find it difficult to comply with prescriptive regulations as these laws do not take into consideration the special qualities and limitations of these kinds of structures. This frequently leads to a conflict between following safety guidelines and preserving historical integrity. Inconsistent safety procedures and other risks may result from a lack of regulations specifically designed for heritage structures.

C. Fire Safety Management for Heritage Buildings

Fire safety management is the purposeful implementation of policies, standards, and procedures to minimize the risks of fires while safeguarding the structure and historical significance of the building (Howard & Kara-Zaitri, 1999). Pickard (1994) advises that an effective fire safety management plan focuses on active and passive fire protection, regular maintenance and training of staff and emergency procedures.

a) Fire Detection and Suppression System

The decrease of fire damage in historic structures depends on early identification and quick suppression. However, because of worries about the structural and aesthetic effects, it might be difficult to install modern fire detection and suppression systems (Figure 2.0) in heritage buildings. According to Torero (2019), good fire protection may be achieved without compromising the building's historic beauty by utilizing wireless fire detection systems and hidden sprinkler heads. Water mist systems are especially well-suited for heritage buildings because they minimize water damage to historic materials by using fine water droplets to extinguish fire (Watts & Solomon, 2002).



Figure 2.0 Fire Detection System
(Source: VESTIRO)

b) Importance of Fire Risk Assessments

The basis of fire safety management in historic buildings is carrying out an overall fire risk assessment. Due to a lack of finance and experience, fire risk assessments in Malaysian heritage structures are frequently insufficient, claim Abdul Hamid and Ahmad Zawawi (2023). Finding fire dangers, analysing possible sources of ignition, and determining how vulnerable building materials and residents are should all be part of a thorough risk assessment.

Table 2.0 Fire Risk Assessment
 (Source: National Fire Protection Association (NFPA) and National Park Service)

Assessment	Description
Identification of Fire Hazards	Flammable materials, electrical faults, and heat sources should be documented and removed where possible.
Occupant Safety	Adequate fire exits, emergency lighting, and evacuation plans should be established and tested regularly
Fire Detection and Suppression Systems	Fire alarms, smoke detectors, and sprinklers should be installed and maintained in working order.
Staff Training and Awareness	All building occupants should receive basic fire safety training and participate in regular fire drills.

Table 2.0 Fire Risk Assessment lists several important elements that are necessary for heritage buildings to have efficient fire safety management. Identification of fire hazards include identifying potential fire sources, such as electrical malfunctions, heat sources, and flammable items, which should be noted and eliminated wherever feasible to lower the chance of a fire. Another important consideration is occupant safety, which involves making sure there are enough fire exits, emergency lights, and routinely tested evacuation procedures to enable a quick and safe evacuation in case of an emergency. To ensure early detection and efficient fire suppression, fire detection and suppression systems, including sprinklers, smoke detectors, and fire alarms, must be installed and kept in good operating condition. Furthermore, employee awareness and training are crucial to fire safety management, as all building occupants should receive basic fire safety training and participate in regular fire drills to ensure preparedness and quick response in case of a fire emergency.

D. Case Studies of Successful Heritage Fire Protection Program

a) Issues regarding on not put Fire Safety in Heritage Building

- i. Notre Dame Cathedral, Paris (2019)
 - A large fire during the renovation process destroyed the overtake and a large part of the roof of the Notre Dame Cathedral (Financial Times, 2019). Fire spread rapidly due to the aged timber structures and the absence of a system to suppress modern fires (Financial Times, 2019).
- ii. Glasgow School of Art, Scotland (2014 & 2018)
 - Glasgow Art School has undergone two major fires within four years, causing many damages (Wikipedia, 2024a). Investigation shows that the lack of a system to eliminate fires operating fully and the presence of walls and emptiness with wood has contributed to the rapid spread of fire (Wikipedia, 2024a).
- iii. Heritage Buildings in Georgetown, Penang, Malaysia
 - Studies on the home of the Georgetown's heritage houses has revealed major fire risks, including the use of wood, without official fire safety policies and lack of fire extinguishers (Mohamed et al., 2015). These gaps preserve these significant risk cultural standards (Mohamed et al., 2015).

b) Case studies of Successful heritage Fire protection programme

Globally, some heritage buildings have implemented active fire safety strategies while maintaining historical integrity. However, although these examples provide valuable information, blind applications must be avoided in different contexts.

Edinburgh City (Scotland) presented a leading model in which UNESCO World Heritage Site has integrated hidden reactionary systems, strategic fire cavities and regular risk assessment (SCOTLAND historical environment, 2019). However, Scotland climate, conservation and conservation culture mechanisms significantly contrast from tropical regions such as Malaysia, where high humidity and various preparations of materials (for example, tropical hardwood against European stones) can affect the behaviour of fire and system efficiency.

Similarly, Queen Victoria building in Sydney, Australia has undergone the process of fire safety improvement, using wireless detection systems and hidden water fog to preserve the aesthetics of the building (Weinstein, 2017). However, this success is mainly based on significant government allowances and commercial profits, resources may not be easily available for heritage structures in Malaysian countries with little urbanization.

It is also instructive to consider partial failures. Notre-Dame Cathedral in Paris, despite having a detailed fire risk plan, still suffered catastrophic damage in 2019 due to human error and procedural lapses (Gaillard et al., 2020). This emphasizes that technical measures alone are insufficient without continuous vigilance, training, and operational readiness. Thus, while case studies can inform Malaysian heritage fire safety strategies, critical localization is essential, considering climate, resource availability, and socio-cultural context.

E. Legislation And Guidelines on Fire Safety for Heritage Buildings

a) Malaysian Legal Framework

In Malaysia, fire safety in buildings is administered through several legislative frameworks. However, there is little guidance on fire safety for heritage buildings, and the apparent fire safety regulations often contravene heritage preservation laws (Salleh and Ahmad, 2009). Major pieces of legislation in Malaysia regulating fire safety and the conservation of heritage buildings are:

Table 3.0 Malaysia Legal Frameworks
 (Source: Salleh and Ahmad 2009)

NO	Legal Frameworks	Description
1.	Street, Drainage, and Building Act 1974 (Act 133)	This act regulates the construction and maintenance of buildings, including fire safety measures such as fire exits, emergency lighting, and fire alarm systems
2.	Uniform Building By-Laws 1984 (UBBL 1984)	The UBBL provides specific requirements for fire protection systems, such as fire-rated walls, sprinkler systems, and emergency escape routes. However, heritage buildings are often exempted from strict compliance due to structural limitations
3.	Fire Services Act 1988 (Act 341)	This act establishes the authority of the Fire and Rescue Department of Malaysia (FRDM) to inspect buildings, issue fire certificates, and enforce fire safety compliance. However, many heritage buildings in Malaysia lack fire certification due to preservation concerns
4.	National Heritage Act 2005 (Act 645)	This act governs the protection and preservation of heritage buildings in Malaysia. It allows heritage buildings to be gazetted and provides for financial assistance for conservation. However, it lacks specific requirements for fire safety management in heritage buildings
5.	Occupational Safety and Health Act 1994 (Act 514)	This act requires employers to ensure the safety and health of building occupants, including fire safety preparedness. However, enforcement in heritage buildings remains inconsistent

Table 3.0 Malaysia Legal Frameworks shows that fire safety management in Malaysian heritage buildings is governed by several regulatory frameworks. Building construction and maintenance, including fire safety features like alarm systems and fire escapes, are governed by the Street, Drainage, and Building Act 1974 (Act 133). Although the Uniform Building By-Laws 1984 (UBBL 1984) provide precise standards for fire safety measures, such as sprinkler systems and fire-rated walls, heritage structures are sometimes exempt from rigorous adherence because of structural constraints. The Fire and Rescue Department of Malaysia (FRDM) is authorized under the Fire Services Act 1988 (Act 341) to conduct building inspections, provide fire certifications, and enforce compliance; however, enforcement in heritage structures is sometimes constrained by preservation considerations. Although it offers financial support for conservation and regulates the preservation of historic structures, the National Heritage Act 2005 (Act 645) does not include any fire safety regulations. Employers are required under the Occupational Safety and Health Act 1994 (Act 514) to protect building occupants' health and safety, including fire safety, however implementation of this law changes throughout heritage structures.

b) Integration of Recent Legislation and Building Codes

Recent international frameworks demonstrate a shift toward performance-based and context-sensitive fire safety regulations for heritage structures. For instance, the British Standard BS 7913:2013 explicitly advises that fire safety interventions must balance public safety with preservation, suggesting non-invasive measures wherever possible (British Standards Institution, 2013).

Similarly, the Australian Building Code allows the "performance solution" for heritage buildings, allowing fire engineers to provide personalized safety strategies without applying modern normative standards (Australian Building Code Board, 2019). This flexibility is essential to conserve historical fabric while meeting the essential requirements of life security.

In the context of Malaysia, while the Uniform Building By-laws (UBBL) 1984 (amended) stipulate strict fire prevention measures, they lack specific provisions adapting to heritage buildings, creating a potential regulatory distance (Jabatan Bomba Dan Penyelamat Malaysia, 2021). No updates, specific heritage fire safety codes, Malaysia's conservation efforts are capable of weakening security by exemption or harmful authentication through heavy improvement.

Table 4.0 Comparative Overview of Fire Safety Legislation for Heritage Buildings (Compiled from; BSI, 2013; ABCB, 2019; JBPM, 2021)
 (Source: Direct National Standard and official building codes)

NO	Legislation/Standard	Country	Key Focus	Strength
1.	BS 7913:2013 – Guide to the Conservation of Historic Buildings	United Kingdom	Balances conservation with building safety, encourages minimal intervention	Strong emphasis on maintaining historic integrity; promotes risk-based, tailored fire safety strategies
2.	Building Code of Australia (Performance Solutions)	Australia	Allows flexible, non-prescriptive fire safety solutions for heritage structures	High flexibility to innovate fire safety measures without damaging historic fabric
3.	Uniform Building By-Laws (UBBL) 1984 (Amended)	Malaysia	General fire safety regulations, including means of escape, fire suppression, and compartmentation	Strong general fire protection rules; mandatory fire systems installation

Table 4.0 by checking important legislative frames for fire safety in heritage buildings, the remarkable contrast appears between BSI, ABCB and JBPM standards. The standard of BS 7913:2013 emphasizes a conservation approach, arguing about minimum intervention and safety strategies based on risks in accordance with the uniqueness of historical structures (British Standard Institution, 2013). On the other hand, the Australian Building Code (ABCB, 2019) provides solutions based on performance, allowing flexibility to achieve fire safety goals without rigid convention - an approach that facilitates innovation but often requires higher professional expertise and costs. Meanwhile, the regulations for Uniform Building By-Laws (UBBL), managed by JBPM, mainly provides common fire safety requirements that are often adapted to common buildings, with limited adaptation to sensitive heritage conservation needs (Jabatan Bomba Dan Penyelamat Malaysia, 2021). This comparison highlights that if the United Kingdom and Australia have mechanisms to support both fire safety and heritage integrity, Malaysia is still based on rigid frameworks, potential conflict risks between preserving efforts and compliance with regulations.

III. METHODOLOGY

- a) **Research Formation:** This stage includes focusing the inquire about foundation, investigate issue, inquire about destinations, and inquire about scope to set up a clear establishment for the ponder.
- b) **Literature Review:** A detailed audit is conducted focusing on fire security management in heritage buildings, challenges in fire security, case studies of fire incidents, the success of fire security programs, and relevant legislation and guidelines.
- c) **Data Collection:** Data is collected through two strategies first, essential information utilizing qualitative research (questionnaires) and secondary data through a literature review of books, journals, internet sources, conference articles, and newspapers.
- d) **Data Analysis:** The collected information is analyzed to translate the findings and produce significant comes about related to the investigate objectives.
- e) **Conclusion:** The final phase summarizes the key discoveries and gives conclusions based on the analysis.

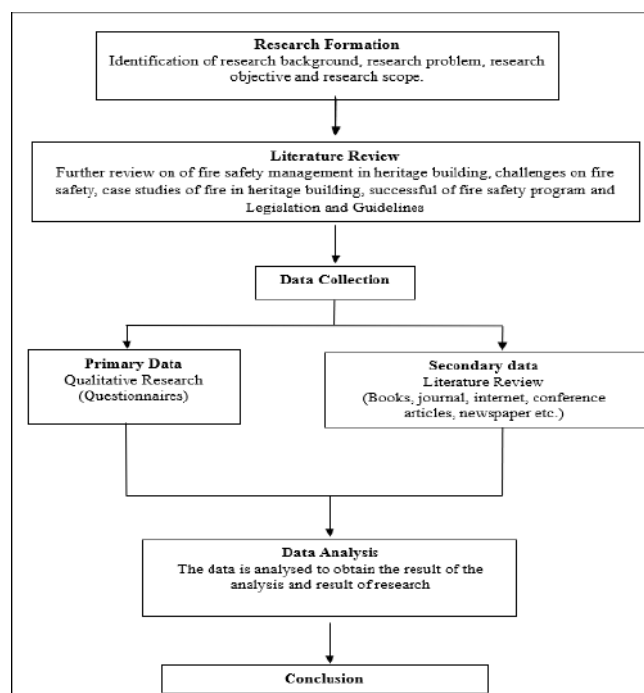


Figure 3.0 Methodology Diagram

CONCLUSION

This study highlights the significant challenges and considerations in implementing fire safety management in heritage buildings in Penang, Malaysia. The findings from the literature review and questionnaire analysis indicate that while some heritage buildings have adopted modern fire protection systems, substantial gaps remain in fire safety management practices. Structural limitations, outdated fire protection technology, and conflicts between preservation requirements and fire safety regulations contribute to these challenges. The research underscores the importance of balancing fire safety compliance with heritage conservation. Implementing passive fire protection measures, such as compartmentation and fire-resistant materials, can reduce fire risks without compromising the architectural integrity of heritage buildings. Additionally, active fire protection systems, such as wireless smoke detectors and sprinklers, should be integrated where possible to enhance early fire detection and suppression. A comprehensive fire safety management framework should include regular fire risk assessments, staff training, and the establishment of clear emergency protocols. Building managers and conservation authorities must collaborate to develop fire safety strategies tailored to the unique needs of heritage buildings. Strengthening legal frameworks and introducing specific fire safety guidelines for heritage buildings would improve compliance and enhance fire protection efforts. This study contributes to the broader understanding of fire safety management in heritage buildings and provides a foundation for future research and policy development. A proactive approach that integrates modern fire safety systems with heritage preservation principles is essential to safeguard Malaysia's rich architectural and cultural heritage.

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