

## Implementation of Green Technologies in Building Maintenance, Repair and Rehabilitation for The Historical Building

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**Abstract:** In order to realize the potential of environmentally conscious upkeep practices, historic buildings need to be equipped with the appropriate infrastructure. A preliminary investigation into the historic building maintenance plan found that the use of green technology in heritage building maintenance is still at a modest level and needs further development. A lack of knowledge of the need to maintain historic buildings with environmentally friendly technology components has been identified as a significant factor contributing to the prevalence of such practices. The historical building will benefit from using environmentally friendly building care, repair, and rehabilitation practices, which are the aim of this research. The fundamental objective of this study is to identify the role that environmentally friendly technologies play in the operation of building maintenance, repair, and rehabilitation processes for a historical building. These methods consider a variety of elements, including the aspect of green technology that provides the best upkeep for historic structures. In order to gather information for the study, questionnaires were sent to historic building experts. For the inquiry, the History and Ethnography Museum, The People's Museum, and The Governor's Museum are the three buildings that have been selected to compete with one another to determine which is the best heritage building museum.

**Keywords:** Maintenance, Green Technology, Historical Building, History and Ethnography Museum, People's Museum, Governor's Museum

### 1. Introduction

Heritage is something from the past that has been carefully kept so that it may be seen in the present and inherited by future generations. It is material that may be shown abstractly or implicitly by tangible evidence, such as monuments, buildings, streets, and landscapes, as well as human activities. People relate to and learn about not just the lives of their forefathers, but also the structural developments created in the past, through recognizing the attributes of structures [1].

Many historical buildings need to be repaired using traditional method which is high in cost and involves using harmful substances. Repair, maintenance, and preservation of historic structures, on the other hand, frequently need particular sets of skills and knowledge about the right procedures and handling of materials and structural elements. Individuals with the necessary skills are significantly less readily available today than they were when the edifice was built. However, it is strongly advised that the owner seek out those experts to work on a historic structure [2].

It is vital to develop a management system based on green processes and products in order to reduce pollution. Governments, companies, and industries all over the world have been looking for methods and techniques to reduce waste. However, in a roofed area, such as an office with mechanical ventilation but no circulation, instruments like as computers may contribute to sensory pollution burdens [3].

### 1.1 Problem Statement

Many green building standards and codes don't always give a clear path for redeveloping and reviving historic and other existing structures. Communities that want to increase their environmentally sustainable investments must reconcile standards and policies that can sometimes clash. Preserving the historic integrity of older buildings can be difficult when changing windows and doors, which are important parts for an energy-efficient building envelope [4].

Conservation is the process of halting further deterioration or providing structural safety and well-being of heritage buildings; which includes improving the structure of the heritage building; and operation and maintenance. According to The National Heritage Act of Malaysia 2005 (NHA), the conservation process encompasses preservation, restoration, rebuilding, rehabilitation, and adaptation, or any combination of the aforementioned components [5].

In general, there are issues that the construction has been severely damaged, remodelled several times, and the utility of historical structures has been altered. Due to the overrun of most historical structures, the function and security of historical buildings would not satisfy the criteria of modern specifications. Appropriate methods for evaluating historical buildings should be used [6].

### 1.2 Aim and Scope

The aim of the research is to identify the knowledge of the significance implement green technologies in building maintenance, repair and rehabilitation for the historical building. The purpose of the research is to collect information by giving survey questionnaires to respondents and by interviewing respondents using a set of questionnaire forms. The participants in this interview are the heritage building management unit, the chief conservator, the assistant engineer, and the maintenance unit. The objectives of this study were as follows.

- i. To determine part of green technology element in building maintenance, repair and rehabilitation for the historical building.
- ii. To examine the most significant green technology element.
- iii. To propose the best heritage museum buildings using green technology.

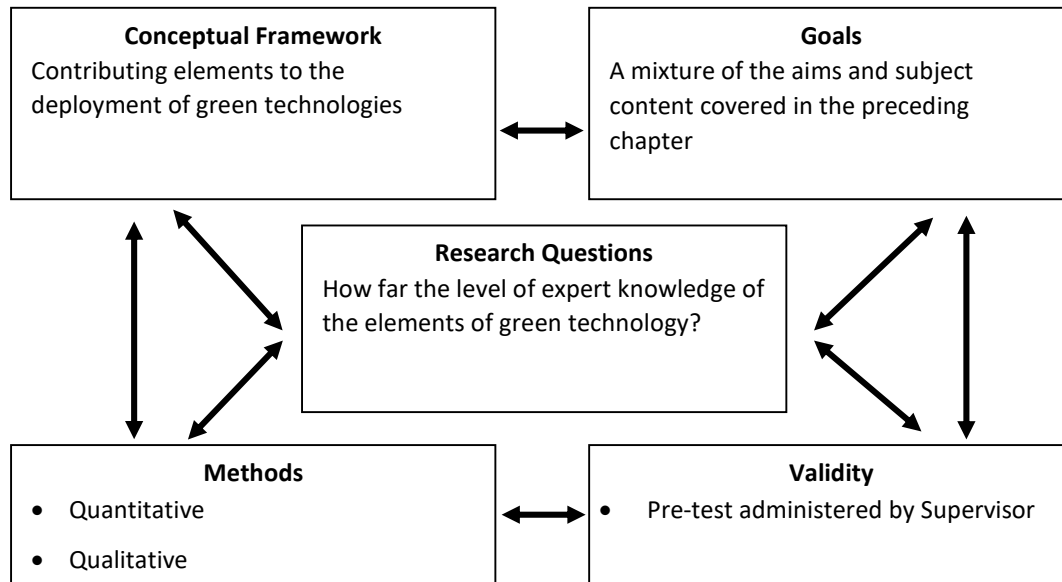
## 2. Methodology

### 2.1 Research design

In this research, the quantitative approach is used to develop the best research design for collecting data from respondents. Questionnaires regarding implementing green technologies will be distributed among participations. This is because as the participations have limited time, a simple questionnaire can be answered within a few minutes.

The research question is regarded as the primary focus of a dissertation. The objectives, conceptual framework, methodologies, and research questions have a link with validity [7]. All components must be verified, either by validation and organised interviews with subject matter experts or by using system software.

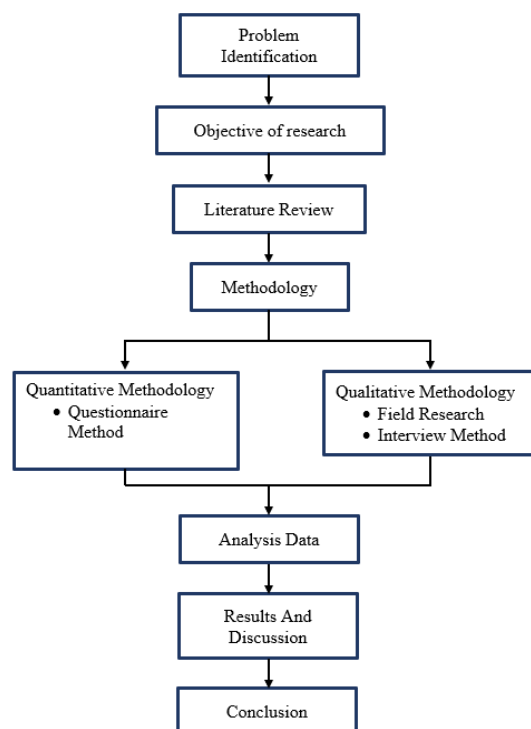
The study is based mainly on the problem statement, which can be identified by reading or doing a literature study. Next are the objectives and scope of the research, which are required to generate a successful dissertation.



**Figure 1: Research design chart**

## 2.2 Flow chart

A flow chart is an infographic depicting a system's sequential operations, components, or activity. Figure 2 illustrates a flowchart that might be used to demonstrate the research techniques and operation of the study in a more clearly and understandably way than a typical diagram.



**Figure 2: Flow chart of the study**

### 2.3 Quantitative

A survey has been developed to gather quantitative data. In this regard, the questionnaires are distributed by directly visiting the site and meeting with the staff that maintain the building. Distribution of questionnaire was used in the study as it is easy to be access within a few minutes.

In this study, the researcher uses quantitative methods to collect precise data from 8 respondents in order to achieve the three objectives. The selection of the 8 respondents based on their expertise in conservation field. Researcher received responses from 8 experts in the maintenance of the historic building. Before it can be analysed using statistical methods, the questionnaire-collected raw data must undergo preparatory processing.

#### 2.3.1 Development of survey instrument

Questionnaires should always have a defined purpose related to the research objectives [8] and should make it clear how the data will be used.

The ideal requirements for a questionnaire include the following: a simple, straightforward language; a need for a single, unidimensional answer; the provision of a truthful and accurate response; and the ability to accommodate any circumstance. The questionnaire must be completed in English and contains examples of several kinds of fire prevention systems.

**Table 1: Separated section of the question.**

Section	Items
Section A	Demographic respondents (Experts)
Section B	Determine green technology in heritage building
Section C	Open ended question

#### 2.3.2 Scale

A Likert-type scale allows respondents to indicate whether they strongly agree (SA), agree (A), moderated agree (MA), do not agree (DNA), or strongly disagree (SD). This was used to measure respondent self-efficacy based on objectives 1, objectives 2, and objectives 3.

**Table 2: Likert scale**

Scale	1	2	3	4	5
Description	Strongly disagree	Do not agree	Moderated agree	Agree	Strongly agree

### 2.3.3 Section A – Demographic respondents (experts)

Under Section A, the questionnaire contains information about experts on duty at the Melaka Museum Corporation (PERZIM), which includes the following:

- a. Genders.
- b. Ages.
- c. Race.
- d. Scope of job/position.
- e. Working experience.

The respondents need to select the provided blank selection boxes.

### 2.3.4 Section B – Determine green technology in heritage building

Under Section B, the questionnaire is focused on the second objective, to examine the most significant green technology element.; therefore, the responder will be questioned about it.

### 2.3.5 Section C – Open ended

Under Section C, the questionnaire is focused on analysing the level of knowledge and awareness by experts on historical buildings and subsequently irrigating their comments and views on this study.

## 2.4 Qualitative

For this research, the researcher will do a direct observation and participation in the observation.

### 2.4.1 Field research

The researcher will observe and analyse the workability of the maintenance of the building using traditional methods or new technologies that are more convenient for the historic building.

### 2.4.2 Interview method

The researcher will conduct a qualitative interview which is asked directly about the expertise that does the maintenance of the building. The interview is semi-structured and standardised with open ended questions.

## 2.5 Data analysis

The data obtained from respondents will be examined using SPSS, Microsoft Excel, and Google Forms. The success or failure of this study will be determined by its goals and objectives. The data will be given in the form of a table, pie chart, and bar chart to guarantee their clarity.

In Sections A and B, the question in Sections A is a Likert-scale pattern graded on a variable based on the amount of agreement shown by survey respondents. It may be accomplished by computing the frequency, percentage, mean, and mean average of the replies to the questions.

### 2.5.1 Mean score

The means of the items on a Likert scale should be relatively equal. The maximum standard deviation to lowest standard deviation should be around 2:1 as a rule of thumb. If an item does not comply with the regulation, it must be standardized such that its values within a scale do not vary significantly.

**Table 3: Mean score and their explanation**

Mean score	Description
1.00-2.00	(1) Strongly disagree
2.00-3.00	(2) Do not agree
3.00-4.00	(3) Moderated agree
4.00-5.00	(4) Agree
5.00	(5) Strongly agree

## 3. Results

### 3.1 Mean analysis for each museum

#### 3.1.1 The History and Ethnography Museum (Muzium Sejarah dan Etnografi)

The Museum of History and Ethnography Building below shows a table of respondents' data collected according to the breakdown of questions posed to respondents and to find the mean data for each question. The total mean for this museum is 28.25.

**Table 4: The History and Ethnography Museum (Muzium Sejarah dan Etnografi)**

Green Technology Parameters	The History and Ethnography Museum (Muzium Sejarah dan Etnografi)					Mean
	1	2	3	4	5	
A proper design of automatic lighting system can reduce energy consumption	0	0	2	3	3	4.125
Efficient HVAC system can influence indoor environment quality inside of the building	0	0	0	4	4	4.5
Low emitting carpets can provide environmentally friendly flooring	0	0	2	5	1	3.875
Tall window can provide admission of light and air of the building	0	1	2	4	1	3.625
Access to outside views can provide the scenery the location of the building	0	0	1	5	2	4.125
External site will attract more people to visit and to add knowledge	0	0	2	3	3	4.125

The effects of indoor vegetation can cool the environment indirectly through evapotranspiration	0	0	2	5	1	3.875
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3.1.2 The People’s Museum (Muzium Rakyat)

The Museum of People’s Building below shows a table of respondents' data collected according to the breakdown of questions posed to respondents and to find the mean data for each question. The total mean for this museum is 28.75.

**Table 5: People’s Museum (Muzium Rakyat)**

Green Technology Parameters	People’s Museum (Muzium Rakyat)					Mean
	1	2	3	4	5	
A proper design of automatic lighting system can reduce energy consumption	0	0	0	6	2	4.25
Efficient HVAC system can influence indoor environment quality inside of the building	0	0	0	5	3	4.375
Low emitting carpets can provide environmentally friendly flooring	0	0	2	4	2	3.25
Tall window can provide admission of light and air of the building	0	0	1	4	3	4.25
Access to outside views can provide the scenery the location of the building	0	0	1	4	3	4.25
External site will attract more people to visit and to add knowledge	0	0	0	3	5	4.625
The effects of indoor vegetation can cool the environment indirectly through evapotranspiration	0	1	2	3	2	3.75

3.1.3 The Governor’s Museum (Muzium Tuan Yang Terutama)

The Museum of Governor’s Building below shows a table of respondents' data collected according to the breakdown of questions posed to respondents and to find the mean data for each question. The total mean for this museum is 30.75.

**Table 6: Governor’s Museum (Muzium Tuan Yang Terutama)**

Green Technology Parameters	Governor’s Museum (Muzium Tuan Yang Terutama)					Mean
	1	2	3	4	5	

A proper design of automatic lighting system can reduce energy consumption	0	0	0	4	4	4.5
Efficient HVAC system can influence indoor environment quality inside of the building	0	0	0	4	4	4.5
Low emitting carpets can provide environmentally friendly flooring	0	0	0	3	5	4.625
Tall window can provide admission of light and air of the building	0	0	1	2	5	4.5
Access to outside views can provide the scenery the location of the building	0	0	2	4	2	4
External site will attract more people to visit and to add knowledge	0	0	0	6	2	4.25
The effects of indoor vegetation can cool the environment indirectly through evapotranspiration	0	0	0	5	3	4.375

### 3.2 Analysis of the best Heritage Museum Buildings

From the table below show about which historic buildings are best among the three buildings. It was found that the best Museum of Historic Buildings is the People's Museum Building which has a score of 4.416 and this makes this building the most adopting of green technology elements.

**Table 7: Analysis the best Heritage Museum Buildings**

List of Museum	No. of Question	Mean	Weightage Mean	Standard Deviation	Score
The History and Ethnography Museum (Muzium Sejarah dan Etnografi)	1	4.125	0.589	0.781	4.035
	2	4.5	0.642	0.5	
	3	3.875	0.554	0.599	
	4	3.625	0.518	0.857	
	5	4.125	0.589	0.599	
	6	4.125	0.589	0.781	
	7	3.875	0.554	0.599	
People's Museum (Muzium Rakyat)	1	4.25	0.607	0.433	4.416
	2	4.375	0.625	0.484	
	3	3.25	0.464	0.829	
	4	4.25	0.607	0.661	
	5	4.25	0.607	0.661	



		6	4.625	0.661	0.484	
		7	3.75	0.536	0.968	
Governor's (Muzium Terutama)	Tuan Yang	1	4.5	0.643	0.5	
		2	4.5	0.643	0.5	
		3	4.625	0.661	0.484	
		4	4.5	0.643	0.707	4.393
		5	4	0.571	0.707	
		6	4.25	0.607	0.433	
		7	4.375	0.625	0.484	

The data and result have been collected and analysed. The best heritage building between three building have been decided which is People's Museum with the score of 4.416 that is the highest from the other building. All the result is from collected data from expertise from Perbadanan Muzium Melaka (PERZIM).

#### 4. Discussion

4.1 First Objective: To determine green technology element in building maintenance, repair and rehabilitation for the historical building.

Based on the result, the part of green technology elements in building maintenance, repair, and rehabilitation for the historical building was identified. Eleven items of the element's parameters were considered because it was common and dominant based on the previous study. Among them are automatic lighting system, Efficient Heating, Ventilation, and Air Conditioning (HVAC), low emitting carpets, educational signs on the certification, energy, water, and food savings, and local food sourcing, tall window, access to outside views, bike rack, external site, indoor vegetation, stairway, and overall layout. All elements have been submitted to experts, and data collection can be carried out. By selecting eleven parameters, four were eliminated because of a lack of issues that can be conducted in heritage building museums.

4.2 Second Objective: To examine the most significant green technology element.

Based on the research, three historical buildings, namely the Museum of History and Ethnography, the People's Museum, and the Governor's Museum, have data collected successfully. Out of these eleven elements, the researcher made a questionnaire for interviewing eight experts. Researchers ask questions based on the likert scale to find the most significant part of green technology elements used in historic buildings. The questionnaire form is given to the expert, gets a mean ranking, and is used as a weightage.

4.3 Third Objective: To propose the best heritage museum buildings using green technology.

Three case studies have been conducted. Among the three museums, the best heritage museum building using green technology is The People's Museum because the score is 4.416, which is the highest score between the Museum of History and Ethnography, which is 4.035, and the Governor's Museum which is 4.393. An approach for preparing an effective maintenance program for heritage buildings was achieved. Based on Perbadanan Muzium Melaka (PERZIM) to become the best effective maintenance program for green technology elements heritage building. The approach reduces redundant decisions and might decrease the time required to determine the maintenance schedule.

## 5. Recommendations

It is necessary to provide a suggestion to improve and expand the research on this issue. Research is a continuous process that is mutually supportive. Therefore, a more exhaustive study should be conducted to offer a clearer view of green technology elements to be applied in the historical building. This study may serve as a resource for beginner researchers and an advanced study for individuals who want to examine the activity from various perspectives. This study found that the knowledge and interest in green technology are still low. As a result, new researchers are encouraged to conduct a study on how to put the element of green technology into the building or to not have that element for the installation.

## 6. Conclusion

In this research, all aspects of understanding the green technology element in the historical building have been thoroughly covered. The mean score as weightage between the three museums shows that the People's Museum is the best museum that adopts green technology elements in buildings. This has been demonstrated by examining data collected through questionnaires and interviews. Overall, this study has achieved all three objectives of the research question based on the research.

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