SALT ATTACK AND DAMPNESS DIAGNOSES OF HERITAGE BUILDINGS IN PENANG, MALAYSIA

by

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Thesis submitted in fulfillment of the requirements

for the degree of

Master of Science

April 2011

ACKNOWLEDGEMENTS

This research project would not have been possible without the support of many people. I would like to express my gratitude to my supervisor, Professor Dr. A. Ghafar Ahmad who had been helpful and had offered invaluable assistance, support and guidance throughout my candidature period. Special thanks also to all my colleagues, friends and the academic and the supporting staffs from the School of Housing, Building and Planning, Universiti Sains Malaysia for their invaluable assistance.

Lastly, I owe my deepest gratitude to my beloved wife and children for their support, understanding & endless love, through the duration of my studies.

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LIST OF ABBREVIATION

CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPC	Damp-Proof Course
GIS	Geographical Information System
HIA	Heritage Impact Assessment
ICOMOS	International Council on Monuments and Sites
MAINPP	Majlis Agama Islam Negeri Pulau Pinang (Penang State Islamic Religious Council)
NGOs	Non-Governmental Organisations
ppb	parts per billion
UNESCO	United Nations Educational, Scientific and Cultural Organisation

DIAGNOSIS SERANGAN GARAM DAN KELEMBAPAN PADA BANGUNAN WARISAN DI PULAU PINANG, MALAYSIA

ABSTRAK

Kebanyakan pemuliharaan yang dijalankan di Malaysia tertumpu pada bangunan bersejarah untuk tujuan pameran dan tarikan pelancong dan juga monumen dan bukan untuk penggunasuaian (*adaptive re-use*). Konservasi bangunan untuk penggunasuaian adalah lebih mencabar kerana banyak masalah yang perlu dipertimbangkan untuk pemuliharaan, termasuk faktor-faktor keselamatan, keselesaan, ketahanan, keperluan ruang dan penggunaan serta estetika. Hal ini memerlukan pemahaman yang mendalam dalam bangunan, tidak hanya tentang nilai-nilai senibina, tetapi juga tahap keusangan. Pemuliharaan bangunan di Malaysia dianggap baru berbanding dengan negara-negara lain. Oleh yang demikian, tiada banyak penyelidikan serta dokumentasi keusangan dilakukan sebagai salah satu kaedah dan prosedur untuk pemuliharaan di bangunan bersejarah. Antara kecacatan bangunan yang terdapat di bangunan warisan, serangan garam dan kelembapan adalah dianggap sebagai yang paling mencabar. Tujuan utama penelitian ini adalah untuk mengenalpasti jenis garam yang menyerang bangunan-bangunan warisan di Pulau Pinang, menganalisa faktor-faktor yang menyebabkan masalah penggaraman tersebut mengikut tahap serangannya; menghasilkan cadangan untuk rawatan umum untuk penyahgaraman dan kelembapan yang sesuai untuk konteks dan iklim Malaysia, berdasarkan kajian-kajian kes yang dipilih. Penyelidikan ini menggunakan pendekatan kajian kes bangunan bersejarah di Pulau Pinang yang sedang dibaik pulih

dan mengalami masalah penggaraman dan kelembapan. Lima bangunan yang dipilih adalah Mahkamah Tinggi, Dewan Bandaraya, Dewan Bandaran, Makam Noordin dan Masjid Alimsah Waley serta empat unit rumah kedai. Kajian keusangan dan ujian makmal (ujian ion kromatografi) sampel garam dijalankan ke atas bangunan-bangunan tersebut. Ujian makmal menunjukkan bahawa jenis garam utama yang menyerang bangunan-bangunan bersejarah tersebut adalah klorida (Cl), nitrat (NO_3) dan sulfat (SO_4). Faktor-faktor yang menyebabkan masalah penggaraman pada bangunan-bangunan tersebut termasuklah lokasi bangunan di atas tapak yang mempunyai kandungan air yang tinggi, percikan air laut, dilindungi oleh pohon-pohon dan bangunan, kurangnya sistem kalis air dan masalah pencemaran udara.

SALT ATTACK AND DAMPNESS DIAGNOSES OF HERITAGE BUILDINGS IN PENANG, MALAYSIA

ABSTRACT

Most conservation done in Malaysia focuses on old historical buildings not for adaptive re-use but mainly for exhibition and tourist attraction buildings and monuments. Conserving buildings for adaptive re-use is more challenging because many issues have to be taken into consideration for the conservation such as safety, comfort, durability, spatial requirements and usage; and aesthetic. This needs an in depth understanding of the building; not only in terms of its architectural values but also its state of dilapidation. Conservation in Malaysia is considered new compared to other countries, thus, there is not many research documentations and dilapidation reports done on methods and procedure for conservation in heritage building. Amongst the common conservation problems of heritage buildings, salt attack and rising damp are considered the most challenging to resolve. Thus, the main objectives of this study are to identify the types of salt attacking the selected colonial building in Penang; to analyse the factors that cause salt attack problems in the selected colonial building in Penang according to its degree of severity and; to come out with suggestions for a common treatment for salt desalinations and rising damp that suits Malaysian context and climate, based on the selected case studies. The study uses a case study approach of historical buildings in Penang that have salt attack and rising damp problems and are being restored. Five buildings are chosen - the Old Penang High court, Old City Hall, Old Town Hall, Makam Noordin and the Masjid Alimsah Waley with the adjacent four units of shophouses. Dilapidation survey and laboratory test (the ion chromatography test) of salt samples are taken from the buildings selected. Findings show that the main types of salt attacking the colonial building are chlorides (Cl), nitrates (NO_3) and sulphates (SO_4). Factors that cause salt attack problems in the selected buildings include the location of building on high water table, building exposed to sea spray, building shaded by trees and buildings, lack of waterproofing and air pollution.

CHAPTER 1 - Introduction

1.1 Introduction

Conservation in Malaysia is considered new compared to other countries, especially the developed countries. Most conservation work done in Malaysia focuses on old historical buildings not for adaptive re-use but mainly for exhibition and tourist attraction buildings and monuments such as fort (example Fort Cornwallis in Penang), *chandi* (Bujang Valley *chandi* in Sungai Petani), old Malay castle (*Istana lama* at Kuala Kangsar), mosque (Kapitan Keling Mosque in Penang) etc. Conserving buildings for adaptive re-use is more challenging because many issues have to be taken into consideration such as safety, comfort, durability, spatial requirements and usage; and aesthetic. Conservation needs an in-depth understanding of the building, not only in terms of its architectural values but also its state of dilapidation. A poor understanding of the extent and nature of building defects will result in inappropriate repair works during a conservation project or further damage to the building, which can lead to disagreements and substantial cost implications amongst building owners, clients and building contractors. Thus, the survey prior to restorations for the purpose of adaptive re-use needs to be detail, intricate and meticulous. The methods of treatments also need to be more comprehensive and adhere to the correct procedures.

Heritage buildings are susceptible to deterioration due to several factors including climatic conditions, dampness and structural failures (http://www.saltdamp.com.au/index.htm#intro.html). Among common building defects that occurred in heritage buildings, salt attack and rising damp are considered the most challenging. In Malaysia, salt attack problems and treatment are often ignored compare to rising damp problem. Although the problem of salt attack is closely related to rising damp, it needs special and different treatment.

Salt attack has been considered one of the major building defects found in heritage buildings. Sometimes, it is also known as salt damp. It refers to damage in buildings commonly caused by the destructive action of moisture and salts. It can be detected by the presence of salt, seen as a white efflorescence or flowering on the wall surface (City of Adelaide, Department of Environment and Natural Resources, 1997). Other signs of salt attack include tell-tale signs such as spalling of the surface and fractured materials when through to the destruction of the internal structure of the masonry (http://www.saltdamp.com.au).

Salt attack is mainly related to rising damp. Heritage buildings (especially built in the nineteenth century) are susceptible to salt attack because they have no damp-proof course (DPC). The absence of DPC allows moisture from the ground to soak upward, which is termed as capillary action. This moisture will dissolve the soluble salt from the building material itself and also carry soluble salt from the ground (from soils and groundwater), thus causing damage to the building (City of Adelaide, Department of Environment and Natural Resources, 1997). The moisture will evaporate but salts cannot, therefore salt residues are left behind on the wall. There are two types of salt attack depending on whereabouts the salt penetrates. One is when the salt penetrates on the surface that will be shown as powder while the one penetrating below the surface is more serious as salt will be crystallised. The growth pressure from the crystallisation process will cause building materials to crumble, causing serious damage to the buildings.

Young (2008) identified other causes of salt attack which include:

1. Windborne salt spray, if the building is near the sea
2. Airborne salt (meteoric)
3. Pollution from nearby factories
4. Biological, for example bird droppings, fallen leaves in block gutters, sewer leakage
5. Brick clay puddling (salts used for the process will go into the soils)
6. Unsuitable chemical for cleaning

There are different types of salts that can cause damage to the building masonry. Sodium chloride and calcium sulphate are commonly found in masonry walls even though other forms of salts including calcium carbonates, chlorides, nitrates, magnesium, potassium and sodium may be the culprits. Sources of such salts may be from saline soils, groundwater (rising damp), sea-spray, air-borne (meteoric), cleaning compounds (detergent), urine, air pollutants and natural salts found in stone, brick clay or mortar sand. High salt concentrations in masonry walls may cause extensive fretting and crumbling of the lower parts of walls (City of Adelaide, Department of Environment and Natural Resources, 1997).

In temperate region, salt weathering is most severe during hot season (summer) due to decrease in relative humidity and strong sunlight. This occurs during the month of November to April and the effect usually will increase the water movement (in the wall) to go upwards. Significant temperature fluctuations and the increase in the rate of evaporation will trigger the increase of water movement, thus facilitating the process of crystallisation of salts (Aranyanark, 2002). In tropical regions, salt weathering is optimum during dry season.

Generally, sodium chloride is commonly found in coastal areas while sodium nitrate is contributed by pollution and also human or animal activities. Sodium sulphates is the most damaging salts in masonry building due to the expansion from sodium sulphates to hydrated sodium sulphates. The existence of hydrated magnesium sulphates are due to use of domilitic limestone as raw materials in the preparation of mortars and plasters, especially in brick buildings. Salt-induced weathering is due to three factors, namely geographical location, type of sandstone (building materials), and the cleaning regime (maintenance of the building). Apart from that, environmental factors also contribute to the acceleration of the process of decay (Pombo-Fernandez, 1999).

Fremantle (2000) mentioned that rising damp phenomenon that occurs in buildings is the results of salt crystallisation in the brick pore that in turn will damage the brick itself. According to Freemantle (2000), the more soluble chlorides and nitrates are found on higher part of building due to rising damp and the less soluble sulphates is concentrated at the lower part of buildings. Salt attack problem and its treatments have not been prioritised and treated seriously in Malaysia. For example, out of the many heritage buildings conserved in early 2000, only three had undergone salt treatment: one in Sarawak (the Kuching High Court) and two in Penang (Seri Mutiara building and 116-118, Lebuh Acheh). This is partly due to the lack of understanding and experiences in tackling such problems in Malaysia. Currently, there is no proper research carried out on the treatment of salt attack and rising damp in Malaysia. Heritage buildings are conserved based on certain scope of work set by the conservation consultant. At times, aspect of salt attack and rising damp are not highlighted in the scope of work, leading to higher cost when such defects need to be solved. This research hopes to provide a better understanding of salt attack and rising damp in heritage buildings in Malaysia. It also hopes to create more awareness amongst the public, building owners, professionals, building contractors, local authorities and particularly the agencies involved in conservation work.

1.2 Objectives of the Study

The main objectives of the study are:

1. To identify the types of salt attacking the selected colonial buildings in Penang.
2. To analyse the factors that cause salt attack problems in the selected colonial buildings in Penang according to their degree of severity.
3. To diagnose the salt attack and rising damp problems in the buildings of the selected case studies.
4. To come out with suggestions for a common treatment of salt desalinations and rising damp that suits Malaysian context and climate, based on the selected case studies.

1.3 Research Questions

1. Chlorides, sulphates and nitrates are the common salts that commonly attack heritage building in other parts of the world. This study tries to identify the

common salt attacking colonial building in Penang, thus, the first research question is "What are the common types of salt attacking colonial buildings in Penang?",

2. In other parts of the world, the common factors that contributed towards salt attack problems include constant exposure to sea spray/water, contaminated ground waters and pollution. For colonial building in Penang, there is yet study to confirm whether the factors are similar or not. Therefore, the next research question is "What are the factors that contribute to salt attack problems of colonial buildings in Penang?",

3. Salt attack and rising damp are diagnosed by visual inspection and then concurred by scientific testing. This study aims to diagnose salt attack and rising problem in colonial building of Penang, thus the third research question is "What are the diagnoses for salt attack and rising damp problems?"

4. The common treatment for salt attack is using poultice methods to extract salt from the affected walls. Whereas for rising damp, the treatment is using chemical-based or metal treatment to stop water from rising up the wall. The last research question for Penang experiences is, "What are the best common treatments that can be standardised for most masonry colonial heritage buildings in Malaysia?"

1.4 Organisation of the Thesis

This thesis is divided into seven chapters. Chapter One provides the background and problem statement of the study, identification of objectives and research questions. Chapter Two is the literature review. Chapter Three discusses the issues of salt attack and rising damp. Chapter Four is on research methodology. Chapter Five is on the case studies and elaborates on the findings and analyses. Lastly, Chapter Six concludes the thesis by suggesting the proposed guidelines for the treatments of salt attack and rising damp.

CHAPTER 2 - Literature Review

2.1 Introduction

In architecture, conservation describes the process through which the material, historical, and design integrity of mankind's built heritage are prolonged through carefully planned interventions (Weaver et al., 1997). The professional that deals with architectural conservation is widely known as an architectural conservator. Architectural conservation is the process of prolonging the life and integrity of architectural materials, such as stone, brick, glass, metal, and wood which are commonly the building materials. It refers to the "professional use of a combination of science, art, craft, and technology as a preservation tool" (http://www.new4old.eu/guidelines/B1_introduction.htm). It may also refer to issues of identification, policy, regulation, and advocacy associated with the entirety of the older built environment (Weaver et al., 1997).

In Asia, the issue of protecting built heritage and architectural conservation has become synonymous with urban conservation such as in Singapore, where the authority directs urban planning and urban architectural conservation. In some countries, for example, in China and Ireland, heritage conservation is divided into archaeology and architectural conservation. In Malaysia, conserving heritage building is regarded as important for its aesthetic value and cultural-historical significance. Heritage building in Malaysia is also an important asset to promote tourism.

2.2 Global Initiative on Conservation

The global initiative on conservation started in Athens in 1931, which was later known as the Athens Charter. It has contributed towards the development of an extensive international movement known as ICOMOS (International Council on Monuments and Sites). United Nations Educational, Scientific and Cultural Organisation (UNESCO) later established the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) at the Second International Congress of Architects and Technicians of Historic Monuments, taking place in Venice in 1964.

In chronological order, initiatives in conservation initiated under the Athens Charter of 1931 are as follows:

Table 2.1: Initiatives under the Athens Charter.

Initiative	**Year**	**Issues**
Athens Charter	1931	The earliest initiative
Venice Charter	1964	2nd International Congress of Architects and Technicians of Historic Monuments, Venice, May 25th - 31st 1964
ICOMOS	1965	ICOMOS adopted the Venice Charter
5th General Assembly of ICOMOS	1978	Resolutions of the 5th General Assembly of International Council on Monuments and Sites (ICOMOS) (Moscow 1978)
Burra Charter	1979	Adopted by Australia ICOMOS on 19 August 1979 at Burra, South Australia Revisions were adopted on 23 February 1981, 23 April 1988 and 26 November 1999
The Nara Document on Authenticity	1995	Conceived in the spirit of the Charter of Venice, 1964 (Japan)
The Hoi An Protocols	2001	Best Conservation Practice in Asia, UNESCO, 2001 workshop

Source: http://www.international.icomos.org/charters.htm

The International Congress has been approved, agreed and laid down on an international basis, with each country responsible for applying the plan within the framework of its own culture and traditions through the following text:

Table 2.2: Text approved during the Second International Congress of Architects and Technicians of Historic Monuments, Venice from May 25th to 31st 1964 (The Venice Charter)

Article	**Note**
Article 1	The concept of a historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or a historic event. This applies not only to great works of art but also to more modest works of the past which have acquired cultural significance with the passing of time.
Article 2	The conservation and restoration of monuments must have recourse to all the sciences and techniques which can contribute to the study and safeguarding of the architectural heritage.
Article 3	The intention in conserving and restoring monuments is to safeguard them no less as works of art than as historical evidence.
Article 4	It is essential to the conservation of monuments that they be maintained on a permanent basis.
Article 5	The conservation of monuments is always facilitated by making use of them for some socially useful purpose. Such use is therefore desirable but it must not change the lay-out or decoration of the building. It is within these limits only that modifications demanded by a change of function should be envisaged and may be permitted.
Article 6	The conservation of a monument implies preserving a setting which is not out of scale. Wherever the traditional setting exists, it must be kept. No new construction, demolition or modification which would alter the relations of mass and colour must be allowed.
Article 7	A monument is inseparable from the history to which it bears witness and from the setting in which it occurs. The moving of all or part of a monument cannot be allowed except where the safeguarding of that monument demands it or where it is justified by national or international interest of paramount importance.
Article 8	Items of sculpture, painting or decoration which form an integral part of a monument may only be removed from it if this is the sole means of ensuring their preservation.

Table 2.2. Continued

Article	**Note**
Article 9	The process of restoration is a highly specialized operation. Its aim is to preserve and reveal the aesthetic and historic value of the monument and is based on respect for original material and authentic documents. It must stop at the point where conjecture begins, and in this case moreover any extra work which is indispensable must be distinct from the architectural composition and must bear a contemporary stamp. The restoration in any case must be preceded and followed by an archaeological and historical study of the monument.
Article 10	Where traditional techniques prove inadequate, the consolidation of a monument can be achieved by the use of any modern technique for conservation and construction, the efficacy of which has been shown by scientific data and proved by experience.
Article 11	The valid contributions of all periods to the building of a monument must be respected, since unity of style is not the aim of a restoration. When a building includes the superimposed work of different periods, the revealing of the underlying state can only be justified in exceptional circumstances and when what is removed is of little interest and the material which is brought to light is of great historical, archaeological or aesthetic value, and its state of preservation good enough to justify the action. Evaluation of the importance of the elements involved and the decision as to what may be destroyed cannot rest solely on the individual in charge of the work.
Article 12	Replacements of missing parts must integrate harmoniously with the whole, but at the same time must be distinguishable from the original so that restoration does not falsify the artistic or historic evidence.
Article 13	Additions cannot be allowed except in so far as they do not detract from the interesting parts of the building, its traditional setting, the balance of its composition and its relation with its surroundings.
Article 14	The sites of monuments must be the object of special care in order to safeguard their integrity and ensure that they are cleared and presented in a seemly manner. The work of conservation and restoration carried out in such places should be inspired by the principles set forth in the foregoing articles.

Table 2.2. Continued

Article	Note
Article 15	Excavations should be carried out in accordance with scientific standards and the recommendation defining international principles to be applied in the case of archaeological excavation adopted by UNESCO in 1956. Ruins must be maintained and measures necessary for the permanent conservation and protection of architectural features and of objects discovered must be taken. Furthermore, every means must be taken to facilitate the understanding of the monument and to reveal it without ever distorting its meaning. All reconstruction work should however be ruled out "a priori". Only anastylosis, that is to say, the reassembling of existing but dismembered parts can be permitted. The material used for integration should always be recognizable and its use should be the least that will ensure the conservation of a monument and the reinstatement of its form.
Article 16	In all works of preservation, restoration or excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs. Every stage of the work of clearing, consolidation, rearrangement and integration, as well as technical and formal features identified during the course of the work, should be included. This record should be placed in the archives of a public institution and made available to research workers. It is recommended that the report should be published.

Source: (http://international.icomos.org/charters/venice_e.htm)

The framework is quite comprehensive, indicating the need to cover all spatial areas, regardless whether it is an urban or a rural setting; to take into consideration both aesthetic and historical values; to ensure that the conservation project can be utilised by the public and that the conservation is maintained sustainably. It is also important to take into consideration the scale and originality of the buildings or monument to be conserved. All conservation works must be followed by excavations and detail reports. During the conservation, modern techniques or materials can be applied provided that the conservation is harmonised with the original design.

The 1995 Nara Document on Authenticity is conceived and built in the spirit of the 1964 Charter of Venice. The 1995 Nara Document on Authenticity also extends the 1964 Charter of Venice in response to the expanding scope of cultural heritage concerns and interests in our contemporary world. The document touches on the issue of Cultural and Heritage diversity in the world and also on values and authenticity. The Hoi An Protocols for Best Conservation Practice in Asia, UNESCO, 2001 workshop has produced a set of guidelines for the conservation of cultural landscapes, archaeological sites, monuments and historic towns. With increasing threats to heritage buildings and monuments worldwide, it is essential for standardised principles guiding the preservation and restoration of ancient buildings to be agreed upon and laid down on an international basis, with each country being responsible for applying the plan within the framework of its own culture and traditions (Rowney, 2004). The Burra Charter provides guidance for the conservation and management of places of cultural significance (cultural heritage places), and is based on the knowledge and experiences of Australia ICOMOS members (Walker and Marquis-Kyle, 2004). In Malaysia, conservation practices follow the guidelines stated by ICOMOS and also referring to other charters for guidance such as the Burra Charter as Malaysia has yet to produce its own charter.

In Malaysia, the task of issuing guidelines and procedures to protect and maintain heritage buildings and monuments is under the responsibility of the Department of Museums and Antiquities under the Antiquities Act (*Akta Benda Purba*), 1976. In 2005, a new department has been established primarily to undertake the responsibility for heritage conservation, known as the Department of National Heritage (*Jabatan Warisan Negara*) under the Ministry of Information, Communications and Culture. In 2005, a new act known as the National Heritage Act 2005 (Act 645) [Akta Warisan Kebangsaan 2005 (Akta 645)] has been passed at the parliament to replace the Antiquities Act (*Akta Benda Purba*). Since then, the Department of National Heritage has under laid the guidelines and procedures for maintaining heritage buildings and monuments in Malaysia (Muhamad, 2009).

2.3 Conservation of Heritage Buildings in Malaysia

Malaysia's heritage building and monuments history can be traced back hundreds of years ago, through the discovery of 'chandis' at Lembah Bujang, Kedah built by traders from India plying the Straits of Malacca. Early historical records by Chinese traders also revealed the existence of forts in Malacca in 1416. However, the invasion of Malacca by the Portuguese in 1511 had marked the turn of the events that influenced the history of heritage buildings and monuments in Malaysia when they built a fort, A Famosa. After the Dutch defeated the Portuguese in 1641, they built new buildings to mark their existence in Tanah Melayu. Finally, when the British started their colonisation in Tanah Melayu in the early nineteenth century, they had since built numerous buildings throughout the country (Mohamed, Ahmad and Ismail, 2001).

Restoration of heritage buildings in Malaysia portrays an important milestone towards retaining and conserving Malaysia's invaluable heritage buildings, as these structures are reminiscence of an intriguing past. Moreover, from an economic viewpoint, heritage buildings are lucrative assets in promoting tourism in Malaysia. Initially, conservation works in Malaysia are done following the guidelines stipulated by the Department of Museum and Antiquities under the Ministry of Culture, Arts and Tourism. Since 2006, the Department of National Heritage, now under the Ministry of Information, Communications and Culture took over the custodianship of heritage buildings in Malaysia. The new department is led by the Commissioner of Heritage. Several local authorities, for example, the Penang Municipal Council (*Majlis Perbandaran Pulau Pinang*) and Historical Malacca City Council (*Majlis Bandaraya Melaka Bersejarah*) also have their own guidelines on conservation which are derived from the earlier guidelines of the Department of Museums and the Department of Antiquities and Heritage (Muhamad, 2009). Conservation projects in Malaysia normally involve the building owner, government agency, consultant teams which include the architect, engineers, quantity surveyors and building conservator and sometimes Non-governmental Organisations (NGOs). Conservation bodies in Malaysia can be divided into three groups - the Official Conservation Committees, the Non-Governmental Organisation (NGO's) and the Charitable Trust.

2.3.1 Official Conservation Committees

One of the official conservation committee pioneers is Conservation and Urban Design Unit (*Unit Pengekalan Dan Seni Bandar*) of Kuala Lumpur City Hall, now known as the Urban Design and Building Department (*Jabatan Rekabentuk Bandar & Bangunan*). The Unit was founded by Kuala Lumpur City Hall in early 1988 for the purpose of carrying out research, providing guidelines and implementing regulations for its urban environment and conservation areas (Mustafa et al., 2009). In Penang, a Conservation Unit (*Unit Warisan*) now known as Heritage and Conservation Development/Control Section (*Bahagian Pembangunan Warisan dan Konservasi*) was formed under the Building Department, Penang Municipal Council in early 1991 for the purpose of preserving old buildings, streetscapes, retaining the unique character of George Town; and revitalising old areas without having to destroy old fabric. Some of its conservation works include identifying buildings and sites for conservation zoning, controlling and considering any new development planned in the conservation areas and formulating guidelines as well as development of policies for the conservation areas (Saleh, 2003).

The City of Melaka also has a Conservation Committee. The Melaka Conservation Unit is placed under the Urban Planning and Building Control Department, the Historical Melaka City Council (*Majlis Bandaraya Melaka Bersejarah*) to monitor and enforce the conservation guidelines in the city. In 2008, the historic cities of Melaka and George Town were jointly inscribed as UNESCO World Heritage Sites. For George Town, this is due to its unique architectural eighteenth century colonial residential and commercial buildings (http://whc.unesco.org/en/list/1223). As a result of this, all developments including restoration and renovation within the core and buffer zones have to go through the Heritage Technical Review Panel (the state government) with the implication of submitting the Heritage Impact Assessment (HIA) report. The HIA is a report that determines how significant a cultural heritage resource might be and how a proposed land use development, demolition or site alterations may impact that resource (Bassetlaw District Council, 2011).

2.3.2 Non-Governmental Organisations (NGOs)

There are few private societies in Malaysia which are currently active in promoting and educating the public on building conservations. One of the active societies in Penang is the Penang Heritage Trust. Founded in 1987 by architect Dato' Lim Cheong Keat, the Trust is a voluntary society which seeks to preserve and enhance

Penang's heritage. It cooperates with the Penang Conservation Unit through good planning and activities to advance the goals of conservation. The Trust also organises public seminars on building conservation and invites representatives from different local authorities, private agencies, museums and the Public Works Department. Its work is prominent in publicity and intervention of local and regional development proposals (Steinberg, 1996).

Another private society in Penang is the Acheh Mosque Heritage Group, also known as the *Badan Warisan Masjid Melayu Lebuh Acheh*. The group was formed in December 1992 by the local community and former residents of the Acheh Street Mosque areas in Georgetown, Penang. The main objectives of the group include (i) to preserve the historical and cultural heritage of the mosque and its surrounding properties, (ii) to collate and document information relating to the Acheh Street Mosque, (iii) to promote the permanent preservation of all historic buildings for the benefit and education of the public, (iv) to consider and support any new development to improve the socio-economic conditions of the area; and (v) to enhance good relationships among community members through regular meetings and cooperation (Ahmad, 1996).

2.3.3 Charitable Trust

The best known charitable trust which is active in promoting conservation in Malaysia is the *Badan Warisan Malaysia* (Heritage of Malaysia Trust). *Badan Warisan Malaysia* was formed officially in 1983 as a charity trust. It was set up by a group of volunteers who were keen to preserve Malaysia's built heritage and areas of architectural interest in all parts of the country.

In 1984, a society called *Sahabat Warisan Malaysia* (The Friends of the Heritage of Malaysia Trust) was set up to support the *Badan Warisan Malaysia* in its objectives, primarily in the areas of fundraising, education and public awareness of heritage preservation. However, the society was dissolved in 1995 and its membership was merged with the *Badan Warisan Malaysia* in order to strengthen and unify the heritage movement. The objectives of the *Badan Warisan Malaysia* include (i) to promote the permanent preservation for the benefit and education of the people in Malaysia on all historic buildings, (ii) to preserve the setting of historic buildings and where appropriate their historic content, (iii) to preserve the character of groups of attractive buildings which enhance a street, a town or a village; and (iv) to preserve sites of archaeological or prehistoric interest. *Badan Warisan Malaysia* also organises talks, exhibitions, visits and competitions in their efforts to promote the conservation of historic buildings, monuments and sites (Badan Warisan Malaysia, 1990).

2.4 Conservation Process in Malaysia

Although building conservation has been done for quite some time in Malaysia, the level of public awareness about the importance to protect the architectural heritage is still low. In 1980, things had started to change when a wet market was preserved successfully for adaptive re-use in Kuala Lumpur and known today as Central Market. The project opened up the public's perception positively about the importance of building conservation as tourist attraction which in turn generates the local economy.

There is currently no formal framework for systematic conservation work in Malaysia. However, based on previous conservation projects, five phases in the conservation project are identified. These include:

i. Initial Research
ii. Dilapidation Survey
iii. Tender Documentation
iv. Conservation Works
v. Maintenance Period

In Malaysia, conservation works are usually awarded and carried out by experienced and knowledgeable contractors. To ensure that the conservation works are carried out with the right methods and techniques, the four principles are imposed (Brereton, 1991):

i. Minimal disturbance
ii. Scientific testing
iii. Thorough documentations
iv. Proven methods and techniques

Dilapidation study is one of the most important phases in any conservation process. It involves in depth study of the defects of all parts of the buildings such as roofs, walls, floor, structure, etc. The dilapidation survey also involves analyses of the historical aspects of the buildings and evolution for example, in terms of changes in use and expansion.

2.5 Types of Building Defects

Buildings can become defective through age and also the lack of maintenance. Defect can also be the result of improper construction and the lack of proper building practices and bylaws during the time that particular building was built (www.buildingdefects.com.au). Building defects occur not through the lack of basic knowledge but due to non-application or misapplication of knowledge (Ransom, 2001). Current trends in design concentrate on what to do rather than what not to do. Understanding defects through inadequate design or construction is taught explicitly rather than implicitly. Therefore, there is a need to understand defects and produce guidance on how to deal with them in an implicit manner.

Most defects are caused by external agencies such as weather (solar, moisture, air, solid and gaseous contaminants), biological agencies (moulds, fungi, bacteria, insects, ground salts and waters) and manufactured products used in conjunction with the building such as calcium chloride (Burkinshaw and Parret, 2004; Ransom, 2001; Oliver 1997). Defects are mainly caused by moisture and condensation. Excess water can be due to no or poor maintenance, incorrect application of new building techniques or inappropriate use of new material during construction or after renovation. Dampness is usually linked to water retention in the building (Oliver, 1997). The effects of dampness range from discomfort for the tenants living in the building; health hazards as dampness attracts bacteria, mites, fungi and other microorganism; aesthetic and physical damage to the buildings (Oliver, 1997). Type of building defects varies from structural, defective materials, damp, etc. Several of these building defects can be categorised as below:

2.5.1 Dampness Problems

Damp can be caused by either rising damp, falling damp, penetrating damp and condensation (Burkinshaw and Parrett, 2004). Rising damp is caused by dampness rising from the ground through the capillaries through the pores of the walls whether the materials are made from brick, block, stone or mortar in which they are laid into the structure of the building (Massari, 1985). Rising damp occurs at the bases of walls. Falling damp are caused by leaking roofs, pipes etc., which if ponding near a wall can increase rising damp. Penetrating damp is caused by water moving horizontally through a wall at any height which often creates a damp patch. Condensation occurs when moist air inside a building condenses into its liquid state if it touches cold windows, walls, or the underside of metal roof sheeting (Oxley and Gobert, 1994).

It is common for old heritage buildings to experience severe rising damp problems. Sometimes, the extent of the problem is very bad and the damp can been detected on all plastered wall surfaces, covering an area as high as between five and seven feet above the ground. Rising damp usually affects the walls and columns causing the plasters to crumble due to constant expansion and contraction as the temperature fluctuate causing the paints to peel, and making it prone to mould growth and dust mite population to rise, which is detrimental to health. Falling damp also caused timber rot, woodworm and termites attack. Damp also affects the walls due to inadequate or broken rainwater goods, damaged plumbing and drainage system (Burkinshaw and Parrett, 2004). However, rising damp is mainly related to salt attack, as the most destructive source of salt is from the ground, which is common in old building due to the absence of damp-proof cause (DPC).

2.5.2 Salt Attack

Salt attack and rising damp are different but interrelated processes. In the discussion of dampness in building, salt attack tends to be downplayed by rising damp and yet the problem should not be ignored in an attempt to minimise damage in building, especially when the soils become more saline as the building gets older (Young, 2008). Salt attack is also known as salt weathering which describes the damage caused by soluble salts crystallising within the pores of masonry materials. During a dry period, when the water evaporates from the wall, salts will be left behind, as salts cannot evaporate until it becomes more concentrated and saturated to form crystals. In cases where the rate of evaporation is high, the salt crystallises forming long thin needles extruding from the wall face, known as efflorescence. When the rate of evaporation is much greater, the evaporative front will be inside the wall and salts will crystallise within the pores of the masonry known as subflorescence (Young, 2008). The salts are hygroscopic, adding dampness by absorbing moisture from the air. One of the indicators of salt attack is when persistent dampness occurs up to 600 millimetre of the wall (Oliver, 2002). Salt attack can lead to slow but complete loss of stones and bricks in a wall (NSW Heritage Office, 2004). The presence of white salt deposits not only caused crumbled plaster walls but can also affect to the porosity of bricks, as certain bricks become soft and powdery. This could in turn affect the strength of the existing load-bearing walls (Burkinshaw and Parrett, 2004).

2.5.3 Inadequate or Defective Rainwater Goods

Rainwater goods are gutters and down pipes which are important to protect buildings from damage by rainwater. However, they are frequently neglected, and if not properly maintained they may cause extensive harm to the fabric of the building

(Hunt and Suhr, 2008). The condition of the rainwater goods in old building are usually in a poor state. In some cases, the rainwater goods are installed inside the building, which posed a threat of leakage. Rainwater goods if not maintained will damage a building, such as overflowing gutters and cracked down-pipes that will concentrate rainwater in particular areas on a wall which can result in erosion of pointing, damage to brickwork and masonry, rotting of structural timbers built into the wall and internal dampness (Fielden, 2003).

2.5.4 Termite Infestation

Termite usually attack fibrous materials, in the case of building mainly woody structure. Termite treatment is very expensive. There are two types of termite – subterranean and drywood termites (Teles and Valle, 2001). The Subterranean termites are predominantly the cause of problems in Europe, United States of America and Latin America. They live outside the wood attacked by them and have faster and bigger impact than the drywood termite (Teles and Valle, 2001). The drywood termite lives in smaller colonies, nesting inside the wood that they attack. Although the impact is slower compared to the subterranean termite, the result can be devastating as any wood in contact to the infected wood will also be infected and as a result it is difficult to find their nest. Old building usually suffers from serious termite attacks, which occurs as a result of dampness and the lack of maintenance. The dampness will cause timber to rot and attract the termites. It is not easy to terminate termite problems completely. Termite infestation problems are treated mainly through ventilation and chemical treatment of the building (Teles and Valle, 2001). However, too much chemical treatment can instead destroy the building. Treatment is done before construction (pre) and after construction (post) (Edwards and Mills, 1986). Treatment before construction includes spraying insecticides on the soil before a sub-structure work is done, acting as a barrier against termite intrusion into the building. Post construction treatment includes spraying of insecticides and soil treatment by injecting insecticides around the perimeter of the building and the baiting system (Chow, 2002).

2.6 Other Studies on Salt Attack and Rising Damp

Studies on salt attack and rising damp are mainly done in Europe (Collepardi et.al, 2000; Freemantle, 2000) and Australia (Spennemann, 2001; Busea et al., 2005). Studies in Europe normally take place in Venice due to the location of the city surrounded by sea whereby buildings are prone to the problem of salt attack and rising damp (Collepardi et al., 2000). Collepardi et al. (2000) studied the damage of historic buildings and monuments in Venice and found out that the damage was strongly related to the capillary rise of seawater. However, other culprit to the damage of the historical buildings was related to acid rain, from sulphuric acid emission from nearby industrial areas. The salt attack study also showed that damages are related to the salt weathering producing efflorescence and subflorescence and to the formation of ettringite or thaumasite accompanying salt crystallisation.

Freemantle (2000) also studied the causes of the principal decay patterns on Venetian historical buildings, monuments and stonework. No doubt the causes of building's deterioration are similar to those described by Collepardi et al. (2002) which is mainly due to the spatial position of Venice in Venice lagoon, giving it a unique exposure to sea water and difficulties to restore and also costly to maintain.