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SUSTAINABLE BUILT ENVIRONMENT

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DAMPNESS DEFECTS ON WALL USING INFRARED THERMOGRAPHY AT PASAR BESAR SITI KHADIJAH, KOTA BHARU KELANTAN

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ABSTRACT

Using infrared thermography for the analysis of buildings and structures is reliable and accurate. To measure the extent of dampness to a structure or building, an infrared scanner detects energy and maps the temperature contours over the surface of a target object. There is consideration of the application of infrared thermography in two specific situations - the delamination of external/ internal wall finishes and the assessment building's physical condition. However, this study will focus on dampness on the building surface as well as the causes that affect this problem through the use of infrared thermography. Accordingly, a samples test (imager pictures) was taken to find the cause and effect of the occurrence of the defect dampness in the case study. From the research done, it can be concluded that there is indeed an effect of humidity on the walls of Pasar Besar Siti Khadijah, that is from an average temperature of 30 degrees Celsius, the colour from the observation of the thermograph image is purple which the indicator from the device shows in the lower range, the relative humidity is 70 percent to 79.4 percent. This percentage also shows the presence of moisture in the air around the building. In addition, there are also various defects that exist which show the action of this dampness. Finally, from the findings of this study, it is to identify the existence of this dampness. The data and findings obtained can be used by the Kota Bharu Municipal Council and vendors to ensure the safety of consumers and residents of the market as well as being able to carry out better maintenance plans in the future.

Keywords: *BCARS, dampness, defect, infrared thermograph, Pasar Siti Khadijah*

INTRODUCTION

Public buildings play an important role in our communities, serving as gathering spaces and economic hubs. However, a lack of regular maintenance and limited awareness among users can lead to the deterioration of this important structure. An issue of great concern is the presence of problems related to dampness, which not only affects the functionality of the building but also poses a risk to the well-being of its occupants. Consequently, research on dampness was conducted. This research will assist the Kota Bharu Municipal Council, vendors, and consumers in achieving and sustaining optimal performance. To achieve this objective, two objectives have been outlined: (1) identify the dampness problem using an Infrared Thermograph, and (2) ascertain the severity of the dampness-related problem in Pasar Siti Khadijah, Kota Bharu, Kelantan. Defects related to dampness, such as peeling paint, discoloration and mould growth, are becoming increasingly apparent, creating an uncomfortable and potentially unsafe environment for traders and visitors. According to (Ismail, 2014) review of the elements that contribute to concrete defects in Malaysia, seven different types of defects, including cracks, failed joints, leaks, corrosion of steel reinforcement, sedimentation, honeycombing, and disintegration of concrete, commonly occur on concrete structures. Design errors, building materials, geotechnique, construction errors, and unexpected errors are the five main causes of problems in concrete structures. (Organization, 2021) recognizes dampness problems as the visible, measurable of excess dampness or water leakage in buildings. In a tropical country like Malaysia, where the average temperature is around 26 degrees Celsius and the relative humidity rate reaches 80 percent, the prevalence of dampness issues in public buildings is an urgent concern. My focus is on Pasar Besar Siti Khadijah, an open market bustling with history and cultural significance. For several decades, it became the heart of trade and commerce in Kelantan. However, like most aging structures, this market suffers from a number of defects, including the harmful effects of dampness in the form of walls with signs of peeling paint, discoloration, and unsightly mould growth.

In order to comprehensively understand and deal with dampness defects in Pasar Besar Siti Khadijah, infrared thermography equipment was used. By using this non-destructive testing technique, dampness problems plaguing the market can be identified. Through thermal imaging, a picture of temperature variations that indicate the presence of dampness is found, in addition, the use of a carefully selected colour palette also helps in analyzing the severity and distribution of these defects.

This study aims to shed light on the causes and consequences of the dampness in the Siti Khadijah Market. By leveraging the capabilities of infrared thermography, problem areas in this market can be determined and be able to assess how climate factors affect building structures. Through the investigations that have been carried out, knowledge gaps can be bridged, in addition to advancing the theoretical

framework and providing practical insights that benefit academics, industry and the wider community.

This research holds significant promise in improving the understanding of dampness problems as well as guiding toward effective maintenance and repair strategies. By delving into the challenges faced by Pasar Besar Siti Khadijah, guidelines and good practices can be outlined as a guide that will not only restore the glory of the market but also contribute to the overall improvement of the market and public buildings.

Finally, the research aims to understand the contribution and the causes of dampness on the case study building through infrared thermography at Pasar Siti Khadijah, Kota Bharu, Kelantan to create a healthier, more sustainable environment for traders, visitors and society in general. While embarking on a journey exploring the blemish of dampness and its impact on Pasar Siti Khadijah, it is an effort to make a meaningful contribution to the preservation and restoration of this iconic market, ensuring its continued relevance and enjoyment for future generations.

LITERATURE REVIEW

Definition of dampness

The Public Works Department (PWD) (RAYA, 2021) defines dampness as an unwelcome intrusion of moisture into a building, resulting in the appearance of dampness and the development of mould on surfaces. According to (Halim, 2012), when a building is connected to a water source, water seeps through the walls and into specific areas of the structure, causing moisture. Using the defect data to construct a data access system for monitoring and decision-making, the building's condition can be quickly and easily located. Setting priority for maintenance duties and addressing the risk of component failure is one method for addressing issues with limited maintenance resources (Yacob, 2016)

Types of dampness

According to the research of (Halim, 2010)the character of the wall and the rate of evaporation influence the increase in humidity. In addition, the height range for this rising damp is between 0.5 and 1.5 meters above the ground. Penetrating dampness is precipitation that penetrates the building envelope through openings. A study published in the journal (Trotman, 2004) defined rain penetrating a wall as rain infiltrating a wall through the wall's surface, a window opening, or a similar installation. According to research conducted by Othman et al., environmental factors such as precipitation, wind, groundwater, and temperature were to blame for the moisture

problems in the structures. With temperatures spanning from 25°C to 34°C, the climate is consistently moist and humid for a tropical nation. (Chew and others, 2004). High groundwater levels can seep into basements, leak, and discolour walls. The lower levels' wall laying may be affected by capillary moisture rising on pores in the base's massif and sole from damp ground. Groundwater can also harm foundation and subsurface components (Salomovich, 2020). According to (Mydin, 2017), faulty waterproofing can be the underlying cause of moisture-related defects. The purpose of installing a waterproofing membrane is to prevent concrete from leaking. When an excessive quantity of water is absorbed by concrete without a waterproofing system, not only will the reinforcement bar corrode, but the structure will also begin to produce water, leading to a leaking issue. Two categories of roof defects exist: flat roof defects and pitch roof defects. (HANG, 2016). (Mydin, 2017) noted that rising damp and salt crystallisation are interconnected processes. This type of damage, also known as salt attack or salt decay, is typically the result of salt phase transitions induced by moisture transfer (Delgado, 2016).

Causes of Dampness

Water from the earth and surface water are the two primary sources of building moisture. The rate of water seepage into the building structure or building surface depends on the amount of water that comes into contact with the building structure or surface, the orientation of the building and the design of the building, particularly the openings in the building, the thickness of the building wall, the level of evaporation on the building surface, and the presence of salt in the wall. Regardless of the location, surface drainage and ground drainage defects as well as a leaking underground plumbing system can contribute to the rising moisture problem (Hassan et al., 2015).

Limitations and Constraints of Inspection

This investigation focuses solely on the Pasar Siti Khadijah in Kota Bharu, Kelantan. This market, which has distinctive characteristics, is well-known and a major destination for domestic and international tourists. Consequently, one of the limitations of conducting the case study is the congestion caused by Market visitors, which extends the inspection work time and necessitates the relocation of the spot area. In addition, due to time and resource limitations, the upper floor door will be locked at 05:30 pm. Overloaded merchandise is also one of the limiting factors when vendors utilise the building's wall space for product display.

RESEARCH METHODOLOGY

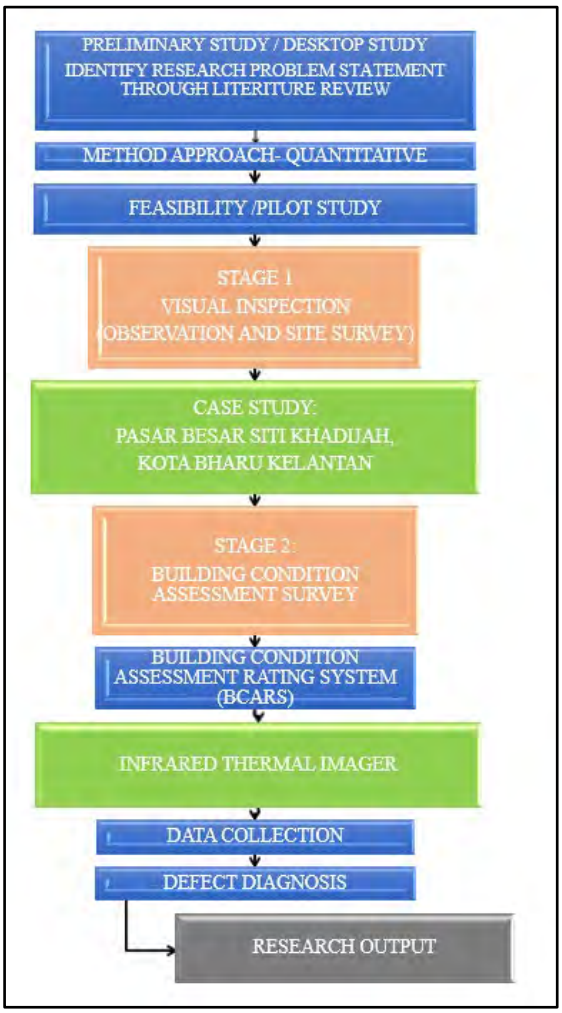

Figure 1: Research Design Work Process.

Tools and Equipment: Infrared Thermograph

Non-destructive infrared thermography (IRT) displays surface temperatures. Infrared radiation will provide the item with a visual image while determining its temperature. Infrared energy is converted into thermal images and temperature estimates by IRT.

Infrared thermography can detect concrete surface flaws and monitor inside temperatures, according to Zheng (2021). If the inspected concrete contains a fault, size and depth will affect temperature. Experimental results reveal that temperature affects infrared picture brightness. The thermal imager is brightest at high temperatures and darkest at low temperatures. The proportional coefficient of

brightness and temperature changes with time because the temperature range changes while the brightness range does not.

Table 1: Infrared Thermograph setting.

IR Fusion	Dew Point (^{0}C)	Transmission (T)	Temperature (^{0}C)	Emissivity
Mid IR Fusion Level	Auto setting (in IRT) follow by surround dewpoint future.	100%	-21 -150 c	0.95% (Concrete)
		Colour palette:	**ironbow**	

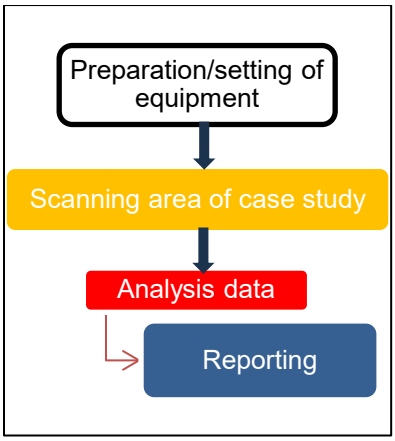

Figure 2: Procedure of Infrared Thermograph.

Data Collection and Data Analysis

Data collection

The Public Works Department (PWD) defines dampness as an unwelcome intrusion of moisture into a building, resulting in the appearance of dampness and the development of mould on surfaces. According to (Halim, 2012) when a building is connected to a water source, water seeps through the walls and into specific areas of the structure, causing moisture. Using the defect data to construct a data access

system for monitoring and decision-making, the building's condition can be quickly and easily located. Setting priority for maintenance duties and addressing the risk of component failure is one method for addressing issues with limited maintenance resources (Yacob, 2016). Table 2 shows that each floor is divided into four zones. In each zone, three pictures will be taken, which means that each window has twelve pictures except for the first window, there is a limitation because it is blocked by the seller's sales. Total image for two days 132 units.

Table 2: Image capture using Infrared Thermograph.

Floor	Floor one	Floor two	Floor three
Day/ Infrared Thermograph	**IR image**	**IR image**	**IR Image**
Day one (Morning)	9	12	12
Day one (Evening)	9	12	12
Day two (Morning)	9	12	12
Day two (Evening)	9	12	12
Total Image of every floor	36	48	48
TOTAL IMAGE			**132**

Table 3: Temperature data.

	Day 1	Day 1	Day 2	Day 2
	Morning	**Evening**	**Morning**	**Evening**
Temperature (^{0}C)	30.5	34	31.4	33.7
	32.8	35.1	32.4	37.8
	34.8	37.3	33.4	35.1
	32.7	**35.5**	**32.4**	**35.5**

The case study's two-day temperature is shown in Table 3. On April 7, 2023, a thermal imager was used to measure the Pasar Siti Khadijah building's average temperature between 09:00 am and 11:30 am, which was 32.7 degrees Celsius. In the evening, it was 35.5 degrees Celsius. On April 8, 2023, morning and evening temperatures were 32.4 and 35.5 degrees Celsius, respectively. The morning temperature variance on both days is 0.3 degrees Celsius, whereas the afternoon deviation is 0 degrees Celsius.

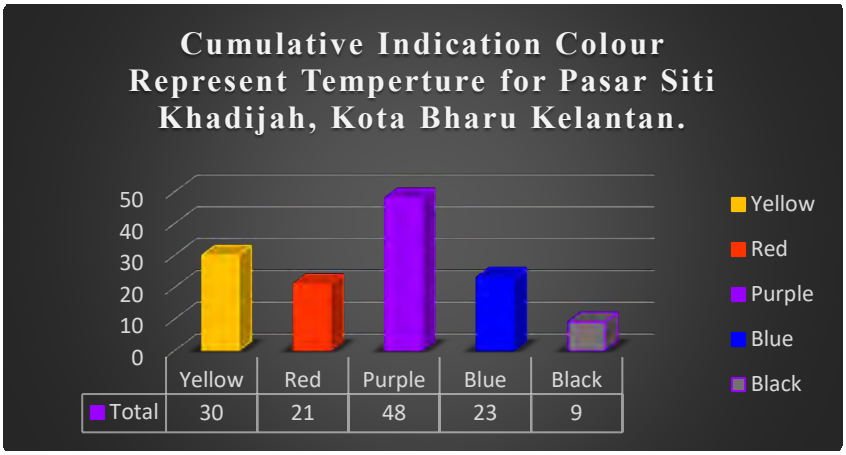

Figure 3: Cumulative indicator colour.

Bar chart Cumulative indication colour represents temperature for Pasar Siti Khadijah, where it can be seen that the maximum value for the entire structure is purple, the second highest is yellow, the third highest is blue, the fourth highest is red, and the lowest value is black.

Data of Relative Humidity

According to the observations, the Pasar Siti Khadijah area has a relative humidity level of: (1) 07 April 2023: RH between 70% and 71% (2) RH 70.0% to 79.4% on 8 April 2023.

Inspection Data Building Condition Assessment Rating System (BCARS)

BCARS assesses a building's construction, roofing, plumbing, electrical, and HVAC systems. It assesses the building's condition and suggests improvements. The Building Condition Assessment (BCA) rating system involves:

1. Evaluate various building components (eg, structural, HVAC, plumbing).
2. Use a rating scale (eg, 1 to 5) to rate the condition of each component.
3. Collect data through inspection and evaluation.
4. Generate detailed reports with ratings and identified issues.
5. Prioritize maintenance based on criticality.
6. Plan for long-term maintenance and improvement.
7. Support decision making for budget and resource allocation.

Data Analysis

Table 4: Colour indicator result for Pasar Siti Khadijah.

Temperature Range	Colour Indicator	Floor 1	Floor 2	Floor 3	Total
		Spot area			
High	Yellow	9	5	16	30
Moderately High	Red	3	13	5	21
Lower	Purple	16	15	17	48
Cold	Blue	5	10	8	23
Coldest	Black	2	5	2	9

Objective 1: The Siti Khadijah Market building's dampness was the first research goal. The infrared thermograph showed 48 places on the building with decreased dampness, purple. Each floor's Table 4 revealed spot area percentages by indicator colour. The thermograph's iron palette gave accurate results. The building's dampness was confirmed.

Objective 2: Sought market humidity reasons. Due to weather, damp penetration, and building defects, all three floors were humid. The market generated dampness around internal walls on the first level. Weather and design mistakes dampened the second floor. Weather and faulty downspouts caused the third floor to have the maximum humidity. The investigation identified dampness problems' causes.

BCARS assessed the building's physical condition. The market was rated D, requiring rehabilitation. Objective 2 revealed the dampness problem's severity and influence on the building.

Finally, the data analysis confirmed the humidity in the Siti Khadijah Market building and identified the cause, where the inspection carried out using an infrared thermograph and the relative humidity data obtained, both showed that low temperature and high relative humidity had occurred in this market.

Dampness must be addressed to protect the integrity of the building and provide a market-friendly environment.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the main goal of this study is to get an overview of the factors that contribute to the failure of the case study building, Pasar Siti Khadijah, which is located in Kota Bharu, Kelantan. Through the application of infrared thermography, this study aims to reveal the source and nature of moisture issues prevalent in the market. The specific objective of the study is twofold: first, to use infrared thermography as a tool to identify areas affected by moisture; second, to categorize the severity of problems related to humidity found in Pasar Siti Khadijah. By gaining this objective, this study seeks to provide a comprehensive understanding of the underlying causes of the failure in the market. The use of infrared thermography enables the visualization and quantification of humidity-related temperature variations, offering valuable data to pinpoint problem areas. Furthermore, the classification of the severity of issues related to humidity contributes to a more nuanced understanding of the challenges faced by Pasar Siti Khadijah. By achieving its objective, this study helps in devising a targeted strategy for the prevention and management of dampness, contributing to the improvement of the overall condition of buildings and the maintenance of market infrastructure.

Recommendation of Renewal lease between the building owner and the tenant is one possibility among others because the building is in bad condition and could get worse if effective maintenance is not performed. Among the proposals for contract renewal are:

1. Comply with Maintenance Services:

Regular upkeep and repairs for the building that the Tenant Party has rented are the responsibility of the Maintenance Party. Building structures, electrical systems, water pipes, sanitization, and building safety conditions are all maintained through maintenance services.

2. Contract Term: This Agreement shall be in force as of (Contract Start Date) and shall terminate on (Contract End Date). With both parties consent, this arrangement may be extended.

3. Service Charge: Monthly fees are charged for maintenance services.

The Maintenance Party shall receive payment at the beginning of each month on or before the due date to avoid late payment and to ensure the maintenance work can be done smoothly.

4. The Maintenance Party's Duties

Maintenance must supply knowledgeable and qualified personnel to carry out maintenance tasks. According to the established plan, maintenance must carry out

maintenance tasks on a regular basis and on time. Any timetable modifications or urgent repairs must be disclosed in advance by maintenance.

5. Tenant's Responsibilities: During the designated working hours, the Tenant shall permit the Maintenance Party complete access to the building. Any maintenance or repair issues that call for the Maintenance Party's attention must be reported by the renter.

6. Contract Termination: This agreement may be terminated by the building owner by giving the other party (tenant) written notice prior to the termination date.

7. Resolution of Disputes: If there is a disagreement between the parties arising out of or relating to this Agreement, the parties undertake to attempt to resolve it by amicable dialogue and mediation.

This contract, which supersedes any prior agreements that may have existed, contains the entire understanding between the parties. Only a written document that has been signed by both parties may alter and modify this agreement.

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