MINIMALLY INVASIVE ACTIVE FIRE PROTECTION SYSTEMS IN HERITAGE TIMBER BUILDINGS

BY

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ABSTRACT

The implementation of timber construction differs in most countries often symbolizes the country architectural style and represents the historical identity of the local community and its surrounding context. These heritage timber buildings have withstood the test of time and are still standing strong to this day. However, they are highly exposed to the threat of fire due to the combustible nature of the timber material itself. In order to prevent further loss to the heritage timber buildings, many new systems were developed to serve as the active fire protection system for the buildings. The main purpose of this research is to identify the appropriate types of active fire protection systems and their ideal methods of installation in the context of heritage timber buildings. The study begins by understanding the criteria of selection for implementing active fire protection systems and identifying the existing active fire protection systems which are commonly used in heritage buildings. In comparison to the newer buildings, the installation of these systems in heritage timber buildings require minimally invasive method to prevent any further damage to the original building's structure and should blend in well with the building's design aesthetic. Several international and local heritage buildings were also documented to determine the active fire protection system implemented in each of the respective buildings and the comparison between each building were evaluated. A variety of methods of implementation and installation were identified and compared. The findings of the research indicate that the selection of active fire protection system was determined based on key factors such as aesthetic, cost, and impact towards the original building structure. The outcome of these research findings would be useful for architects, conservators, and building owners as guidelines for future conservation projects towards heritage timber buildings.

Keywords: heritage buildings, timber buildings, building conservation, fire safety, active fire protection system

خلاصة البحث

إن تنفيذ العمارة الخشبية التي تختلف في معظم البلدان غالبا ما يرمز إلى الطراز المعماري للبلاد وتمثل الهوية التاريخية للسكان المحليين والمناطق المحيطة بها .هذه المباني الخشبية القديمة لها عمر طويل ولا تزال قوية حتى يومنا هذا، ولكنها معرضة الآن لتهديدات الحريق من استخدام مواد الخشب القابلة للاشتعال .لمنع فقدان المزيد من المباني الخشبية القديمة، لقد تم إدخال أنظمة جديدة مختلفة الذي يخدم نشط نظام الحماية من الحرائق لهذه المباني .يتمثل الهدف الرئيسي من هذا البحث في تحديد نوع نظام الحماية من الحريق النشط المناسب وطريقة التثبيت المتوافقة مع مبنى الخشب القديم .تبدأ هذه الدراسة بفهم معايير اختيار نظام الحماية من الحريق النشط للمباني القديمة وتحديد أنظمة الحماية النشطة من الحريق التي يتم استخدامها غالبًا في المباني القديمة.مقارنةً بالمباني الجديدة، ويتطلب تركيب هذه الأنظمة في المباني القديمة طريقة تؤدي إلى الحد الأدنى من التأثير أو الضرر في بنية المبنى الأصلي، ويجب أن تتماشى مع بنية المبنى.وقد تم اختيار العديد من المباني من كل من الدول الأجنبية والمحلية لتحديد نظام الحماية من الحريق النشط المستخدم في كل مبنى وكذلك تحديد الاختلافات بين كل مبنى .تم تحديد وطرق مختلفة للتنفيذ والتركيب، وتم اختيار كل من هذه الطرق لمعالجة القضايا المختلفة التي تنشأ خلال عملية الحفاظ على المباني التراثية .يعتمد اختيار نظام الحماية النشطة من الحريق على عدة عوامل مختلفة مثل الجمال والتكلفة والأثر على هيكل المبنى الأصلي .من المتوقع أن تكون نتائج هذا الاكتشاف مثالًا عامًا أو إرشادات موجزة لمشروعات الحفظ المستقبلية على المباني القديمة الأخرى.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Built Environment).

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DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF ABBREVIATIONS

BOMBA	Jabatan Bomba dan Penyelamat Malaysia
BSI	British Standard Index
CCTV	Closed-circuit television
CFPA	Confederation of Fire Protection Associations Europe
COST	European Cooperation in Science & Technology
HUD	United States Department of Housing and Urban Development
ICOMOS	International Council on Monuments and Sites
JMM	Jabatan Muzium Malaysia / Department of Museum Malaysia
JPBD	Jabatan Perancangan Bandar dan Desa
JWN	Jabatan Warisan Negara / Department of National Heritage
LMNK	Lembaga Muzium Negeri Kedah
LMNS	Lembaga Muzium Negeri Sembilan
NFPA	National Fire Protection Association
PAM	Pertubuhan Arkitek Malaysia
SIRIM	Standard and Industrial Research Institute of Malaysia
UBBL	Uniform Building By-law
UNESCO	United Nations Education, Scientific and Cultural Organization

CHAPTER ONE

INTRODUCTION

1.1 Background

One of the most valuable historical assets of any civilization or country is the existence of its heritage buildings. Heritage buildings can be easily described as buildings that were constructed in the past and may contain a certain historical value within its design. According to Siemens Switzerland Ltd. (2015), heritage building helps to provide a general glimpse of the past of a particular community or civilization through its craftsmanship and technology used in the building's design and construction. Aside from the workmanship, heritage building also represents the living condition and way of life of its previous occupants. These buildings of the past designed and constructed have withstood the test of time and may play an important role towards the development of its surrounding civilization. This is further supported by the Malaysian National Heritage Act 2005 that defines heritage building as a building or groups of separated or connected building that stands out amongst the rest due to their architectural essence, their cultural homogeneity, or even their placement within the surrounding landscape from the perspective of history, arts, and science.

Fire is a constant risk that causes various types of destruction towards most buildings and its contents. In the case of heritage building, fire is considered as the most significant threat towards the historic essence of the building and its context especially with the increasing age of most of the heritage building materials and insufficient safety provision. According to Historic Scotland (2005), fire usually

occurs due to the presence of three main elements which includes heat, oxygen, and fuel. Additionally, fire can also easily spread when its movement is unhindered from any types of separation. This is a main threat to heritage buildings since most of them were constructed using traditional methods and tend to contain numerous paths that fire can easily pass through. Aside from the threat towards the building occupants, the spread of fire also creates several negative impacts towards the building and its surrounding context.

During the historical period of Malaysia, timber was considered as the main choice of material for construction purposes. According to Zainab (2005), brick was eventually introduced in Malaysia since 350 years ago but it was rarely accessible to everyone and was usually limited to government-related buildings. Thus, timber was regarded as the easiest available material and can easily be constructed. Table 1.1 shows the list of some of the heritage timber buildings that had been registered under the National Heritage Act 2005 and acknowledged by Department of National Heritage (JWN) in their website. The list showcases only a small fraction of the number of heritage timber buildings that can be found throughout Malaysia.

Table 1.1: List of heritage timber buildings in Malaysia

Types of Buildings	List of Buildings
Places of worship	1. Masjid Insaniah Iskandariah, Kg Kuala Dal, Perak 2. Masjid Mulong, Kota Bharu, Kelantan 3. Balai adat Kampung Putera Jelebu, Negeri Sembilan 4. Masjid Kampung Laut, Kelantan 5. Gereja All Saints, Taiping, Perak* 6. Surau Kampung Tuan, Kemaman, Terengganu
Private property	1. Rumah Tiang Kembar & Rumah Tiang Limas, Terengganu 2. Rumah Penghulu Mat Nattar, Jasin, Melaka
Government administration	1. Bangunan Sanitary Road, Taiping, Perak 2. Muzium Islam, Kota Bharu, Kelantan 3. Kota Ngah Ibrahim, Taiping, Perak
Palace	1. Istana Lama Ampang Tinggi, Negeri Sembilan 2. Istana Jahar (Muzium Adat Istiadat Diraja), Kota Bharu, Kelantan* 3. Istana Kenangan (Muzium Diraja Perak), Kuala Kangsar* 4. Istana Seri Menanti, Kuala Pilah, Negeri Sembilan*
Commercial	1. Gedung Raja Abdullah, Klang, Selangor*

* Buildings gazetted under National Heritage Act 2005

(Source: heritage.gov.my)

When a heritage building changes its function and is opened to the public, the building is required to conform to the various building regulations and by-laws in particular to the fire protection system. In most cases, after a certain period of time, most of these heritage timber buildings were later converted to suit a different purpose. As mentioned by Kidd (2001), the building faces potential risk of arson or wilfully set fires by allowing public access. He also added that since the number of visitors or occupants had increased, great consideration should also be made towards the improvement risk assessment programme. According to Jabatan Bomba dan Penyelamat Malaysia (2017), 1,438 cases involving incendiary fire were reported from the year 2013 to 2016. Thus, the installation of appropriate fire protection system into the heritage building to conform to the fire regulations is important and would reduce the potential risk of fire exposure towards the occupant. In addition, the risk of damages towards the heritage building iconic construction elements can also be greatly reduced by having fire protection system available throughout the whole

building. As emphasized by The Confederation of Fire Protection Associations Europe (2013), awareness towards the risk of fire and the possibility of its occurrences is vital towards the protection of the heritage building and its content.

1.2 Research Problem

When it comes to fire-related issues, timber has always been an immediate concern on its resistance to fire and many considered timber buildings to be prone to fire spread. In addition, heritage timber buildings rely heavily towards the application of fire protection system in order to prevent any further damage caused by fire from spreading. However, detailed consideration and assessment should be made regarding the choice of methods to be used since it may instead cause irreplaceable damage towards the building itself and may stand out differently compared to the building's fabric.

1.3 Problem Statement

1.3.1 Heritage Timber Building Risks to Fire

One of the main concerns when it comes to the application of fire protection system in a heritage building is the choice of methods available particular to the condition of the building materials and design. Different material may cause a different reaction compared to others when it comes to interaction with fire. In the case of heritage timber building, the combustible nature of timber material proofs to be a significant challenge in implementing adequate fire protection system. This has

always been a main concern since most the heritage buildings in Malaysia are constructed using timber as its main material. Table 2 highlights the list of heritage timber buildings which had been severely damaged or destroyed by fire in Malaysia. Unfortunately, no official statistic was able to be obtained from Jabatan Bomba dan Penyelamat Malaysia (BOMBA).

Table 1.2: Fire statistic for heritage timber buildings in Malaysia from 2003-2016

Date	Building	Estimated Loss (MYR)
2 May 2003	8 Double-storey wooden shop houses (1950), Batu Kawa Bazaar, Kuching	
25 July 2003	138-years old semi-wooden girls dormitory, St Joseph Home, Penang	100,000
20 Oct. 2003	Rumah Pak Ali (1876), Gombak, Kuala Lumpur	>1 mil.
5 May 2008	38 units of Punan Bah longhouse, Belaga, Sarawak	>500,000
5 Feb 2009	5 Heritage houses, Chew Jetty, Penang (In World Heritage Site Zone)	
24 Feb 2010	Ho Ann Kiong Temple, Kampung Cina, Kuala Terengganu	

(Source: thestar.com.my)

Figure 1.1: Aftermath of fire in Ho Ann Kiong Temple (left) and Punan Bah Longhouse (right)
(Source: thestar.com.my)

Most of the heritage timber buildings in Malaysia are designed to allow the timber material to be exposed. According to Gerard & Barber (2013), the presence of exposed timber material will contribute to the combustible fuel load as well as the room fire behaviour and structural fire resistance. From this statement, it can be understood that the material used in the heritage building construction plays a significant role towards the fire safety performance. Hill (2004) stated that the interaction between timber and fire would result to smouldering fire. Smouldering fire tends to burn slower than flaming fire; thus, it may initially release less smoke particles. As a result, certain detectors may have a slower reaction time before the fire start to spread.

1.3.2 Aesthetical Integration of Fire Protection System with Building Fabric

Another main issue that occurs during the installation of fire protection system in heritage timber building is the appearance of the equipments stands out differently compared to the building fabric, as shown in Figure 1.2. The installation of the fire protection system should not contradict with the design elements of the building since it will most likely lose the purpose of historical preservation. As mentioned by Allwinkle, Bell et al. (1997), changes should only be made where it is deemed absolutely essential for the building's safety. This is further supported by Siemens Switzerland Ltd. (2015), in which they stated that the procedures involved should be done with the least amount physical impact towards the fabric and decor of the building. In the context of heritage timber buildings, the installation of the fire protection system should be carried out with minimally invasive methods.

Figure 1.2: Exposed sprinkler piping and smoke detector
(Source: Arvidson [2006])

1.3.3 Damages Caused to the Building Fabric During Installation

The third concern of this research is on the installation process of the selected fire protection system that would damage the highly valuable and irreplaceable building elements or structure as evidently shown in Figure 1.3. During the installation process, drilling or alterations may take place to the existing building elements in order to allow the implementation of the fire protection system equipments for compliance to fire regulations. Without proper established methods, guidelines and assessment, this outcome may lead to a devastating result since most of the building elements in a heritage timber building play an important role towards its structural integrity. According to United States National Fire Protection Association (2015), one of the main objectives of historical preservation is to fully utilize the level of protection of the heritage buildings against damage and loss to fire. Thus, it is important to note that the choice of choosing the ideal fire protection system to be implemented in a heritage timber building is important towards the preservation of its authenticity and safety.