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# BUILDING PERFORMANCE OPTIMIZATION STRATEGIES AND PRACTICES – AN IMPACT AND ACHIEVEMENT ON SUSTAINABLE BUILT ENVIRONMENT

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**Abstract**
*Building performance optimization is one of the trivial of the building characterization according to sustainable built environment approach. The introduction of Optimize Building Performance and System Control Strategies helps to optimize the usage for building in particular to Productivity, Functional or Operational - Product or Systems Integration, Meet Performance Objectives. Aesthetics Preservation, Secure or Safe, Sustainable - Optimize Site Potential, Protect and Conserve Water, Use Environmentally Preferable Products, Enhance Indoor Environmental Quality and Optimize Operational and Maintenance Practices. The building industry has been judged to consume large quantities of material resources and energy. So as to promote sustainability in this sector, definite intend and programs need to be cultivated to nurture awareness among team member, including developers, owners, designers, engineers, contractor, occupant and authorities. The anticipated finding of this research is to substantiate the importance of building performance optimization including whole building design process, cost effective, functional or operational, productive, Building Information Modeling (BIM), products and systems, energy efficiency programs, building commissioning, operational and maintenance practices, Facility Performance Evaluation, Codes and Compliances Standard and associated strategies including Building Monitoring, High-Efficiency Equipment, Life Cycle Assessment, Rightsizing Equipment, Staff Training, Systems Tune-up and Total Building Commissioning.*

**Keywords:** Building Performance Optimization, Strategies and Practices, Sustainable Built Environment Approach

## 1. Introduction

On an annual basis, buildings in the Malaysia utilize 39% of Malaysia's energy and 68% of its electricity. Furthermore, buildings emit 38% of the carbon dioxide (the primary greenhouse gas associated with climate change), 49% of the sulphur dioxide, and 25% of the nitrogen oxides found in the air. Currently, the sizeable majority of this energy is produced from non-renewable, fossil fuel resources. With Malaysia's supply of fossil fuel declining, alarms for energy supply security increasing (both for general supply and specific needs of facilities), and the impact of greenhouse gases on world climate rising, it is vital to find ways to contribute through building performance optimization initiatives.

At some stage in the facility design and development process, building projects shall have a comprehensive, integrated perspective that seeks to:

- Reduce heating, cooling, and lighting loads through climate-responsive design and conservation practices;
- Employ renewable energy sources such as day-lighting, passive solar heating, photovoltaic, geothermal, and groundwater cooling;
- Specify efficient HVAC and lighting systems that consider part-load conditions and utility interface requirements;
- Optimize building performance by employing energy modelling programs and optimize system control strategies by using occupancy sensors $CO_2$ sensors and other air quality alarms; and
- Monitor project performance through a policy of commissioning, metering, annual reporting, and periodic re-commissioning.

Current appreciation on the effect of human activities on the environment has intensified the challenge for sustainable development. This leads to an increasing demand on building developers and designers to construct buildings with a high intensity of environmental performance. Building environmental assessment methods has come to light as legitimate means to appraise the performance of building across a broader spectrum of environmental considerations.

The sustainable building movement promotes sustainable architecture design and building practices. There are various green building eco-labelling certification indicators that have been established around the globe, such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establish Environmental Assessment Method), CASBEE (Comprehensive Assessment System for Building Environment Efficiency), GBIM (Green Building Index Malaysia) and GBCA (Green Building Council Australia). In other word these are the current systems deployed to assess sustainable building performance and labelling system.

We have to keep pace with the experienced countries to enable us to seriously contribute to the sustainable built environment agenda in Malaysia. In-line with the theme of going green that are reiterating in Malaysia, sustainable built environment assessment should continue the struggle to establish real building performance optimization result for government and commercial buildings in the country. It shall be exploited as a tool to steer architects, designers, government bodies, building owners and developers towards constructing energy efficient and green buildings. In addition, the country set a wonderful focus on technological development in the construction industry and one of the promising areas is sustainability.

## 2. Background To Research

At the onset of the introduction of the concept of sustainability and sustainable development by the United States during Conference on Environment and Development Rio Summit 1992, Agenda 21 stressing on integration of environment and development concerns and attention to them will show the way to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future (Saki Hirano, 2003).

One of the trivial of the building characterization according to sustainable built environment approach is building performance optimization. The introduction of Optimize Building Performance and System Control Strategies helps to optimize the usage for building in particular to Productivity, Functional or Operational - Product or Systems Integration, Meet Performance Objectives. Aesthetics Preservation, Secure or Safe, Sustainable - Optimize Site Potential, Protect and Conserve Water, Use Environmentally Preferable Products, Enhance Indoor Environmental Quality and Optimize Operational and Maintenance Practices.

The building industry has been judged to consume large quantities of material resources and energy. So as to promote sustainability in this sector, definite intend and programs need to be cultivated to nurture awareness among team member, including developers, owners, designers, engineers, contractor, occupant and authorities. The definite strategies, purpose of standards and classification policy should be capitalized on the innovation in product, system or building efficiency and performance. Over the last decade the development has been done on environmental assessment methods to evaluate buildings over lifecycle. The focus of concentration for the building assessment is environmental performance; primarily during building operation for example energy usage, water usage and green house gas emission.

All of the building performance assessment and labelling systems under review and cover almost all the elements with best practices that minimise adverse environmental impact and incorporate criteria that identify the environmental sustainability attributes of the building. The anticipated finding of this research is to substantiate the importance of building performance optimization including whole building design process, cost effective, functional or operational, productive, Building Information Modeling (BIM), products and systems, energy efficiency programs, building commissioning, operational and maintenance practices, Facility Performance Evaluation, Codes and Compliances Standard and associated strategies including Building Monitoring, High-Efficiency Equipment, Life Cycle Assessment, Rightsizing Equipment, Staff Training, Systems Tune-up and Total Building Commissioning.

The next step is to evaluate on this building performance systems or performance characteristics availability in a few selected government building through two methods which are data gathering and questionnaires-guided interviews among professional involved and the occupants. From the evaluation of collected data, a qualitative analysis will be deployed to analyse the characteristics of building components are that suitable and presumption can be made to optimize building performance and strategy for long term. The final anticipated result is also to cultivate a practical approach for implementing building performance optimization for sustainable built environment.

## 3. Problem Statement

With distressing intensity of environmental issues pertaining to building performance, the implementation of the optimization efforts towards sustainability in Malaysian buildings is rather crucial. Success rates in the implementation of building performance optimization initiatives and strategies may be non-committed practices that result in questionable contribution to the sustainability of the buildings.

In term of energy, Malaysia ranked 33rd in the list global electricity consumption and 25th in the list os man-made carbon dioxide emissions (Mohd Yunus, 2007). If energy consumption continues to increase at its current rate, domestic petroleum reserve in Malaysia is predicted to be depleted by 2020 (UNDP & EPU, 2005). There are numerous schemes and researches done in assessing performance of building. Extent of the efficiency or performance optimization can sustain the building and impact on the built environment. For example tapping from the nature such as day-lighting design in promoting energy saving instead of electrical lighting, since the nature of light which is energy in the form of electromagnetic wave consist of various wavelength can cause wide range of effects.

Building performance assessment methods contribute significantly to the understanding of the relationship between buildings and the environment (Cole, 1998). However, the interaction between building construction and the environment is still widely unknown. The environmental building assessment methods all have limitations that may hinder their future usefulness and effectiveness in the context of assessing environmental performance of buildings. Building projects are increasingly requiring performance certifications such as GBI, Energy Commission, DOSH, and others. The project team must discuss and decide on certification requirements in planning and design phases so that a commissioning for certifications can be included in the OPR and Commissioning Plans.

Building Information Models (BIM) is an emerging technology that enables accumulation and management of facility life-cycle information. BIM is a simple concept; a master, intelligent data model, resulting in an as-built database that can be readily handed over to the building operator upon completion of commissioning. The BIM standard could someday integrate CAD data with product specifications, submittals, shop drawings, project records, as-built documentation and operations information, making printed O&M and Systems manuals virtually obsolete. Clearly, if BIM offers a genuine solution to reduce errors and rework, while improving building operations, it will eventually change the way all project team members develop and share information over facility life-cycle phases.

## 4. Research Objective

The research aim is to highlight the building performance optimization strategies and practices adopted while identifying its impact and achievement towards sustainable built environment. Therefore there are four objectives concern due to importance of the research:

i. To identify the factors that contributes to the building performance optimization and strategies for sustainable built environment.
ii. To identify building performance optimization strategies deployed in government buildings
iii. To identify the importance of products and services that related to performance optimization in sustainable built environment
iv. To determine the potential guidelines adopted on building performance optimization i.e. productivity, efficiency, functionality, maintainability and performance measurement
v. To recommend an appropriate strategy on building performance optimization practices pre or post-construction

Information gathered from data or information gathering and questionnaires-guided interviews would reflect the practices of building performance optimization in relation to sustainable built environment of selective government buildings.

## 5. Research Methodology

i. Information or data gathering activities shall be undertaken on selected or identified buildings within the government buildings.
ii. Journals reading, published articles, reference document, procedures, reports, guidelines (Green Building Index Malaysia Standard Code of Practice, etc) or related documents
iii. Building plans review and research to acquire specifications and building dimension including size, usage and building materials consumed.
iv. To undertake “walkthrough survey” on the buildings to ascertain the adopted practices or strategies.
v. Analytical observation on the building performance in relation to the building plan and design.
vi. Conduct questionnaire-guided interviews with respective level of personnel in the organization, agencies or authorities.
vii. Qualitative analysis based on the guidelines, frameworks or document adopted as Code of Practices. From the analysis, comparison shall be established to establish the variations.

## 6. Literature Review

Various building performance optimization methods and strategies for sustainable building are being practice or adopted globally. For instance Integrated Design Process, GB Tool (Green Building Tool) from Canada, Facility Performance Evaluation (FPE), Building Information Modeling (BIM) and Sustainable O&M Practices.
In 2003, the Organisation for Economic Co-operation and Development stated:

"The building sector has major impacts not only on economic and social life, but also on the natural and built environment. Various building activities, such as the design, construction, use, refurbishment and demolition of buildings, directly and indirectly affect the environmental performance of the sector. Against this background, the concept of "sustainable building" – reducing the harmful effect on the environment of buildings and construction activities – has been attracting the attention of stakeholders in OECD countries."

According to the definition by the Architectural Institute of Japan (AIJ) "A sustainable building is one which is designed:

i. To save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life cycle;
ii. To harmonize with the local climate, traditions, culture and the surrounding environment, and
iii. To be able to sustain and improve the quality of human life while maintaining the capacity of the ecosystem at the local and global levels."

*(AIJ, 2005, "Architecture for a Sustainable Future", Tokyo: IBEC)*

Instituting an assessment system to rate the environment impact and performance of building is one strategic measure that will encourage the industry to pay greater attention to such issues and to subscribe to 'green building practices. (Yeoh, 2005)

Building performance is now a major concern of professionals in the building industry (Crawley and Aho, 1999) and environmental building performance assessment has emerged as one of the major issues in sustainable construction (Cole, 1998; Cooper, 1999; Holmes and Hudson, 2000). According to Brundtland Report (1987), sustainable development is a development that meets the needs of the present without compromising the ability of future generation to meet their own need. While Sage (1998) defined the meaning of sustainable development is where the human needs can be fulfilled through the conservation of the earth natural systems and the simultaneous socioeconomic and technological progress. Referring to Malik et al. (2002), sustainable development comprise of three broad themes often known as 'triple bottom line' which are social, environmental and economic.

### *6.1 Adopting the Integrated Design Process*

The design of buildings requires the integration of many kinds of information into a synthetic whole. An integrated process, or "whole building" design process, includes the active and continuing participation of users, code officials, building technologists, cost consultants, civil engineers, mechanical and electrical engineers, structural engineers, specifications specialists, and consultants from many specialized fields.

Importantly, the design objectives shall take into serious consideration of Aesthetics; Engage the Integrated Design Process, Cost-Effective, Functional or Operational, Historic Preservation; Update Building Systems Appropriately, Productive, Secure or Safe, Sustainable; Optimize Site Potential, Protect and Conserve Water, Use Environmentally Preferable Products, Enhance Indoor Environmental Quality and Optimize Operational and Maintenance Practices

Every owner wants a cost-effective building. But what does this mean? In many respects the interpretation is influenced by an individual's interests and objectives, and how they define "cost-effective".

- Is it the lowest first-cost structure that meets the program?
- Is it the design with the lowest operating and maintenance costs?
- Is it the building with the longest life span?
- Is it the facility in which users is most productive?
- Is it the building that offers the greatest return on investment?

### *6.2 Facility Performance Evaluation (FPE)*

According to Craig Zimring et al. (1980), facility performance evaluation (FPE) is an extension of what had been called "post-occupancy evaluation." FPE is a continuous process of systematically evaluating the performance and/or effectiveness of one or more aspects of buildings in relation to issues such as accessibility, aesthetics, cost-effectiveness, functionality, productivity, safety and security, and sustainability.

*6.3 Building Information Modeling (BIM)*

A Building Information Model (Model) is a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward.

A basic premise of Building Information Modeling is collaboration by different stakeholders at different phases of the life-cycle of a facility to insert, extract, update or modify information in the Model to support and reflect the roles of that stakeholder. The Model is a shared digital representation founded on open standards for interoperability.

Some have identified BIM as dealing with only 3D modeling and visualization. While important and true, this description is limiting. A more useful concept is that a Model should access all pertinent graphic and non-graphic information about a facility as an integrated resource. A primary goal is to eliminate re-gathering or reformatting of facility information; which is wasteful.

The scope of BIM is from the smallest part rolled up to the world or portfolio view, from inception onward in the lifecycle of a facility and includes all stakeholders that need facility information from the designers to the occupants.

*6.4 Document Compliance and Acceptance*

It is often said that commissioning is all about good project documentation. The purpose of commissioning documenting is to record the standards of performance for building systems, and to verify that what is designed and constructed meets those standards. Commissioning is a team effort to document the continuity of the project as it moves from one project phase to the next. In the Planning and Development phase of a project, planning and programming documents begin to define an owner's requirements for building performance. When the entire project delivery process is documented in a consistent manner, an historical perspective is created that explains the iterative process of determining the agreed-to project requirements at each step of the development process. Commissioning documentation becomes the road map for the success criteria to be met by facilities that are put in service.

At post-occupancy, commissioning documentation becomes the benchmark to ensure that the building can be maintained, retuned, or renovated to meet future needs. It documents the Owner's Project Requirements (OPR) in the beginning of the project and records compliance, acceptance, and operations throughout the facility's life.

*6.5 Optimize Operational and Maintenance (O&M) Practices*

No matter how sustainable a building may have been in its design and construction, it can only remain so if it is operated responsibly and maintained properly. Ensure operation and maintenance personnel are part of the project planning and development process including the establishing of commissioning criteria at the onset of a project. The use of toxic cleaning products can deteriorate indoor air quality; failure to test sensor control points on a regular basis can compromise energy efficiency; and poor training can lead to early system failures. Buildings must be operated and maintained with the security, safety, health, comfort, and productivity of their occupants in mind, and with an understanding of the next generation's need to reuse and recycle building components. To the extent possible, the systems that are easily maintained are selected. Throughout the building's life cycle, operations and maintenance should seek to:

- Train building occupants, facilities managers, and maintenance staff in sustainable design principles and methods;
- Purchase cleaning products and supplies that are resource-efficient, bio-degradable and non-toxic;
- Use automated monitors and controls for energy, water, waste, temperature, moisture, and ventilation;
- Reduce waste through source reduction and recycling to eliminate disposal off-site; and
- Minimize travel by supporting telecommuting programs and enabling teleconferencing.

  An effective, properly designed O&M plan includes upkeep of the HVAC and building systems so that building energy efficiency targets are met over the life of the building. It can also foster achievement of a facility's pollution prevention goals, which aim to reduce use of hazardous materials, minimize solid waste, and eliminate the use of ozone depleting substances.

All strategies relate to each other in some way. However, it is recommended that investigating these strategies should be considered to assist in gaining a deeper understanding.

- Building Monitoring
- High-Efficiency Equipment
- Life Cycle Assessment
- Rightsizing Equipment

- Staff Training
- Systems Tune-up
- Total Building Commissioning

## 7. Conclusion

In conclusion, this research can be divided into two categories which are to highlight the current practices or strategies adopted by government buildings in comparison to the international standard and significantly can contribute to the environmental issue and optimization benefits. This research is intended to be a contributing knowledge or information as references to any parties/organisation, which involved in sustainable building. In addition, this research can;

i. Apply or propose building performance optimization strategies for sustainable built environment in government building.
ii. Suggest value-added solution in building performance optimization problem solving.
iii. Propose guidelines for sustainable development policy and regulation.
iv. Supplement data to Public Client (Council and Local Authorities) and construction industry to identify level of building performance optimization in sustainable construction.
v. Reference document for GBI Malaysia, PWD, CIDB and others in benchmarking building performance in optimization solution.
vi. Contribute in promoting awareness on availability of technology and solution to public or building user.

### References

Bruntland, G (ed), (1987), Our Common future: The World Commission on Environment and Development, Oxford: Oxford University Press, May 2002.

Cole, 1994 Cole, R.J., 1994. Assessing the environmental performance of office buildings. In: Proceedings of CIB Congress, Watford, UK.

Cole, 1998 R.J. Cole, Emerging trends in building environmental assessment methods, *Building Research and Information* **26** (1) (1998), pp. 3–16.

Cole, 1999 R.J. Cole, Building environmental assessment methods: clarifying intentions, *Building Research and Information* **27** (4/5) (1999), pp. 230–246. Cole, 2005 R.J. Cole, Building environmental assessment methods: redefining intentions and roles, *Building Research and Information* **35** (5) (2005), pp. 455–467.

Cooper, 1999 I. Cooper, Which focus for building assessment methods—environmental performance or sustainability?, *Building Research and Information* **27** (4/5) (1999), pp. 321–331.

Cooper, 2002 I. Cooper, Transgressing discipline boundaries: is BEQUEST an example of the new production of knowledge?, *Building Research and Information* **30** (2) (2002), pp. 116–129.

Crawley and Aho, 1999 D. Crawley and I. Aho, Building environmental assessment methods: application and development trends, *Building Research and Information* **27** (4/5) (1999), pp. 300–308.

Fisher, T.A., (1992), Principles of Environmental Architecture, AIA, Nov. 1992.

Ger Herbert, (2001), Local Authorities and Sustainable Development on Local Agenda 21, Department of The Environmental and Local Government of Ireland.

Holmes and Hudson, 2000 Holmes, J., Hudson, G., 2000. An evaluation of the objectives of the BREEAM scheme for offices: a local case study. In: Proceedings of Cutting Edge 2000, RICS Research Foundation, RICS, London.

Kandar, MZ. And A. Rahman, A.M. (2005) Awareness and Training towards sustainable energy and development in Malaysia, International Conference on Sustainable Building South East Asia (SBO4 Series) KLIA Pan Pacific April 11-13, 2005, Kuala Lumpur.

Luc Bourdeau, (199), CIB Report Publication 237 on Agenda 21 on Sustainable Construction, July 1999.

Malik M.A. Khaflan, (2002), Susutainable development and sustainable construction, A literature review for C-SanD, Version 1, April, 2002.

Mohd Yunus, M.I. (2007), All must play their part to curb pollution, New Straits Times, Kuala Lumpur dated 18 May 2007.

Sage, A.P., (1198), *Risk Management for Sustainable Development*, School of Infrastructure Technology & Engineering, George Mason University.

Saki Hirano, (2003), *United Nation Sustainable Development*, United Nations Conference on Environment & Development Rio de Jenerio, Brazil, 3 to 14 June 1992, AGENDA 21.

UNDP & EPU, (2005), Malaysia*: Achieving the Millennium Development Goals-Successes and Challenges*, Kuala Lumpur, United Nations Country Team, Malaysia.

Baird, G., Gray, J., Isaacs, N., Kernohan, D., and McIndoe,(1996). *Building Evaluation Technique*, G. Wellington. New Zealand: McGraw-Hill, Inc.

Preiser, W. Federal Facilities Council. (2001). Learning from Our Buildings: A State-of-the-Practice Summary of Post-Occupancy Evaluation - *The Evolution of Post-Occupancy Evaluation: Toward Building Performance and Universal Design Evaluation*. National Academy Press.

Preiser, W., Rabinowitz, H. & White. (1988). *Post-Occupancy Evaluation*. E. T. (Eds.) New York: Van Nostrand Reinhold Company.

Zimring, C. & Reizenstein. (1980). *Post-Occupancy Evaluation: An Overview in Environment and Behaviour* 12: 429-51, J. E

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

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**Abstract**
*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 with focus on museum buildings. A combination of observations, interviews, questionnaires and case studies were employed to provide primary data in this study. Three museums were selected as case studies; each of them represented different criteria in order to gather various information and comparison as much as possible. Fire safety and protection measures in the studied buildings have been audited with reference to the requirements of the Uniform Building By Law (UBBL) 1984, the Fire Services Act 1988, the Occupational Safety and Health Act 1994 and four relevant Malaysian Standards. The finding shows that there are several fire safety weaknesses in the heritage buildings that could put people and heritage properties on fire risks.*

**Keywords:** Fire Safety, Fire Protection, Heritage Buildings, Museum,

## 1. Introduction

Fire does not respect age or historic importance of any buildings. Until today, fire has damaged and destroyed many prominent heritage properties worldwide. 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 1.1). 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. 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.

Table 1.1: 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)

## 2. The Methodology

The methodologies selected in the study are divided into three main methods. The first method involves literature review, where both heritage buildings and fire safety literatures were reviewed in order to identify key issues and recent research that relate or has significance to the research topic. The second method involves the collection of primary data through onsite observations, interviews and questionnaires. Finally, three case studies have been selected as an approach to audit and to examine directly the fire safety and protection measures in the heritage 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 study focuses on museums as a sampling building of heritage buildings. The museums are selected in this study for the following reasons:

i. Museum fires are the second highest fire cases involving historic buildings in Malaysia after historic shop houses.
ii. Both building and contents in the museums have a historical significance. Obviously, unlike other historic buildings, the loss of heritage contents and buildings in fire can be considered as a great lost to the country.
iii. A museum is an educational resource for the community; therefore, the building is normally open to public and receives a large amount of visitors that may increase fire risks to the building.

## 3. 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). They are life safety, contents protection and fabric protection as presented in Figure 1.1. 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).

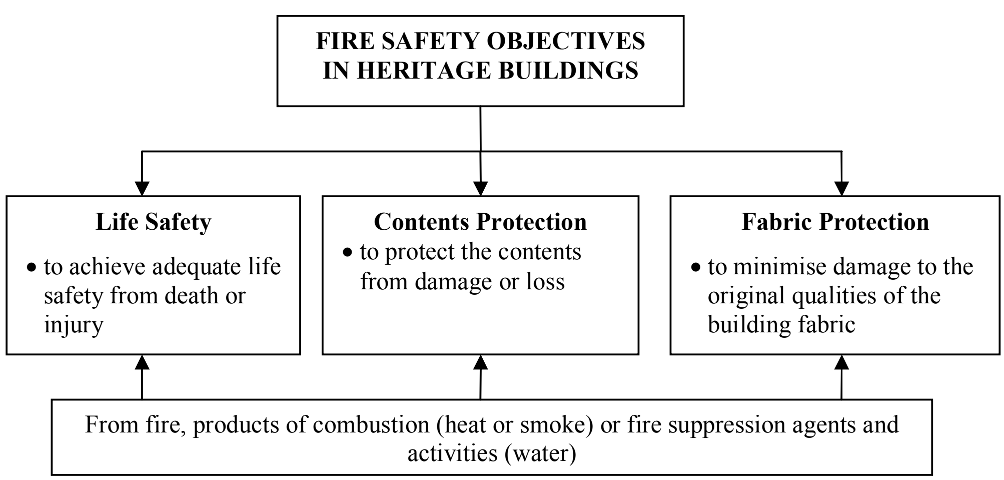


Figure 1.1: Fire safety objectives in heritage buildings

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.

## 4. 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, 2003; 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 standards of fire safety (Kidd, 1995).

## 5. Case Studies

The main aim of this case study is to provide important information which cannot be gathered by the surveys, and to support or complement findings from the surveys. Three buildings have been selected as case studies. Firstly, the 276-year old Kedah Royal Museum in Alor Setar managed by the Kedah State Museum Board (State Government) to represent a timber heritage building. Secondly, the 125-year old Perak Museum in Taiping managed by the Department of Museum Malaysia (Federal Government) has been chosen to represent a masonry heritage building. Finally, the 124-year old Kelantan Royal Traditions and Customs Museum (Istana Jahar) in Kota Bahru, Kelantan managed by the Kelantan State Museum Corporation (State Government) has been selected to represent a combination of timber and masonry heritage building. In this study, fire safety measures and protection in the buildings have been audited and examined with reference to the requirements of the UBBL 1984, the Fire Services Act 1988, the Occupational Safety and Health Act 1994 and 4 relevant

Malaysian Standards.

### *5.1 Case Study 1: The Kedah Royal Museum, Alor Setar, Kedah*

The building was built in 1726 and completed in 1735 during the reign of the late Sultan Muhammad Jiwa Zainal Adilin Mu'adzam Shah II (1710-1778). Originally, the building was built entirely of timber material (Muhammad Amin et al., 2007). However, it was renovated several times and that had influenced the architecture of the building. In 1983, the building was restored to its original architecture before it was officially opened as the Kedah Royal Museum. Nevertheless, in 2000, the Royal Museum was temporary closed to the public for major building restorations including interior refurbishment, a project funded by the Federal Government of Malaysia under the supervision of the then Department of Museums and Antiquities. The works were completed in 2003 and the building was handed over to the Kedah State Museum Board (Lembaga Muzium Negeri Kedah). The museum has a collection of more than 1500 artefacts, most of which are original. It is estimated that the total current value of the artefacts in the museum is approximately up to RM6 million. These include the royal regalia, the royal weapons, the royal musical instruments and the royal collections of the late Sultan Abdul Hamid Halim Mu'adzam Shah, the late Sultan Badlishah, Sultan Abdul Halim Mu'adzam Shah and other Kedah royal descendants. Among interesting items are a headgear of the Sultan Abdul Hamid, an oil painting of the Sultan Abdul Hamid, a set of table and chairs used by the Sultan Abdul Hamid, a set of traditional royal dais and the Royal Bridal Chamber.

(a) (b)

(c)

Plate 1.1: (a) The Kedah Royal Museum, Alor Setar, Kedah ,(b) The Perak Museum, Taiping, Perak
(c) The Kelantan Royal Traditions and Customs Museum, Kota Bharu, Kelantan

### *5.2 Case Study 2: The Perak Museum, Taiping*

The Perak Museum is the first and the oldest museum in Malaysia. Built in 1883, the Perak Museum was built in several phases until 1903. Furthermore, on November 2007 until January 2009, the Department of National Heritage was assigned to supervise major restoration works to the museum. The restoration of the museum was divided into 3 phases, at a cost of more than RM3 million. In 2009, the Perak Museum that directly administrated by the Federal Government under the Department of Museums Malaysia (DMM) was officially declared as a National Heritage under the National Heritage Act 2005 (Act 645). The Perak Museum is rich in natural, zoological, historical and ethnological collections that are displayed in four indoor galleries and few outdoor galleries. The total number of collections in the Perak Museum is 8,474, consisting of 5,074 cultural collections, 523 natural collections and 2,877 miscellaneous collections including archaeological items. Some of them are classified as rare collections, such as animal species like the *benturong* and *pulasan,* skeletons and scores of animal skeletons and smoked clay which are either extinct or extremely difficult to find. In addition, 3,000 of the collections are at least 120 years old in which most of them have been assembled in the 1880s (Seow and Gobal, 2004).

### *5.3 Case Study 3: The Kelantan Royal Traditions and Customs Museum (Istana Jahar), Kota Bharu, Kelantan*

The Kelantan Royal Traditions and Customs Museum is one of six museums managed by the Kelantan state government under its agency, the Kelantan Museums Corporation. Historically, the Kelantan Royal Traditions and Customs Museum was a single storey timber palace known as the Istana Raja Bendahara. According to the Kelantan Museums Corporation, the erection of the building was started at the end of the reign of Sultan Muhammad II (1837-1886) and completed in 1887 during the reign of Sultan Ahmad (1886-1889). The building was famously known as the Istana Jahar. On the 30$^{th}$ of March 1981 after renovated, the building was officially opened as the Kelantan State Museum by Raja Perempuan Zainab II. Nevertheless, in 1990, the Kelantan State Museum was moved to a new building at Jalan Hospital. Since then, the Kelantan Museums Corporation adaptive re-used the building into the Kelantan Royal Traditions and Customs Museum to exhibit the regalia of the Kelantan sultanate. The building was last renovated in 2008 under the supervision of the Department of National Heritage without sacrificing its original structure and design with the total cost of RM170,475. In the building, visitors can find an extensive collection of textiles, antique jewelleries, brass items, traditional weapons and antique exhibits which portray the state's rich cultural heritage. Among important collections in the museum are a 100-year old *Kain Cindai*, two traditional decorative *Chengal* beds, an extensive collection of swords (e.g., a Siamese sword, a Kelantanese sword, an Arabic sword and Chinese swords) and the *Keris* collections.

## 6. Case Study Findings

Among the three studied buildings, it is concluded that higher risks of fire can affect the Kedah Royal Museum compared to the Perak Museum and, Kelantan Royal Traditions and Customs Museum. The Kedah Museum, made of timber which is a highly combustible material, is the least safe building due to its high number of fire safety weaknesses compared to the other two buildings. The building is not only equipped with very limited fire safety measures but there is no fire hydrant provided near the building as well as no fire appliance access to the building. In contrast, the Perak Museum is the building with most equipped fire safety measures. The building managed by the Department of Museums Malaysia (Federal Government) has undergone massive restoration works including an upgrade in its fire safety measures in 2009. The restoration project has proven that upgrading fire safety in an existing building does not require a large amount of money as commonly assumed by many. A total of less than RM100,000 was utilised to install a complete new fire safety system in the Perak Museum. That total amount, in this case is a small amount of money for both the Federal Government and State Government. This study has identified 6 common weaknesses on fire safety and protection measures among the studied buildings:

i. Absence of fire safety policy and plans
ii. Not conducted periodical fire drill, fire training and fire risk assessment
iii. Locked fire exit doors during occupancies
iv. Showcases not designed to quick salvage collections
v. Absence of fire safety signs/notices
vi. Absence of designated assembly points

In terms of compliance with the requirements of Malaysian legislations and standards related to fire safety, evidence from this study has shown that all studied buildings have not abided by a majority of the requirements (Table 1.2). In which, the Kelantan Royal Traditions and Customs Museum is the highest incompliance museum with not fulfilled 63% from the total of 40 requirements and followed by the Kedah Royal Museum with 53%. In contrast, the Perak Museum is the most compliance museum, but however with 43% fulfilled and 48% not fulfilled the requirements. All the museums are also not complied with the majority requirements of the UBBL 1984, the Fire Services Act 1988 and, the Occupational Safety and Health Act 1994 (Nurul Hamiruddin, 2011).

Table 1.2: Summary compliance with the requirements of Malaysian legislations and standards

| Museum | Total requirements | Fulfilled | Not Fulfilled | Partly Fulfilled | Not Applicable |
|---|---|---|---|---|---|
| Kedah Royal Museum | 40 | 14 (35%) | 21 (53%) | 4 (10%) | 1 (3%) |
| Perak Museum | 40 | 17 (43%) | 19 (48%) | 3 (8%) | 1 (3%) |

| | | | | | |
|---|---|---|---|---|---|
| Kelantan Royal Traditions and Customs Museum | 40 | 8 (20%) | 25(63%) | 4 (10%) | 3 (8%) |

## 7. Conclusions

The study found that all the studied buildings may still be considered as potential hazards not only to visitors but also to their contents in the case of fire regardless of the management of the buildings. All the buildings operated without a proper fire safety management including no fire safety policy and plans in place, and not conducted periodical fire drill, fire training and risk assessment. The buildings' staffs are also not well-trained to act in case of fire, particularly on how to evacuate the visitors as well as to salvage the collections. In addition, it has been found in this study that only one fire exit door in the building is unlocked due to security purposes and to control visitor circulation. This situation may cause evacuation difficulties in the event of fire particularly during peak seasons, such as public holidays and school holidays when the buildings normally receive large numbers of visitors. Furthermore, a majority of the collections in the buildings are exhibited in non master-key showcases which may cause difficulties to salvage quickly the collections in the event of fire.

The study also provided sufficient information needed to derive three main conclusions corresponding to the research objectives as follows:

i. Many heritage buildings in Malaysia (either owned by governments, private agencies or individuals) have relatively poor fire safety and protection measures.
ii. The building administrators have given higher priority to security aspects of the buildings rather than the safety aspects of occupants as well as the buildings and their contents from fire.
iii. The existing fire safety requirements in the UBBL 1984 are written primarily for new buildings in which not all fire safety requirements in the law are suitable to be applied in upgrading fire safety system in heritage buildings. The UBBL 1984 also stresses the life safety of occupants as the ultimate principle of fire safety in a building. Unfortunately, fire protection of properties, such as historic buildings, historic contents and objects of value, is not really emphasised in the law.

### References

Feilden, B. M. (2003). *Conservation of Historic Buildings. Third Edition.* Oxford: Architectural Press.

Kidd, S. (Ed.) (1995). *Heritage Under Fire: A Guide to the Protection of Historic Buildings*. London: Fire Protection Association.

Kidd, S. (1998). *Fire Safety Management: Some Problems in the Protection of Historic Buildings from Fire*. [Online]. [Accessed 20th October 2008]. Available from World Wide Web: http://www.risk-consultant.com

Kidd, S. (2005). *Technical Advice Note 28: Fire Safety Management in Heritage Buildings.* Edinburgh: Historic Scotland.

Lilawati, A. W. (2001). *Fire Resistance in Historic Buildings.* MSc. Dissertation, Faculty of the Environment, University of Portsmouth, United Kingdom.

Marchant, E.W. (1989). Preventing Fire in Historic Buildings: The Acceptable Risk. *Journal: Fire Technology, Volume 25, Number 2,* May 1989, p.165-176.

Marsella, S. (2008). Performance Based Codes vs Prescriptive Rules: The Case of The Application to Fire Protection of Heritage in Italy. In I. Maxwell (Ed.), *COST Action C17: Built Heritage: Fire Loss to Historic Buildings: Conference Proceedings Part 1.* (p.78-81). Edinburgh: Historic Scotland.

Muhamad Amin, L., et al. (2007). *Istana Pelamin, Jalan Pekan Melayu, Alor Setar, Kedah, Malaysia- Volume 1*. Heritage Studies Report, Department of Architecture, Kulliyyah of Architecture & Environmental Design, International Islamic University Malaysia.

National Fire Protection Association (NFPA) (2005). *NFPA 909: Code for the Protection of Cultural Resource Properties-Museums, Libraries, and Places of Worship. 2005 Edition.* Quincy: National Fire Protection Association.

Nurul Hamiruddin, S. (2011). *Fire Safety and Protection Measures in Heritage Buildings with Special Consideration on Museum Buildings in Malaysia*. PhD Thesis, School of Housing, Building and Planning, University Sains Malaysia.

Seow, M. and Gobal, L.J. (Eds.) (2004). *Museums of Southeast Asia*. Singapore: Archipelago: Press.

Papaioannou, K.K. (1991), 'Fire Safety in Historic Buildings and Sites'. *Fire Science & Technology*. Volume 11, Number 1,2. Special Issue for CIB W14 (Fire).

Papaioannou, K. (2009). *An International Overview of Fire Protection of Cultural Heritage.* [Online]. [Accessed 26th October 2009]. Available from World Wide Web: http://www.vigilfuoco.it/special/isa/biblioteca/pdf/dl_pdf/21/papaioannou_54_76.pdf

Pickard, R.(1993/4). Fire Safety and Protection in Historic Buildings in England and Ireland- Part I. *Journal: Structural Survey*, Volume 12, Number 2, 1993/4, p.27-31.

Watts Jr, J.M. and Kaplan,M.E. (2003). *Fire Safe Building Rehabilitation*. Massachusetts: National Fire Protection Association