FIRE SAFETY AND PROTECTION MEASURES IN HERITAGE BUILDINGS WITH SPECIAL CONSIDERATION ON MUSEUM BUILDINGS IN MALAYSIA

by

NURUL HAMIRUDDIN BIN SALLEH

Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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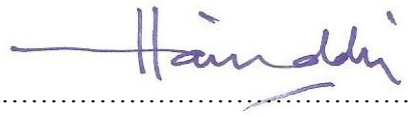
This thesis is dedicated to
my dearest parents,
Allahyarham Hj. Salleh bin Harun (1930-2007) and
Allahyarhammah Hjh. Fatimah bt. Alang Klimun (1936-2010),
may Allah s.w.t. forgives their sins and shortcomings and
admits their souls into Jannah.

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Doctor of Philosophy (Architecture).

Signature	: ……
Name of Supervisor	: PROFESSOR DR. A GHAFAR AHMAD
Date	: ……..

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Sains Malaysia or other institutions.

Signature : 

Name : NURUL HAMIRUDDIN BIN SALLEH

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LANGKAH-LANGKAH KESELAMATAN DAN PERLINDUNGAN KEBAKARAN DI BANGUNAN WARISAN DENGAN PENGKHUSUSAN PADA BANGUNAN MUZIUM DI MALAYSIA

ABSTRAK

Di Malaysia, beberapa bangunan warisan telah musnah dan rosak teruk diakibatkan oleh kebakaran seperti Muzium Rakyat, Melaka (2001), Rumah Pak Ali (2003) dan Kelab Sarawak, Kuching (2006). Kebakaran sememangnya merupakan ancaman kepada bangunan warisan iaitu bukan sahaja kepada penghuninya malah juga kepada bangunan dan isi kandungannya. Bangunan warisan memang tidak boleh ditukar ganti tetapi ia amat terdedah kepada beberapa risiko kebakaran termasuk saiz bangunan yang besar, isi kandungan yang mudah terbakar dan struktur bangunan sedia ada yang lemah rintangan api. Namun begitu, sehingga kini masih tiada perundangan dan garis panduan keselamatan kebakaran khusus untuk bangunan warisan di Malaysia. Oleh itu, kajian ini adalah bertujuan untuk mengaudit langkah-langkah keselamatan kebakaran dan menilai pengurusan keselamatan kebakaran di bangunan warisan di Malaysia dengan pengkhususan pada bangunan muzium. Gabungan metodologi pemerhatian lapangan, temubual, borang soal-selidik dan kajian kes telah dilakukan untuk memperolehi data utama di dalam kajian ini. Sebanyak 37 bangunan warisan dari sembilan negeri di Malaysia telah berjaya dikaji. Tiga daripada bangunan tersebut telah dipilih sebagai kajian kes yang setiap satunya mewakili kriteria berlainan. Hasil kajian mendapati bangunan warisan yang dikaji masih mempunyai kelemahan keselamatan kebakaran dan boleh membahayakan nyawa pengguna serta koleksi bersejarah sekiranya berlaku kebakaran. Empat garis panduan keselamatan kebakaran untuk bangunan warisan ada dicadangkan di akhir kajian ini.

FIRE SAFETY AND PROTECTION MEASURES IN HERITAGE BUILDINGS WITH SPECIAL CONSIDERATION ON MUSEUM BUILDINGS IN MALAYSIA

ABSTRACT

In Malaysia, a number of priceless heritage buildings were badly damaged or burnt down by fire including the People Museum, Melaka (2001), Pak Ali's House, Gombak (2003) and the Sarawak Club, Kuching (2006). Indeed, fire is one of the greatest threats to heritage buildings not only to the buildings' occupants but also to the buildings' fabrics and contents. Heritage buildings are irreplaceable, in addition to being vulnerable to fire due to several factors: large scale buildings, flammable priceless contents, and weak existing structures to fire resistance. Unfortunately, until today, there are no sufficient legislations or guidelines on fire safety for heritage buildings in Malaysia. This study audits the current fire safety measures and examines the management of fire safety in Malaysian heritage buildings that focuses on museum buildings. A combination of observations, interviews, questionnaires and case studies was employed to provide primary data in this study. Thirty seven heritage buildings from nine different states in Malaysia were successfully surveyed as building samples. Later, three of them were selected as case studies; each of them represented different criteria in order to gather various information and comparison as much as possible. Findings from the study revealed that there are several fire safety weaknesses in the heritage buildings that could put people and heritage properties on fire risks. Four fire safety guidelines for heritage buildings are recommended at the end of the study.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is an introductory chapter which introduces background of the study upon which the thesis was based, namely the introduction of the subject matter, research background, problem statements, objectives, research framework, significance, limitations and scope of study.

1.2 Research Background

In Malaysia, there are a number of valuable heritage buildings which have been classified into several categories, namely traditional timber Malay houses, pre-world war shop houses, colonial office buildings, and religious buildings. Some of them have been listed as Heritage Buildings or National Heritage Buildings under the National Heritage Act 2005 (Act 645). However, mostly due to inappropriate management and poor fire protection measures, several irreplaceable heritage buildings in Malaysia were destroyed or burnt down by fire, such as Pak Ali's House (*Rumah Pak Ali*) (Plate 1.1), the former High Court of Kuala Lumpur (Plate 1.2) and the Sarawak Club (Plate 1.3). In fact, in the last decade, at least one heritage building has been destroyed or damaged by fire almost every year in Malaysia (Table 1.1). The worst fire occurred in 2008, where a total of 59 heritage buildings were involved in five different fire incidents. These tragedies emphasise the vulnerability of heritage buildings and their contents to fire and its aftermath. Therefore, this study is an analysis of the current practice of fire safety management in Malaysian heritage buildings, specifically heritage buildings that are used as museums either originally or through adaptive re-use processes.

Plate 1.1: Traditional timber house 'Rumah Pak Ali' that built in 1876 was destroyed by fire in October 2003
(Source: Surainie Mohd Hanif)

Plate 1.2: The former High Court of Kuala Lumpur (1896) was twice destroyed by fire in 1992. The first fire occurred in 16 March 1992 when the building was undergoing renovation works (left) and later in December (right)
(Source: http://www.beritaharian.com.my , 23 March 2008)

Plate 1.3: The Sarawak's oldest club that known as the Sarawak Club (1876), was razed in an early morning fire on 27 July 2006
(Source: http://thestar.com.my/news , 28 July 2006)

Table 1.1: Fire statistics of heritage buildings in Malaysia from 1992 – 2010

Date	Building	Year of Built	Function	Estimated Loss (MYR)	Cause
16 March & Dec. 1992	**The High Court Building,** Kuala Lumpur	1896 / 1904	Court		
17 Sept. 1992	**The National Museum Malaysia** Kuala Lumpur	1959	Museum	100,000	Suspected origin from portable water heater or smoking
12 Sept. 1996	**The Sultan Abu Bakar Royal Museum**, Johor	1866	Museum	Undisclosed	Arson (Molotov cocktail)
15 March 1997	**The Sultan Abu Bakar Royal Museum**, Johor	1866	Museum	Undisclosed	Undisclosed
2 Dec. 2001	**The People's Museum**, Melaka		Museum	**Undisclosed** (Exhibition Hall is totally damaged. Several copies of Dutch manuscripts, old paintings and artefacts were destroyed)	Short-circuit
20 Oct. 2003	**Pak Ali's House,** Kampung Kerdas, Gombak	1876	Museum	> 1 million	Short-circuit
27 June 2005	**23 Shop houses of pre-World War**, Meru, Klang	1920 - 1930	Shop house	5 million	
27 June 2005	**13 Shop houses of pre-World War**, Kampung Sentosa, off Jln Klang Lama, KL	1920 - 1930	Shop house	> 500,000	
30 May 2006	**The Handcraft Village,** Jalan Semarak, Kuala Lumpur		Handcraft centre	300,000	
17 July 2006	**Shop house**, Jalan Laksamana, Bandar Hilir, Melaka	> 1806	Shop house		
27 July 2006	**The Sarawak Club**, Kuching	1876	Club house		
24 July 2007	**The Royal Malaysian Police Voluntary Club** Ipoh	1910	Club house		
30 Sept. 2007	**The PULAPOL Senior Police Quarters,** Jalan Semarak, KL	1940	Quarters	300,000	Short-circuit
19 Mac. 2008	**6 old shop houses,** Taiping, Perak	1895	Shop	> 300,000	
05 May 2008	**38 units of Punan Bah longhouse,** Belaga, Sarawak		Residential	> 500,000	
11 July 2008	**The Memorial Datuk Onn Jaafar,** Batu Pahat.		Memorial	Destroyed 70% of the building and artefacts	Undisclosed
09 Dec. 2008	**7 old wooden shop houses,** Tamparuli, Sabah	1950s	Shop house	(Totally destroyed)	unreported
11 Dec. 2008	**7 old shop houses,** Lebuh Armenian, Penang **(In World Heritage Site zone)**	> 50 years	Shop house	± 600,000	unreported
21 Dec. 2009	**7 shop houses,** Jalan Gambier, Kuching, Sarawak	> 100 years	Shop house		
6 Feb. 2010	**4 shop houses,** Jalan Wayang, Kuching, Sarawak	> 100 years	Shop house		

(Source: Personal survey, 2010)

It is widely regarded that fire is one of the greatest threats not only to the occupants of a building but also to its fabric and contents. However, the "Fire Safety Philosophy" of the Malaysian Uniform Building By-laws 1984 (UBBL 1984) is mainly for the life safety of the building's occupants. In the case of a heritage building, until today, no proper legal requirements have been endorsed to protect historic contents and structures from fire. According to many international fire experts including Ingval Maxwell Obe, Stewart Kidd and John M. Watts, Jr., fire safety systems in heritage buildings must be sympathetically designed in order to minimise the impact on the historic character (authenticity) of the buildings. Nevertheless, although many lessons have been learned and approaches to fire safety in heritage buildings have grown more sophisticated, one simple fact remains: most fires occur as a result of human action or negligence. UBBL 1984 and Act 645 are further discussed in Chapter 2 and Chapter 4 of the thesis respectively.

Historically, fire has long been an enemy of historic structures, with some older structures falling victim many times. One example is the LaFenice Theatre (Venice Opera House) that first opened in 1792 on the site of a theatre that burned down in 1773. After being rebuilt, the building was again extensively damaged by fire in 1836 and 1996 (Bukowski, Nuzzolese and Bindo, 2001). In addition, history shows that fire was recognised as a threat to great civilisations as early as 2000 years ago. The Roman Empire devised a system of corps vigilante whose sole task was to be on the watch for the outbreak of fire. The Great Fire of London in 1666 became the catalyst for the modern day building codes. The fire broke out in a baker's shop and destroyed half of London. The buildings in London at that time were not fire separated and so the fire spread easily. Analysis of how the fire spread led to the creation of the first building regulations.

Spadaccini (1998) stated that when fire is not controlled, it may result in injury or death of people from smoke, gases and heat, destruction of buildings, their contents and other tangible property, temporary or permanent closure of business, loss of income and

possibly bankruptcy, and destruction of irreplaceable reminders of human heritage. In the case of a heritage building, the loss of authentic fabric in a fire is irretrievable. Much could and should be done to minimise the likelihood of fire, starting with the early elimination of major risks and the management of those risks which cannot be eliminated, and alleviating the destructive consequences of fire (Marchant, Marshall and Newson, 1997). While modern buildings are designed from the outset to allow the occupants to leave quickly and easily in the event of a fire, adapting a heritage building is more difficult. Two primary factors must be considered: the protection of persons either living, working or visiting in the premises, and the protection of the building fabrics and its contents. If the building concerned is also open to the visiting public, the requirement for life safety measures is even greater (Forrest, 1996). Moreover, many heritage buildings generally exhibit combustible construction and inadequate exits, for example long, single paths of travel, narrow stairways and unprotected vertical openings that violate modern codes and fire protection practices (Bukowski, Nuzzolese and Bindo, 2001).

In this respect, Marchant, Marshall and Newson (1997) highlight that authentic fabric lost to fire is irreplaceable; no matter how good subsequent restoration may be, the original has been lost forever. It follows that the conservation and protection of heritage buildings must involve giving them the best possible protection from fire. This is not to ignore the safety of occupants, which remains of paramount importance, rather to ensure that fire protection measures look beyond the immediate requirements of life safety to encompass the protection of the building fabric and contents as well. Much can be done by good management to prevent fires from occurring in the first place. Beyond this, the installation of fire detection and protection systems may be required. There are many devices available, from simple smoke detectors to carefully engineered detection, alarm and suppression systems. However, in some instances, such technology demands a level of intervention in the fabric that is unacceptable in conservation terms. Measures taken to protect the fabric must not damage what they set out to protect. A balance needs to be established.

Therefore, when formulating proposals for heritage buildings, a more flexible approach is often called for, which will include a rigorous assessment of the need for proposed works and an exploration of alternative strategies, set against their likely impact on the fabric of the building. In most cases, such an approach will enable a sympathetic solution to be developed to meet the spirit, if not the full requirements of the regulations, whilst minimising impact on the heritage building. Building owners and managers must understand that mere legal compliance guarantees nothing more than verification that the life safety provisions of the building meet the legal minimum and that protection of fabric may be limited. Further measures are likely to be necessary to provide the best level of protection for the building itself against the effects of fire (Kidd, 2005).

Kidd (2001 and 2005) also adds in upgrading fire safety systems in heritage buildings, special considerations should be applied. Not only must the systems aim to comply with the relevant standards and provide the intended levels of protection, but additionally their impact on the building and its fabric must meet a range of tests. Furthermore, it is essential that full consideration be paid to the risks of potential damage to original fabric as well as the aesthetic impact fire systems might have on heritage buildings. Any changes to a listed building must not only address fire protection needs but must fully comply with the law in respect of listed building consent.

In terms of fire safety codes, Watts and Solomon (2002) state that, while building codes have progressed to keep up with developing techniques of modern construction, the issues of fire safety for heritage buildings are relegated to guidance documents, for example, with no legal authority. A few rehabilitation codes have evolved that recognise the inherent differences between new construction and existing buildings but they retain the inflexibility and additional problems of specification-based codes, and are inadequate in their approach to heritage buildings, the subcategory of existing buildings with the highest requirement for

property protection. None of the recent generation of codes has resolved the conflict between the prescriptive language of fire safety and the philosophical language of the Burra Charters and Venice Charters, documents used internationally. This topic is further discussed in Chapter 2.

1.3 Problem Statements

Several key issues with regard to fire safety and heritage buildings in Malaysia have been identified as follows:

1.3.1 Heritage Buildings on Fire

Fire does not respect age or historic importance of any buildings. Until today, fire has damaged and destroyed many prominent heritage properties worldwide. This issue is further discussed in Chapter 2. In Malaysia, the number of fire cases has gradually increased from 2001 to 2008, the highest was recorded in 2005 with 31,138 cases compared to 15,419 cases in 2001 (Table 1.2). According to the Fire and Rescue Department of Malaysia (FRDM), fire has caused a total loss of approximately RM5,769.60 million from 2001 to 2008 that claimed 582 lives and injured 679 people. 25,402 (15%) from the total of fire cases involved buildings. The highest building fires were recorded in 2008 with 3,556 cases compared to 3,447 cases in 2007. Electrical fault was recorded as the highest cause of fire in the both years (Table 1.3).

Table 1.2: Fire statistics in Malaysia from 2001 – 2008

	2001	2002	2003	2004	2005	2006	2007	2008	TOTAL
Fire Cases	15,419	25,726	18,290	22,779	31,138	18,913	20,225	21,524	**174,014**
Death	62	46	100	65	70	71	80	88	**582**
Injured	81	76	68	107	115	86	67	79	**679**
Building Fires	2489	2887	3059	3154	3457	3353	3447	3556	**25,402**
Estimated Loss (RM million)	584.22	603.02	502.40	614.70	794.70	760.70	865.30	1,044.56	**5,769.60**

(Source: Fire and Rescue Department of Malaysia, 2010)

Table 1.3: Statistics of causes of building fires in Malaysia for 2007 and 2008

Cause of Fire	Total Cases	
	2007	2008
Electrical	1248	1323
Cigarette butts	98	130
Fire spark	89	85
Fire crackers	22	22
Mosquito coil/ Candles/ Joss sticks	221	187
Gas stove/ Oil	298	349
Spontaneous action	34	33
Intentionally with good faith	102	120
Arson	128	124
Unknown	651	479
Chemical reaction	12	8
Match sticks	130	123
Others	414	573
GRAND TOTAL	**3447**	**3556**

(Source: http://www.bomba.gov.my, 11 February 2010)

On the 21st of April 2009, Datuk Hamzah Abu Bakar, the former Director General of FRDM, reported that fires have caused a total loss of more than RM235 million in three months (January to March 2009) with 21 deaths and 12 injured (Harian Metro, 22 April 2009). Among the states that recorded the highest amount of fire loss are Selangor (RM80 million), Penang (RM61 million) and Johor (RM21 million). Nevertheless, until recently, there has been no separate statistics for heritage building fires in Malaysia. Based on newspaper cuttings and internet searches, fires have also damaged and destroyed many heritage buildings in Malaysia with a total loss of more than RM5 million. Unfortunately, as mentioned earlier, the FRDM in line with the UBBL 1984 has stressed that the life safety of occupants is the ultimate principle of fire safety in a building (Hamzah, 2006). Property protection, which includes protection of contents such as furnishings, fittings, objects of value as well as the property itself, has not really been emphasised. This scenario is quite similar to England and Ireland, where relevant building and fire regulations have traditionally placed the greatest emphasis on two fire protection objectives, namely life safety protection and prevention of conflagrations (Pickard, 1993).

Furthermore, in order to preserve heritage buildings, most of the buildings have been adaptive re-used into different functions from its original such as museums, galleries, hotels and offices through conservation processes. However, a majority of Malaysian heritage buildings have been converted into museums, galleries and memorials. Similarly, like other heritage buildings, fire has always been a threat to museums where, from 1992 to 2008, at least 6 museums have been involved in fires that destroyed the buildings and its contents. The cases could be considered as an alarming issue and should be given higher priority because the buildings and its contents are categorised as historically valuable, priceless and irreplaceable. This is on the assumption that the problems are due to many factors such as insufficient fire safety systems, poor maintenance, and lack of fire safety guidelines. In fact, the authorities have also failed to provide sufficient guidance and good strategy in safeguarding buildings that may be considered as heritage buildings from fire damages. In a study, Siti Rohamini (2002) has found that active fire protection systems in museums are still insufficient based on the ratio of their contents. Fire in museums is not only a problem in Malaysia but also throughout the world (Table 1.4). The National Fire Protection Association (NFPA) estimates that an average of 89 museum and gallery fires each year in the United States of America (USA) (Kidd, 2005). In Canada, some 316 museum, art gallery and library fires occurred between 1982 and 1993 that caused an estimated loss of over USD17 million (Mills, 2007).

Table 1.4: List of museum fires in the world (1958 - 2008)

Date	Museum Name	Cause of Fire	Fire Prevention Equipment	Estimated Loss
15 April 1958	**The Museum of Modern Art,** New York, USA	Origin was workmen repainting second floor galleries who were smoking on the job.	Detectors but no sprinklers.	**USD 700,000** (Loss of one life, 33 injuries, several galleries, two major paintings, including a Monet, seven paintings severely damaged)
9 Aug.1970	**The Henry Ford Museum,** Michigan, USA	Origin suspected to be an overheated hair curling iron in a dressing room.	Detectors but no sprinklers on part of the building.	**USD 2 million** (Loss of several historic displays of shops and equipment)
30 Sept.1970	**The Smithsonian Institution National Museum of American History,** Washington D.C. USA	Origin was electrical short in the exhibit.	Detectors but no sprinklers.	**USD 1 million** (Loss of two galleries and their exhibits, with some water damage)
22 Feb.1978	**The San Diego Aerospace Museum and International Aerospace Hall of Fame,** California, USA	Arson. Arsonists were two youths seen running away.	No detectors, no sprinklers	**USD 16 million** (Loss of the building and entire collection, including 40 planes and library)
8 July 1978	**The Museum of Modern Art,** Rio de Janerio, Brazil	Suspected origin from smoking or defective wiring.	No detectors, no sprinklers	**USD 50 million** (Loss of most of the interior, the roof, and 900 works of art (90% of the collection)
31 Dec.1984	**The Byer Museum of Art,** Illinois, USA	Suspected electrical origin.	Detectors but no sprinklers.	**USD 3 million** (Loss of the upper two floors and roof, with extensive water damage)
17 Oct.1985	**The Huntington Gallery,** California, USA	Suspected origin was an electrical on the elevator at night, which burst explosively into the first floor.	Smoke detectors in the museum but not in the elevator or elevator shaft. No sprinklers.	**USD 1.5 million** (Loss of elevator and elevator shaft, one minor painting, and extensive smoke damage)
11 May 1988	**The Cabildo Building, Louisiana Museum of Art,** New Orleans, USA	Origin was workmen welding gutters on the exterior igniting an interior hollow space.	Detectors in the museum, but no detectors in the hollow space, no sprinklers.	**USD 5 million** (Loss of furniture collections in the attic, roof, structural and water damage)
17 Sept.1992	**The National Museum Malaysia**, Kuala Lumpur, MALAYSIA	Suspected origin from portable water heater or smoking		**USD 30,000** (Loss of some AV equipments and documentary collections)
20 Nov.1992	**The Windsor Castle,** London, ENGLAND	Suspected origin was blow torch.	No detectors or sprinklers.	**USD 90 million** (Loss of a tower, several rooms, tapestries, and minor paintings)
19 April 1993	**The Yuma Arizona Art Center,** Arizona, USA	Suspected origin was electrical.	Smoke detectors no sprinklers.	**USD 1.5 million** (Loss of historic building and 39 fine art pieces with some smoke and water damage)
09 Aug.1993	**The Oakland Museum,** California, USA	Origin was defective exhibit motor in storage room.	Detectors but no sprinklers.	**USD 1 million** (Loss of gallery and some exhibits on loan)

Table 1.4: Continued

Date	Museum Name	Cause of Fire	Fire Prevention Equipment	Estimated Loss
2 June 1994	**The Oshkosh Public Museum,** Wisconsin, USA	Origin was workmen welding gutters on the exterior igniting an interior hollow space.	Detectors in the museum, but no detectors in the hollow space, no sprinklers.	**USD 2 million** (Loss of 10% of the collection and collection records)
12 Sep.1996	**The Sultan Abu Bakar Royal Museum**, Johor, MALAYSIA	Arson (Molotov cocktail)		**Undisclosed**
15 March 1997	**The Sultan Abu Bakar Royal Museum**, Johor, MALAYSIA	Undisclosed		**Undisclosed**
02 Dec.2001	**The People's Museum**, Melaka, MALAYSIA	Electrical short-circuit		**Undisclosed** (Exhibition Hall is totally damaged. Several copies of Dutch manuscripts, old paintings and artefacts were destroyed in the 9.15pm fire)
16 Sep.2003	**The National Motorcycle Museum**, Birmingham, UK	A cigarette		**GBP 8 million**
20 Oct.2003	**The Pak Ali House,** Gombak, MALAYSIA	Electrical short-circuit	No detectors or sprinklers.	**> USD 500,000** (Building badly damaged and not reopened)
18 Nov.2003	**The Holocaust Museum,** Terre Haute, Indiana USA	Suspected domestic terrorism		
28 Aug.2005	**The Mackinac Bridge Museum**, Mackinac City, Michigan, USA			
18 March 2008	**The Tweetsie Railroad Museum (1957)** Blowing Rock, North Carolina, USA	Lightning may have struck the building causing an electrical fire		(The building is completely unrecognizable, reduced to charred remnants and mangled metal)
4 April 2008	**The Quebec City Armoury (1884),** Quebec, CANADA		Undergoing renovations	(Destroyed many souvenirs linked to the history of fighting for Canada during various wars)
11 July 2008	**The Memorial Datuk Onn Jaafar,** Batu Pahat. MALAYSIA	Undisclosed	Undergoing renovations to open for public	**Undisclosed** (Destroyed 70% of the building and artefacts)

(Source: www.museum-security.org)

1.3.2 Lack of Fire Safety Awareness

From Figure 1.1, it can be assumed that the increment of the total building fire incidents may be due to lack of fire safety awareness amongst the authorities, owners and public. On the 13th of September 2006, Ab. Ghani Daud, the Director of Fire and Rescue Department of Perak stated that poor fire safety awareness among building owners is one of the main causes of building fires in the Perak state. It is believed that most of the buildings'

owners have put more efforts on building security instead of building fire safety (Utusan Malaysia, 2006). This issue was also highlighted in 2002 by Tan Sri Lee Lam Thye, Chairman of the National Institute of Occupational Safety and Health (NIOSH), who stated that fire safety among owners and buildings occupants of shopping complexes, offices and educational institutions has not improved and that their awareness is at a relatively low level (The Star, 2002). For example, in 2001, the Federal Territory Fire and Rescue Department issued 467 notices, of which 329 were to shopping complexes, 265 to hotels, 100 to educational institutions and 163 to factories. Most of the notices were for failing to provide adequate emergency exits, lights and fire hose reels (The Star, 2002).

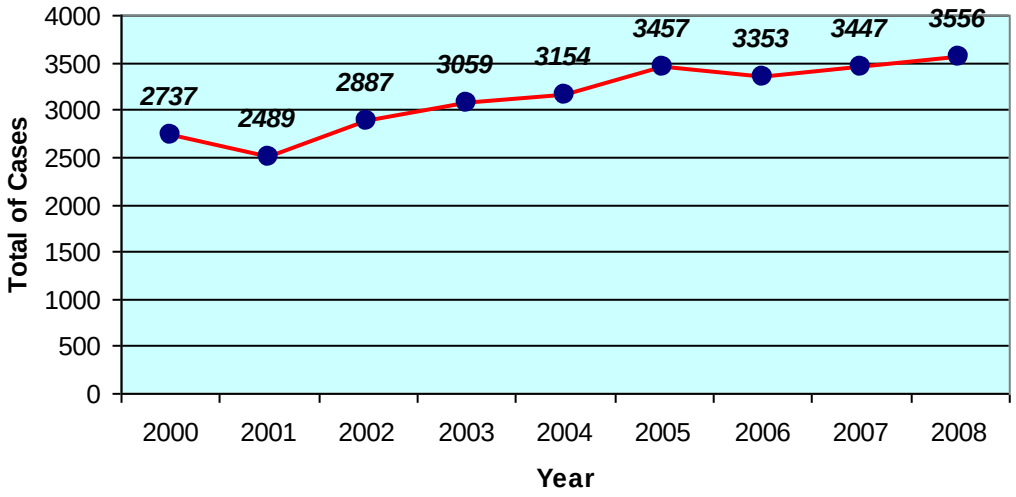

Figure 1.1: Buildings fire statistic in Malaysia for 2000 - 2008
(Source: Fire and Rescue Department of Malaysia, 2010)

In Malaysia, fire safety awareness has always been taken for granted by the public, hence increasing the total number of deaths and injuries due to fire in the country. Mohd Armal Mahfuzan (2007) highlights that various measures have been taken by government authorities and Non-Governmental Organisations (NGOs) in enhancing the awareness of building occupants on fire safety in order to reduce fire incidents and zero-fire. However, the standard level of fire safety awareness among the public is still disappointing. This means that the campaigns have not increased public awareness towards fire safety. This view is supported by Siti Rohamini (2002) in her study discovered that fire safety awareness among

visitors as members of the public, is still low. Nevertheless, fire safety awareness among building staff is at moderate level. However, in a survey conducted by Muna Hanim (2009) amongst the staff of a hospital and two libraries in Universiti Sains Malaysia reveals that respondents from buildings are quite unsure regarding the correct sequence of actions in the event of a fire even though they are quite exposed to various knowledge on fire safety.

1.3.3 Buildings Not Compliance to the Fire Services Act 1988, Regulations and Order (Act 341)

Section 27 of the Fire Services Act 1988 (Act 341) states that every designated building or premise is required to have a fire certificate (FC) and the certificate shall be renewable annually. Any owner of the designated premises without a FC shall be guilty of an offence (Sec. 33, Act 341) and be liable to a fine not exceeding RM5,000 or to imprisonment for a term not exceeding three years or both (Sec. 58, Act 341). Nevertheless, Datuk Hamzah Abu Bakar, the former Director General of FRDM reported that, in 2009 there are 125 buildings in Kuala Lumpur still without FCs (Harian Metro, 2009). In addition, Mohd. Yusof Muhammad, the former Director of the Johor Fire and Rescue Department stated that, until April 2007, 728 buildings were legally required to have FCs in the state in which 43 of them were government buildings and 685 private buildings. However, only 3 government buildings and 663 private buildings applied for the FCs (Utusan Malaysia, 2007). In Perak, only 45 out of 236 high-risk buildings have received FCs since 2003 (Utusan Malaysia, 2006). Actually, this is a never ending issue as the former Director General of FRDM Datuk Jaafar Sidek Tambi, had also highlighted the issue back in 2002. At that time, he reported that 1,208 buildings or 26.4% of 4,564 buildings in Malaysia which required FCs did not obtain the certificate even after 14 years (Bernama, 2002b).

On the other hand, in 2008, the FDRM issued 8,309 Fire-hazard Abatement notices (Form A, Act 341) from a total of 14,980 inspected buildings in Malaysia. 1,526 were issued

to buildings located in Kuala Lumpur (Nor Hisham, 2009). While a total of 1,600 and 1,347 Fire-hazard Abatement notices were issued in 2005 and 2006 respectively in Perak (Utusan Malaysia, 2006). In 2008 until March 2009, the FRDM has filed 21 court cases towards premises and individuals that did not comply with the requirements and regulations of Act 341 in Kuala Lumpur (Bernama, 2002b).

The above statistics are also proven in surveys and observations conducted by the author from September 2007 until May 2008 on 37 heritage buildings located in the nine states of Malaysia (see Plate 5.1 in Chapter 5). In which, 59.4% (22) of the buildings are managed by state governments, 24.4% (9) managed by government agencies (e.g., the National Archives Malaysia, the Royal Malaysian Police and Universiti Sains Malaysia), 10.8% (4) by the Federal government under the Department of Museums, and 5.4% (2) under government linked company and private agency (see Table 5.4 in Chapter 5). Various fire safety management problems in the heritage buildings have been identified from the survey (Figure 1.2). Ten leading problems identified are as follows:

i. Buildings without fire safety plan (100%).
ii. No periodical fire training for staff (100%).
iii. Buildings without fire certificate (97%).
iv. Buildings without emergency escape plan (97%).
v. Buildings not disabled friendly (97%).
vi. Buildings without fire policy (95%).
vii. Buildings without periodical risk assessment (89%).
viii. Buildings without direct link to the local fire brigade (86%).
ix. Buildings without periodical fire drill (84%).
x. Buildings without insurance (68%).

In addition, it is also discovered in the interview surveys that the problems occurred mainly due to three factors which are lack of fire safety guidelines, poor fire safety awareness, and lack of enforcement by respective authorities.

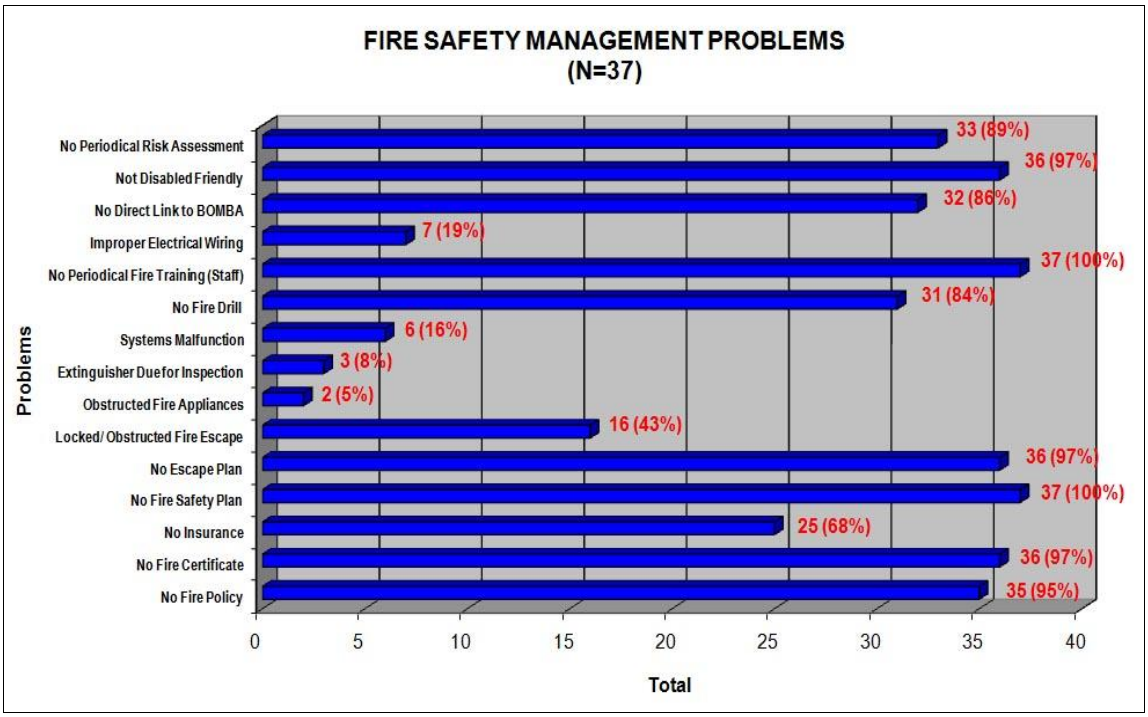

Figure 1.2: Fire safety management problems in surveyed heritage buildings
(Source: Personal survey, 2009)

1.3.4 Lack of Fire Safety Regulations and Guidelines for Heritage Buildings

Presently, fire safety requirements (both passive and active protection systems) for new and existing buildings in Malaysia are required to be designed according to the UBBL 1984 (Part VII: Fire Requirements and Part VIII: Fire Alarms, Fire Detection, Fire Extinguishment and Fire Fighting Access). The law is a prescriptive building code which is most suitable for new buildings. In other words, not all fire safety requirements in the UBBL 1984 are suitable to be applied in upgrading fire safety in heritage buildings. Heritage buildings were built before the law was introduced and most of the buildings have been renovated and adaptive re-used many times. As mentioned earlier, there are some major differences which pose a challenge to the modern designer and fire protection engineer in the application of general fire protection principles in heritage buildings. The challenge in protecting heritage structure is to maintain their historical fabric and authenticity while providing a reasonable level of safety for their occupants and contents. Until today, no proper fire safety guidelines or legal requirements have been provided to protect historic contents and structures from fire.

1.4 Scope of Study

The focus of the study is divided into two aspects. The first, focuses on fire safety, its objectives, components, codes and approaches in the context of heritage buildings. The second focuses on the interaction between fire safety and heritage buildings. Most Malaysian historic buildings are used as public museums, therefore, the scope of the study is limited to museums that have used historic buildings either originally as a museum or through an adaptive re-used process. Nevertheless, only museums that are managed by both the Federal and State governments are selected. In this study, the buildings will be called 'heritage buildings' throughout the thesis. This is in line with the words 'heritage building' defined by Steward Kidd in, *Fire Safety Management in Heritage Buildings:*

> *"a building of historic value or a building (not necessarily historic), such as a museum, library or gallery, housing cultural artefacts."* (Kidd, 2005: 83)

According to the International Council of Museums (ICOM) (2007b), a museum is defined as:

> "*a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment."* (Article 3, Section 1)

Meanwhile, Othman Yatim (1999) defines a museum as *"a building used for storing and exhibiting objects of historical, scientific or cultural interest"*. Therefore, based on the definitions given above, any museum, memorial, archive or gallery may be included in the museum category.

Furthermore, as stated in Table 1.1, statistically fire cases involving heritage buildings in Malaysia are the second highest after historic shop houses. However, it is not the intention of this study to disregard the issue of fire safety of other historic buildings in Malaysia. It is hoped that studying fire safety in heritage buildings could provide a starting

point in understanding and managing fire safety in other historic buildings. Heritage buildings are selected mainly because both building and contents in the buildings have a historical significance (i.e., the buildings are not only classified as heritage buildings but also contain priceless collections such as old artefacts, manuscripts, royal memorabilia and others). Unlike other historic buildings, heritage buildings face greater loss in cases involving fire.

In addition, heritage buildings as educational resources for the community may receive large amount of visitors because the buildings are normally open to public. For example, in 2007, approximately more than 5 million visitors visited 58 heritage buildings managed by nine different agencies in Malaysia. Thus, more visitor means that more people are exposed to danger if a fire were to occur.

It needs to be mentioned that this study is limited to the following aspects:

i. The study attempts to fill a gap by providing a holistic approach on how to manage fire safety programmes in heritage buildings. The success of any fire safety measures in the buildings depend on the effectiveness of its management programmes,

ii. This study audits visually fire safety measures that are provided in the selected museums. It does not examine the ability and reliability aspects of fire safety measures within the buildings, and

iii. The study focuses only on heritage buildings that are currently being used as a museum and are solely managed by the Federal and State governments.

1.5 Objectives of Study

The objectives of this study are to:

i. Audit the fire safety measures in Malaysian heritage buildings,

ii. Examine the management of fire safety by the employees of Malaysian heritage buildings, and

iii. Formulate fire safety guidelines for relevant organisations or those involved (directly or indirectly) in heritage building conservation in order to prevent and protect occupants, fabric and contents of the heritage buildings from the risk of fire.

1.6 Research Framework

This study is based on a mixed method approach using concurrent procedures. In this method, the author collects both quantitative and qualitative data at the same time during the study and then integrates the information in the interpretation of the overall results. Detailed explanations on the selected research methods are discussed in Chapter 5.

1.7 Significance and Benefits of Study

In summary, the contributions of this study towards the fire safety management of heritage buildings are as follows:

i. To provide a theoretical understanding of the concept of fire safety management in heritage buildings. This promotes the best level of fire safety management which could protect the life safety of occupants and at least minimise fire damage to the historic fabrics and contents in Malaysian heritage buildings, and

ii. To contribute underlying fire safety guidelines with reference to the research findings to the relevant organisations or those involved in safeguarding, managing, conserving or upgrading any heritage buildings.

1.8 Structure of the Thesis

Figure 1.3 explains the process taken in completing this study. The thesis is organised into ten chapters as follows:

Chapter 1 is an introductory chapter which introduces background of the study upon which the thesis was based, namely the introduction of the subject matter, research background, problem statements, objectives, research framework, significance, limitations and scope of study.

Chapter 2 is the literature review which is divided into three main parts. The first part reviews the literature on fire safety in heritage buildings which includes its objectives, design approaches and problems. Heritage buildings loss to fire worldwide is also highlighted in this part. The second part of the chapter focuses on the fire safety codes and guidelines for heritage buildings at international levels as well as in Malaysia. Finally, research on fire safety in heritage buildings in Malaysia is discussed.

Chapter 3 is divided into five parts. The first part reviews theories and literature on the principle of fire which include the science of fire and its stages and classifications. The second part discusses on fire safety concept in a building. The third part of the chapter focuses on the common fire protection systems in buildings, namely passive and active measures. The fourth part of this chapter discusses the perceptions and behaviour of people in the event of a fire. Finally, the principles and components of fire safety management in buildings are explained.

Chapter 4 discusses heritage building conservation in Malaysia. The introduction part of this chapter explains architectural heritage in the country followed by the architectural conservation approach in general. All legislations and agencies/ organisations involved in the Malaysian conservation movements are also discussed in this chapter. This chapter ends with discussions on building conservation challenges.

Chapter 5 presents the methodologies selected in this study which are divided into three methods. The first method involves literature review, where both heritage building and fire safety literatures are reviewed in order to identify key issues and recent research that are related or significant to the research topic. The second method involves the collection of primary data through onsite observations, interviews and questionnaires. Finally, the third method, three case studies which have been selected as an approach to audit and to examine directly fire safety and protection measures in the heritage buildings.

Chapter 6 discusses the findings from the selected methodologies and is divided into three parts. The first part discusses the background of respondents in interviews and questionnaires. The second part analyses fire safety measures and fire safety weaknesses in the studied buildings. Meanwhile, the third part presents the audit results on fire safety and protection measures in the studied buildings with reference to the requirements of the UBBL 1984, the Fire Services Act 1988, the Occupational Safety and Health Act 1994 and four relevant Malaysian Standards. This chapter ends with a summary of the analysis and findings.

Chapter 7 is the concluding chapter that is divided into four sections. The first section discusses the conclusions in order to fulfil the objectives of the undertaken study. The second section discusses the recommended guidelines for the betterment

of fire safety management in heritage buildings. The third section highlights the contribution of this study and, lastly, the directions for future research.

This study also contains Appendixes which can be found at the end of thesis to support the author's main discussions in the chapters.

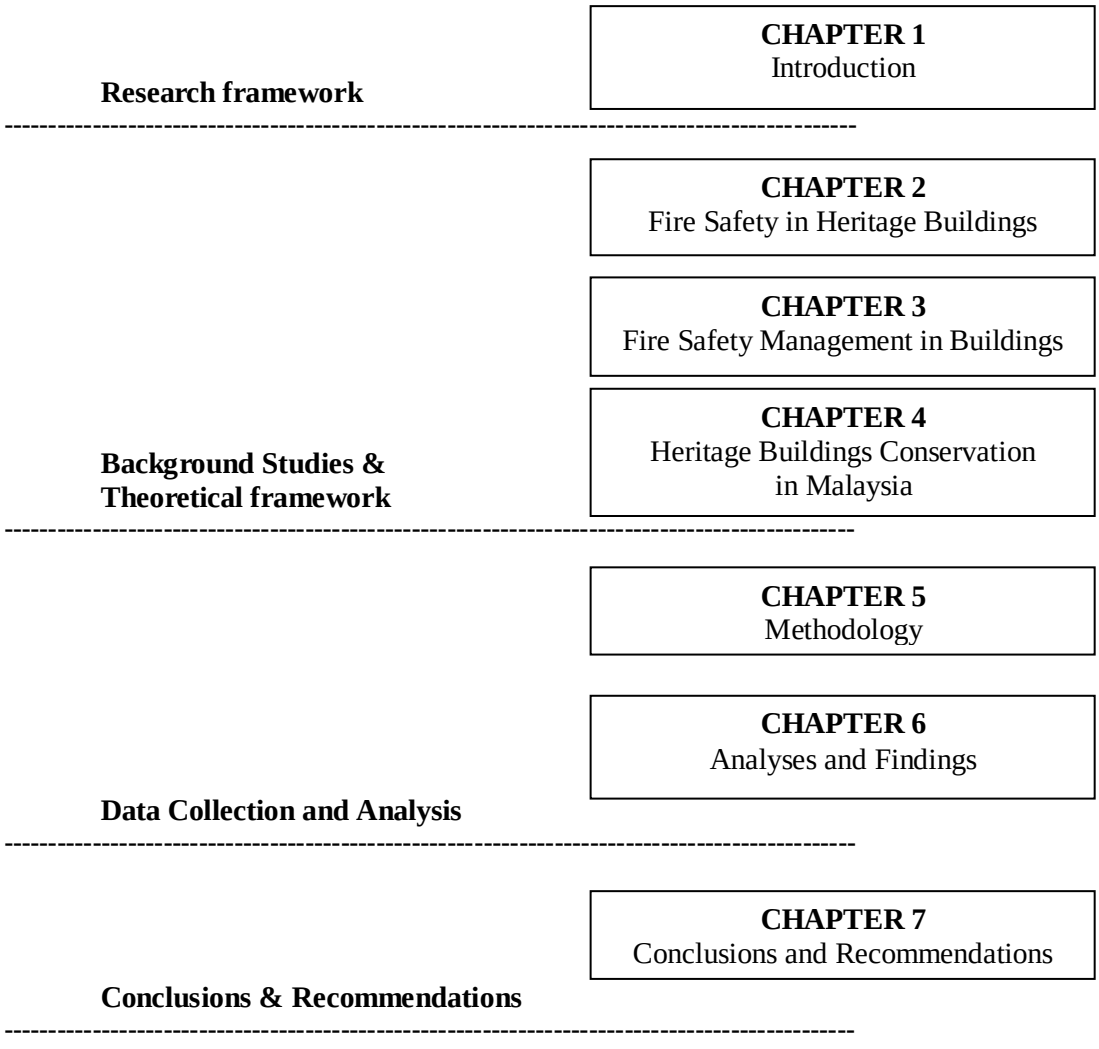

Figure 1.3: Summary of thesis structure

CHAPTER 2

FIRE SAFETY IN HERITAGE BUILDINGS

2.1 Introduction

This chapter is divided into three parts. The first part reviews the literature on fire safety in heritage buildings which includes its objectives, design approaches and problems. Heritage building loss to fire worldwide is also highlighted in this part. The second part of the chapter focuses on the fire safety codes and guidelines for heritage buildings at international levels as well as in Malaysia. Finally, research on the fire safety of heritage buildings in Malaysia is discussed.

2.2 Fire Safety Objectives in Heritage Buildings

Marchant (1989) highlights that there was little or no difference between heritage buildings and new buildings since fire safety objectives are the same for all buildings. Fire may happen in any buildings without knowing whether the buildings are historic or new. However, the differences between heritage and new buildings lie in the heritage values attached to the building with regard to either its fabric or/and contents. In general, the major differences between new and heritage buildings are the aesthetic, economic, and practical constraints on the use of the available methods of providing fire safety (Marchant, 1989). It is widely accepted that there are three fire safety objectives in heritage buildings (Marchant, 1989; Kidd, 1995; Marsella, 2008; Papaioannou, 1991; DEI, 2007). They are life safety, contents protection and fabric protection as presented in Figure 2.1. These objectives can be achieved by the introduction of an improved management emergency capability and by the use of selected components of fire precautions so that the potential probable loss is reduced to an acceptable level (Marchant, 1989). In this context, it is included in *the NFPA 909: Code for the Protection of Cultural Resource Properties- Museums, Libraries, and Places of Worship (2005 edition)* that the additional fire safety goal for collection preservation. In

which, a reasonable level of protection against damage or loss to collections from fire, products of combustion, and fire suppression agents and activities shall be provided. Fire safety and fire protection features shall be designed, approved, implemented, and maintained to preserve the original qualities or character of the collection or a heritage building, structure, site, or environment (NFPA, 2005). The recommendations of fire safety design in heritage buildings are further explained in this chapter.

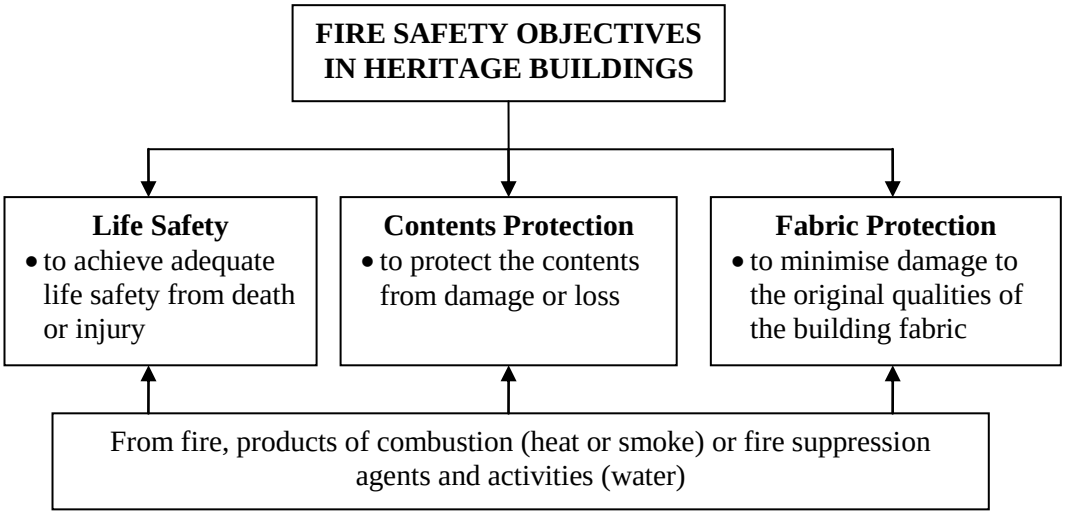

Figure 2.1: Fire safety objectives in heritage buildings

The fire safety regulations in many countries (including Malaysia) state that life safety is the ultimate principle of fire safety in a building. For example, in Part VII and Part VIII of the Malaysian Uniform Building By-Laws 1984 (UBBL 1984) recommend that life safety of the buildings' occupants must be the prime consideration. This is similar to England and Ireland in which property protection that includes protection to the buildings' fabrics and buildings' contents, has been given the least consideration (Pickard, 1993). In fact, it is also stated in the *NFPA 5000: Building and Fire Safety Code* that buildings shall be designed and constructed to provide reasonable safety for occupants and fire fighters (Watts Jr. and Kaplan, 2003). Indeed, it is no doubt that life safety is more important or priceless than property. Nevertheless, property protection should also be considered as a major concern in fire safety as well. This is because some of the buildings and/or contents in the building are irreplaceable especially for properties that have historical values.

Papaionnou (1991) suggests that an acceptable level of safety for both people and property must be determined through an adequate system of risk and safety evaluation. This means that before planning fire safety, all involving parties (e.g., owners, architects, authorities, fire experts, insurance people and others) ought to discuss and to exchange ideas on the various aspects of the problems. This view is supported in the NFPA (2003), that the earlier fire safety objectives established in the design process could identify more effective and economical fire safety methods to be applied. Nevertheless, the firm effectiveness of fire safety in a building is the joint responsibility of the building owners (management) and occupants (staff and visitors). In other words, it must be supported by a sound fire safety management in place. All parties concerned must be aware of their individual duties in ensuring that adequate standards of fire safety and property protection are both provided and maintained (Kidd, 1995). The management of fire safety is further explained in Chapter 3.

2.3 Fire Safety Problems in Heritage Buildings

During the last decades, great concern on the conservation of cultural heritage including fire protection has risen among various countries authorities, fire experts, conservationists and citizens (Papaioannaou, 2009). Many literatures including books and research reports continuously highlight that heritage buildings are more exposed to fire than new buildings (Kidd, 1998; Feilden, 2001; Lilawati, 2001). In general, there are two problems of fire safety in heritage buildings. Firstly, most of them are relatively more exposed to fire risks due to their existing structures and contents that are particularly vulnerable to fire. The hazards present at fires involving heritage buildings generally arise from the building itself, the contents of the building, the nature of the fire situation, the function of the building, and environmental consideration (Kidd, 2005). Most of them are widely exposed to several fire risks such as follows:

i. Existing structures which are weak on fire resistance, aging or decaying building materials and combustible materials (e.g., timber).

ii. Inadequate fire prevention and protection systems, notably passive fire protection.

iii. Lack of fire safety awareness among building owners, managers, staff and public.

iv. Low standard of management, housekeeping and maintenance.

v. Being located at the busiest areas or narrow roads without good access to fire brigade.

vi. Existing electrical wiring which has not been upgraded or replaced accordingly where few historic buildings are still using old electrical wiring.

vii. Storage for many flammable but priceless contents, artefacts or heritage collections such as old books, manuscripts, traditional costumes and antique furniture.

viii. Large numbers of visitors where most are open daily to public.

ix. Dangers from renovation works.

x. Possible dangers from natural factors such as lightning and overheating.

xi. Dangers due to carelessness and arson.

The second problem concerns the method of upgrading fire safety in heritage buildings (Kidd, 1998). The responsibility of fire safety of heritage buildings lies mainly in the hands of the owner. Nevertheless, upgrading fire safety measures in heritage buildings may result in conflict between fire safety standard requirements and the historical significance of the buildings, particularly when the use of a building is changed (adaptive re-use). For example, difficulties will often arise when additional staircases for means of escape and the installation of fire precautions hardware, such as exit notices, emergency lighting and fire detection systems, are required (Kidd, 1995). It is noted that, in cases of conflict between the needs of fire protection and the need to minimise the intrusion into historic structures, a logical and systematic approach to the assessment of fire safety requirements is needed in order to reveal alternative methods of achieving adequate, appropriate, and cost-effective