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THE IMPACT OF CLIMATIC FACTORS ON DAMPNESS IN UNIVERSITY ACCOMMODATIONS: A CASE STUDY ANALYSIS

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Abstract:

Dampness-related defects in university accommodations are persistent, particularly in older buildings, due to aging infrastructure, high occupancy rates, and inadequate waterproofing. This study examines the prevalence and causes of dampness in student accommodations by assessing its correlation with climatic factors, including temperature, relative humidity, transmittance, emissivity, and dew point. A three-phase methodology was employed, comprising visual inspection, Building Condition Assessment (BCA), and Non-Destructive Testing (NDT). A case study involving five accommodation blocks was conducted at a public university in UiTM Perak. The findings from visual inspections revealed recurrent damp-related defects, particularly in rooms adjacent to bathroom areas. The BCA survey incorporated the Building Assessment Rating System (BARIS) alongside NDT, utilizing thermal imaging to determine defect severity. The results indicated that walls in affected areas exhibited high relative humidity levels, ranging from 9.71% to 81.0%, and temperatures between 28.7°C and 34.0°C. Lateral or penetrating damp was identified as the most prevalent defect, primarily caused by leakage from upper-wall pipelines, with 31 recorded occurrences. These findings highlight the need for proactive maintenance strategies and enhanced damp-proofing measures to mitigate moisture-related deterioration and ensure the structural integrity of student accommodations.

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Keywords:

Dampness, University Accommodations, Building Condition Assessment (BCA), Non-Destructive Testing (NDT), Thermal Imager

Introduction

There are numerous challenges facing today's buildings, mainly due to the occurrence of defects caused by the surrounding environment (Hong, 2016). Many examples have shown in the past 20 years where buildings collapsed due to deterioration factors caused by the surrounding environment. For instance, the prominent Malaysian cases of Highland Towers Apartment in Lembah Klang (Utusan Malaysia, 2013) and Sultan Mizan Stadium in Terengganu (Alif et al., 2019). Temperature variations, humidity occurrence, and constant exposure to moisture lead to many issues in building structure (Othman et al., 2015a), which allows defects to occur, and eventually, the building may collapse if improper remedial works have been done.

One of the major sources of defects comes from humidity, which leads to dampness issues. According to Othman et al., (2015b), humidity is defined as the water-vapour content of the air that is expressed in various ways. Normal atmospheric air in most cases is humid. Humid air is also called moist air, which can hold moisture that increases with temperature and can be associated with dampness. Othman et. al., (2015) mentioned that dampness can be defined as a water penetration process through certain elements of the building where it is near a water source. In addition, dampness can also be defined as an extreme moisture that will lead to dampness problems, for instance, rising damp, lateral damp, and condensation damp (Othman et al, 2015).

This situation will lead to poor indoor air quality (IAQ) that has a huge impact on the health and quality of life of building users (Cincinelli & Martellini, 2017), and the rapid growth of mould that will create unhealthy building issues (Tham, 2016). There are many ways that moisture can access into the buildings, such as rainwater that penetrates through leaks in walls, floors, roofs, windows, and doors (Tham, 2016). A study done on 420 buildings in Sweden has shown that moisture can cause vivid microbial growth within 65% of the buildings in that country (Berggren & Wall, 2019) other example, like in the UK, shown that most of buildings with dampness issues, will likely to have unhealthy building conditions (Othman, et al, 2015). Compared to western countries, Malaysia is heavily exposed to moisture problems due to its climatic characteristics, that located in the Tropic region, which leads to adverse effects on health, rapid building deterioration, Sick Building Syndrome (SBS) issue, and decreasing functionality performance (Othman et al., 2015a) (Sundin, 2012).

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Beware of leaks!

Figure 1: Concern On Building Leaks Appeared In The National Newspaper
Source: The Star, 2017

Figure 2: The Building Defects Associated With Dampness
Source: Othuman et al., 2014

The moisture problem that occurs in the buildings is usually take place on the at connection between the floor and the wall of a building (see Figure 1 and 2). The occurrence of water seepage that is related to improper waterproofing installation or deterioration of damp proof course (DPC) may lead to mould growth, flaking of paint and water stain (Luca, 2014).

One of the highest humidity areas in the building is the toilet (Jamaludin et al., 2015) (Kwag et al., 2019). The water seepage from the toilet areas can also affected the internal wall buildings. The peeling paint and blistering of wallpaper finishes occurred due to failure of water proofing layers on the toilet wall that caused water to penetrate through the toilet wall and affect the perimeter wall as shown as in Figure 2.

The similar situation could also occur in buildings with high densities and multiple activities, like in university's accommodation. Over certain period of time, especially for aged- buildings, the water proofing agent may deteoriate and leads to issue of dampness. The sign can be seen at many universities' accommodation in Malaysia, since most of these public universities have been built more than 20 to 30 years. Obviously, the waterproofing agent installed in the building's element (between wall and floor) have been aged and deteriorate. This will influence building leakage and accumulates water penetration. Therefore, it is important to carry out this research, in order to prioritize the defect diagnosis procedure for identifying the dampness-based defect in the university's accommodation. Not all kinds of defects, can be treated in the same way, since there are many influential factors to it (Kuan, 2017). If there are special mechanisms that can allow defect to be diagnosed through priority process based on significant temperature, humidity and timeline, every defect can be treated accordingly and efficiently.

Literature Review

To study the context of building defects in Malaysia, there are several defects that can be found which are fungal attack, unwanted growth, erosion in mortar binding, paint flaking and blistering, defective plaster, wall cracking, defective rain water downpipe, wood or timer decay, insect and termites attack, defective roof structure, dampness, unstable foundation and installation of air-conditioning system that can be a source of building's dampness in building (Halim et al., 2012a). According to Nadia et al., (2014) building defects occur because of design deficiency, or poor-quality workmanship, that may affect due to renovation process that is not fit with the design requirements.

However, for this study, the main focus is on the moisture problem that is associated with dampness defects. Moisture problem can be defined as a situation of "any visible, measurable or perceived outcome caused by excess moisture indication indoor climate problems or problems of durability in building assemblies caused by various leaks of water" (WHO, 2009). However, WHO (2009) also had identified "moisture can be transported in both vapour and the liquid phase by diffusion, convection, capillary suction, wind pressure and gravity (water pressure)."

Moisture problem commonly happens at every building. According to Halim et al., (2012b), moisture is known as a major cause of building defect, whilst WHO (2009) identified that moisture caused 75-80 per cent of building envelopes defects.

The main building moisture problems are caused by leaking at building elements such as roof, wall, and ceiling. For instance, a study done by Othman et al., (2015b) identified that among 14 major defects at walls and floors are water leakages through cracks, water leakages through pipe penetration, and 9 water leakages through joints. According to Othman et al., (2015a) water leakage ranks as the highest (53 per cent) of presence defect at wall and floor. The issue of waterproofing is known as the main contributor to the failure of the building that leads to the moisture problems. For example, Talib, Ahmad, et al., 2015 identified that the flat roof leaky due to waterproofing that was not applied properly by the contractor (Talib, Boyd, et al., 2015).

Public Universities

For Malaysian cases, there are more than 50 numbers of public and private universities that required detailed attention on the maintenance matters, especially involving with defect on humidity (Abdul-Rahman et al., 2014),(Muniapan, n.d.), especially since most of these universities are more than 20 years. Universities in Malaysia with larger capacities of students' accommodation are University Malaya (UM), University Science Malaysia (USM) and Universiti Teknologi MARA (UiTM). These large universities are managed by the Maintenance Department of each university. These universities have more than 100 student's accommodation in all campuses that aged more than 20 years (Ding et al., 2016) (CBP/Catenin Antagonist Safely Eliminates Drug Resistant Leukemia Initiating Cells, 2016). Since these buildings are exposed to weather every day, the humidity in internal spaces is usually accumulated, especially location near to bathrooms or toilets. If humidity defects in this students' accommodation are not treated accordingly, issues may arise on the numbers of occurrence for BRI for these accommodations. Therefore, proactive action is needed and good strategy of building maintenance can prevent more defects to occur in the future. However, now, there is limited study related to defect with the relationship of temperature and time of

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usage for these universities. A necessary experiment needs to be done to identify the relationship of these two elements.

Dampness

Dampness can be defined as water penetration through the walls and certain elements of the building where it is near to a water source. It is not only can speed up the building defects, but also it would detrimental to the building equipment. In addition, dampness can also be defined as extreme moisture that will lead to dampness problems. Problems such as cosmetics defect is harmful in terms of decor, fabric damage, structural problems, or at a certain circumstance it would has an adverse impact on the health of residents (Damalas & Eleftherohorinos, 2011). Other definitions that have been expressed by (To et al., 2016) are extreme moisture can cause structural damage, it would lead to wood decay, and it would damage the decorations and bolster growth of mould and fungus that can harm health. Meanwhile, dampness as the excessive quantity of moisture contained within building materials and components which cause adverse movements or deterioration and results in unacceptable internal environmental conditions (Halim et al., 2012b). According to Halim et al (2012), there are five generally accepted cause of dampness in the buildings. Dampness emanating from the top of the building wall and absorbed into the wall, dampness caused by capillary action of the damp soil and through foundation or wall that hit the ground, leaking of water pipes or mechanical equipment in buildings, the internal dampness resulting from the internal activities such as cooking and building processes such as human respiratory system or temperature control, dampness resulting from the restoration and maintenance of buildings. An analysis conducted by Professor Malcolm Hollis (2000) in a book entitled "Building Surveying classifies the factors that cause dampness to four categories, rising damp, infiltration, condensation and leaking pipes in the building. While Bakri & Mydin, (2014) explains that there were five factors that caused dampness which started with the water vapor condensation infiltration leaking pipes in the building water from the underground, and the source, such as a specific site. 3 types of dampness can see in Table 1.

Table 1: Types of Dampness

Types of Dampness	Causes	Treatment
 **Figure 3: Rising Damp** Source: http://www.1stassociated.co.uk/dampnessbasics.asp, 2001	Rising damp is where water is literally drawn up by capillary action into the wall. Typically, although not exclusively, a brick wall will have rising dap to approximately a metre in height. (Halim et al., 2012b).	The best one is needed to identify the cause, know the cause, and then provide suitable repairing works for the defects (Halim, 2012).
 **Figure 4: Penetrating Damp**	Lateral dampness, also known as penetrating dampness, is dampness that comes through the wall. Often lateral dampness can be mistaken for rising damp if it is at low level and	According to Delgado et al., (2016) for the good treatment of falling damp, it is quite good if the owner can check all water pipes, storm water pipes,

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Source: http://www.1stassociated.co.uk/dampnessbasics.asp, 2001	condensation if it is at high level (Corp, 2005).	roofs, gutters and downpipes
 **Figure 5: Condensation Damp** Source: http://www.1stassociated.co.uk/dampnessbasics.asp, 2001	Condensation occurs when moist air comes into contact with a colder surface like a wall, window, mirror etc. The air can't hold the moisture and tiny drops of water appear. It also occurs in places the air is still, like the corners of rooms, behind furniture or inside wardrobes (Sustainable energy, 2013).	The only way of preventing condensation is to provide ventilation. The warm air, containing the water vapour, will rise and circulate around the room until it finds a cooler surface, unless we let that air out and some cooler air in (EPA, 2013; Seppanen and Kunitskin, 2009).

Source:

Climatic Factors and Their Influence on Dampness

Climatic conditions such as temperature, relative humidity, wind-driven rain, and seasonal changes play a significant role in dampness formation. In humid tropical climates, buildings are more vulnerable due to high moisture content in the air, frequent rainfall, and limited ventilation (Che Ani et al., 2009). High humidity levels can cause condensation on cooler surfaces, especially in inadequately ventilated spaces, while persistent rain can lead to water ingress through poorly sealed external walls (Abdullah & Ismail, 2013).

Malaysia is one of the countries that located to the equator line and there are minimal differences on the sun path movement. Malaysia have received abundant natural daylighting penetration due to the sunrise that comes from east direction (Y.W. Lim & Hemg, 2016). 1643 kpta/m2 is averagely amount of the annual solar irradiation in Malaysia (Hussin et al., 2010; Markos & Sentian, 2016). There are three (3) types of the sky in Malaysia, such as clear, cloudly and overcast. This sky types are significant to the irradiance condition that led to peak sun hour requirements (Mohamed A. Almaktar, Haytha, Y. Mahmoud, Elsenoussi Y. Daoud, 2017). Malaysian Meteorology Department (2018), has highlighted that the peak sun hour for Malaysia is between 8.00 am to 3.00 pm. Therefore, it is significant to carry out the lighting research based on the recommended peak sun hour. However, visual discomfort will be 44 occurred at this peak period. These peak periods of visual discomfort occurred during the best periods of daylighting performance (Konis and Lee, 2015). This has supported by Y. W. Lim & Heng, (2016) and Fairuz Syed Fadzil & Sia, (2004) which argue that the high outdoor natural day lighting has a potential to be utilize as a sustainable lighting energy in the built environment because Malaysia has available natural daylight in abundance and for free. This information is important to be used during building condition assessment.

Relative Humidity

The amount of water vapour contained in the air expressed as a percentage of the amount required for saturation at the same temperature. Humidity is the water content of the mixture of water vapour and other elements contained in the air while the relative humidity is a percentage of water vapour in the air at a specific temperature (Laukkarinen & Vinha, 2017).

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Temperature

This is for every object with a temperature above absolute zero emits infrared radiation. This temperature is invisible to the human eye (laukkarinen et, al., 2017).

Research Methodology

Visual inspections revealed that dampness is a widespread issue across several student accommodation buildings at UiTM Perak, Seri Iskandar. The most frequently observed symptoms included water stains on ceilings and walls, peeling paint and plaster, mould growth in bathrooms, efflorescence on exterior surfaces, and musty odors. These signs align with previously documented dampness indicators in accommodation buildings (Straube & Burnett, 2005; Abdullah & Ismail, 2013). The severity of defects varied, with older buildings showing more extensive deterioration, consistent with findings by Nasir et al. (2014) regarding defect accumulation over time in under-maintained buildings. See Figure 6 it is found that Cempaka Sari College (Block of Anggerik 1 and Anggerik 2) in UiTM Perak has shown a visible defect due to dampness.

All photos related come from rooms that are located next to the toilet (see Figure 6). It is significant to carry out this research based on the proof shown, where the defect is due to a fungus attack because of high humidity. All buildings have visible water stains on the wall surface, patchy surfaces, and flaking paint.

Figure 6: Example Taken From A Pilot Study Of This Study: Cempaka Sari Colleges, UiTM Perak.

Source: Author

The capacity for each block is around 615 students occupying at the same time. Most of the defects usually happen in the area of the toilet and the external area of the blocks, which involves many types of dampness. However, through the observation stage, it is found that the high occurrence of dampness in the pilot study is rising damp.

Case Study

For this data collection, a case study has been selected for the research, namely Cempaka Sari College (Anggerik Block 1 and Anggerik Block 2). For this research, 3 phases of research approaches have been performed. It involves (i) field survey and visual inspection, (ii) Building condition Assessment (BCA) survey, and (iii) Non-Destructive Testing (NDT) survey. 1 student block of female accommodation has been chosen as the case study due to the accessibility factor during the data collection. The colleges have been selected based on specific criteria that have been presented in Figure 7. The information has also been supported by the pilot study and data gained from the Maintenance Department of UiTM Perak.

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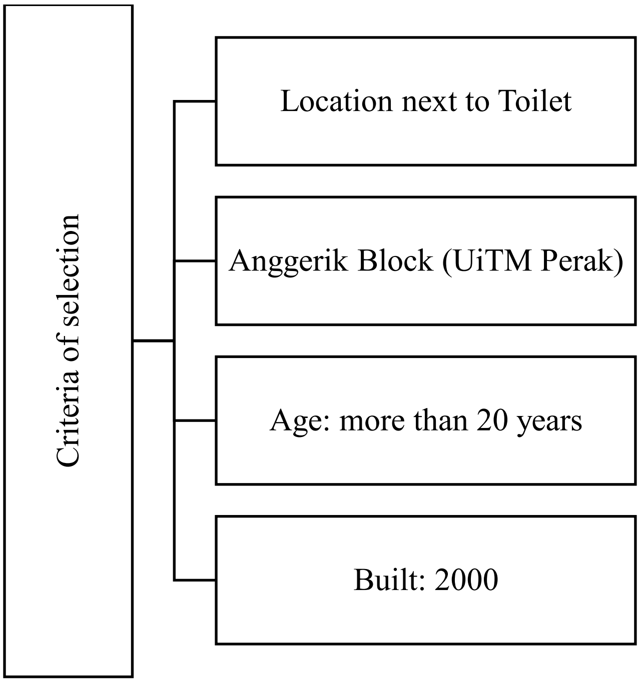

Figure 7: Criteria of Selection

Source: Author

Figure 7 shows the selection criteria for the selected colleges, which are based on the highest occurrence of each research. Locations are chosen based on: i. Located near the toilet areas, ii. iii. Occurrence of defect (higher), Level occurrence of Humidity (higher)

Cempaka Sari College is are female students' accommodation (see Figure 7) that comprises three (3) storeys of the building. The reason for selecting these colleges as the case study is due to the high level of occurrence of humidity problems at all rooms that are located next to the toilets. This issue has been found during the early stage of the Pilot Study (see Figure 6). These findings have also been supported by the Maintenance Department of UiTM Perak, which highlights the location of the highest dampnessoccurrence in UiTM Perak. This research will only focus on rooms which are located next to toilets. Figure 8 shows the case study of Anggerik Block 1 and Anggerik Block 2.

Figure 7: Block Anggerik 1 and 2 (Cempaka Sari College)

Source: Author

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Table 2: The Period of Time for Data Collection.

The Resource	Term	Time
Malaysian Meteorology Department (2018)	Peak Sun Hour	8 am to 3 pm Morning (8 am – 10 am, 10 am 11.59 am) Afternoon (12 pm – 2 pm) Evening (2 pm – 3pm)

Source: Malaysian Meteorology Department (2018)

From all colleges in UiTM Perak, it is found that Cempaka Sari College that consists block of Anggerik have achieved the criteria of selection. Based on table 2, there are 3 periods of data collection, which is morning (0800am-1100am), Afternoon (1200pm-0200pm), and Evening (0200pm-0300pm). The selection of time is based on the peak Sun Hour in Malaysia suggested by the Malaysian Meteorology Department (2018).

Details information Cempaka Sari Colleges

Defect Profiling Grid

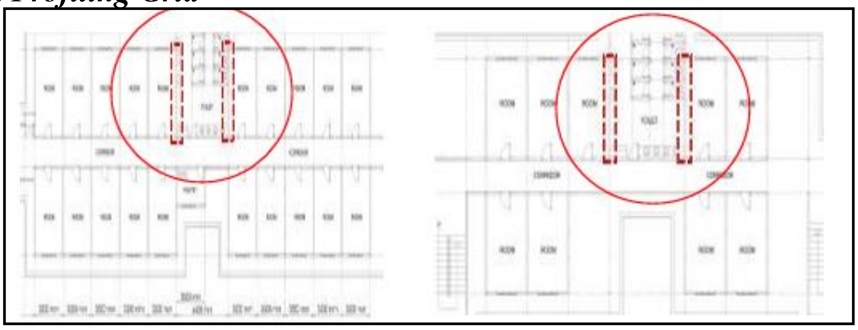

Figure 8: The Case Study Layout Plan

Source: Author

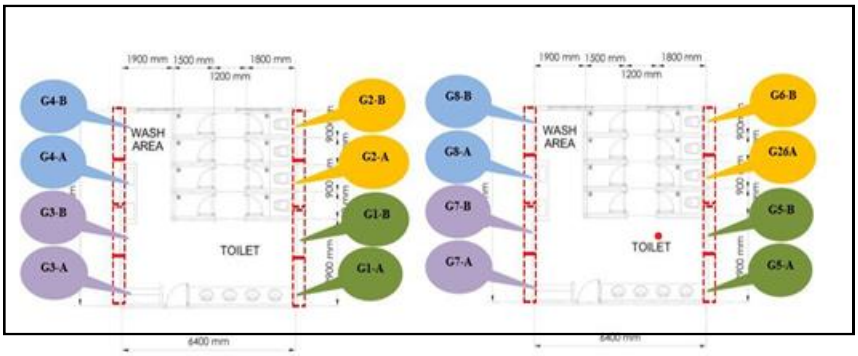

Figure 9: Layout Of Toilets For Every College With A Specific Code

Source: Author

Figure 8 and Figure 9 is the defect profiling grid has been applied during this stage to mark the exact location of defects that occurred in the study. This is supported by the Building Condition Assessment (BCA) survey procedures at the site provided by Royal Institution Surveyors Malaysia (2017). Red- coloured circle in the figure below indicates the location of toilets that have been identified as the main source of dampness during the pilot stage.

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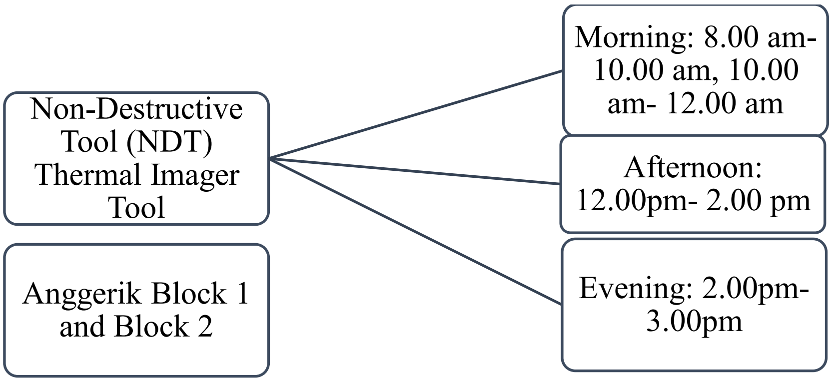

Figure 10: Defect Matrix For The Case Study Based On NDT (Thermal Imager tool)
Source: Author

Defect matrix provided in this section are the results that have been collected from the case study for all levels of the case studies building by using NDT (Thermal Imager) tool. The defect profiling grid in table 4.4 have been applied for each Thermal Imager readings that have been collected on site. Readings from grid G1A and G8B have been shown in this research as a benchmark (based on the condition of dampness and low content of dampness in the rooms) for the session of morning, afternoon and evening. Figure 10 shows the process flow of the data collection by using Thermal Imager tool.

Data Collection Methods

This study used direct visual observation as the primary data collection method to identify and document dampness-related defects in selected student accommodation buildings. Observations were carried out during both dry and wet periods to capture the variability of symptoms. Data were recorded systematically using checklists and photographic evidence, focusing on visible defects associated with moisture intrusion or retention.

Tools And Techniques Used

Phase 1: Field survey and Visual Observation

For the first phase, it is important to perform visual observation during the field visit in order to identify the location of defects in the case studies. During this phase, two approaches will be used, namely condition survey using checklist and colour coding from a standard building condition rating known as Building Assessment Rating System (BARIS) and scientific tool, known as thermal imager device. Figure 11 shows layout drawing room which are located near the toilet areas and also case study.

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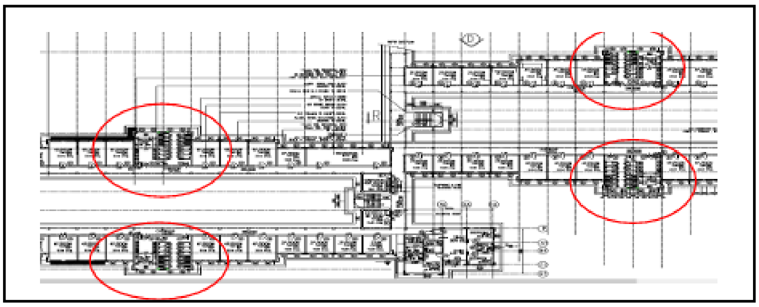

Figure 11: Layout Drawing Based On An Observation Of And Student Rooms, Which Are Located Near The Toilet Areas

Source: Author

Phase 2: Building Condition Assessment (BCA) Survey

In this phase, the Building Assessment Rating System (BARIS) is used to specify the overall condition of the building, whether it is good, fair, or dilapidated (Shuib and Baharum, 2015). Building Assessment Rating System is one of the systems that a Building Surveyor can conclude the performance of the buildings through its physical state (RISM,2017). Through this approach, all the buildings' conditions can be monitored and ranked based on the scale shown in Figures 12 and 13.

Figure 12: BARIS Defect Assessment (RISM)

Source: Royal Institution Malaysian Surveyor (RISM)

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Defect Sheet No :	Level			
Photo :	Location			
	Element/ Component			
	BARIS			
	Condition	Priority	Matrix	Colour
	Defect Description			
	Possible Causes			
	Remedial Works			

Figure 13: The Schedule Of BARIS Which Comprises Of Defect Sheet No, Level, Photos Of Any Defect, Location Of Defect, Element, Components, BARIS Coding (Condition, Priority, Matrix And Colours), Descriptions Of Defect, Possible Causes And Remedial Works For Defect.

Source: Royal Institution Malaysian Surveyor (RISM)

Phase 3: Non- Destructive Test (NDT) using Scientific Tool- Thermal Imager

A thermal imaging camera is a reliable instrument which can scan and visualize the temperature and dampness distribution of entire surfaces accurately through thermal image (see Figure 14). A thermal imaging camera records the intensity of radiation in the infrared part of the electromagnetic spectrum and converts it to a visible image (See Figure 15) (Usamentiaga et al., 2014)

Figure 14: Thermal Imager Devices

Source: Author

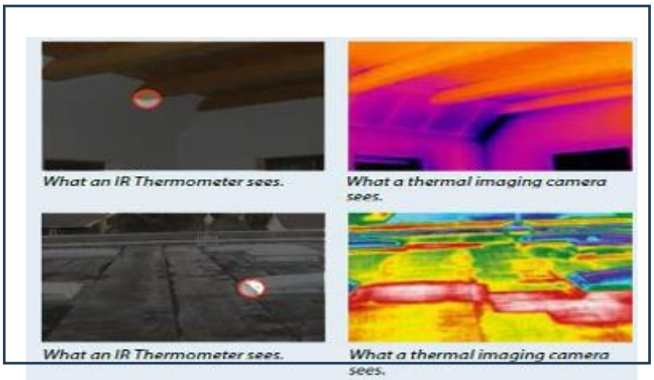

Figure 15: Total View of The Situation and Instant Diagnostic Insights

Source: Usamentiaga et al., 2014

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IR Fusion	Dewpoint	Transmission (T)	Temperature (°C)	Emissivity (Ɛ)
Mid IR Fusion Level	Has been set to automatic, following the surrounding dewpoint value	100%	Has been set according to the site temperature	Concrete: 0.95%

Table 3: Thermal Imager Settings for This Study
Source: Usamentiaga et al., 2014

To complete the condition survey for this case study, it is important to use the scientific tool (see Figure 14) in order to get an accurate analysis result based on climatic factors variables (temperature, humidity, emissivity, and time). A thermal imager will be used to detect the content of humidity on the damp defects in the case studies (see Table 3). If the level of humidity for the defect is higher, it will show the image of thermography on the screen, and it can assist the researcher to make a judgment about the content of humidity content in the defects. This tool can also detect visible and invisible humidity content in any part of the college building during the condition survey and process (see Figure 15). By using this tool, the researcher will get accurate data related to the condition of the defect

Sampling Method and Justification
This study employed a purposive sampling method to select specific student residential buildings at UiTM Perak Branch, Seri Iskandar Campus. Purposive sampling is appropriate for qualitative research where the aim is to obtain rich, detailed insights from cases that are most likely to exhibit the phenomena under investigation. In this case, buildings were selected based on known or reported occurrences of dampness, visible signs of deterioration, and accessibility for on-site observation. Additionally, buildings of varying ages, orientations, and construction types were included to reflect a range of environmental exposures and structural conditions. This targeted approach ensured that the study focused on buildings with a high likelihood of damp-related issues, supporting a meaningful exploration of the impact of climatic factors on building performance.

Limitation
While the study offers valuable insights into dampness in university accommodations, it is subject to several limitations. First, access restrictions prevented observation in some areas, such as locked rooms or restricted maintenance zones, which may have resulted in incomplete data. Second, the study relied solely on visual inspection without instrumentation, meaning that latent or subsurface moisture not visible may have gone undetected. The absence of tools such as moisture meters or humidity sensors limited the ability to validate or quantify the severity of dampness. Third, climatic data were sourced from secondary sources such as Meteorology Malaysia and not gathered through on-site monitoring, which may not fully capture microclimatic variations that influence moisture behaviour at the building level. Additionally, the non-random, purposive sampling limits the generalizability of findings beyond the specific buildings studied. Finally, the lack of occupant feedback meant that the study could not assess user perceptions or health impacts, which are relevant to understanding the broader consequences of damp environments.

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Data Collection

For this study, only selected data collected for Anggerik Block 1 are shown in this defect matrix section (see Table 4). For this Thermal Imager, the tool has been set in an automatic setting, which will follow the current condition at the site Defect Matrix: Anggerik Block.

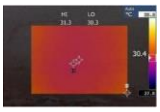
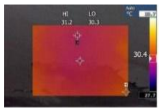
Based on this section, the data collected are based on transmission (T)= 100%, emissivity 0.955, dewpoint (°c) = automatic, weather condition, time of data taken (8.00 am-3.00 pm), wall temperature, and relative humidity (%). For overall condition, it is found that:

i. Most of the zones that have high RH are located near the sink. This is because they have high exposure to water.
ii. Most of the zones that have low RH are located far from sink and shower areas.
iii. RH (%) has decreased during afternoon because the temperature starts to increase.
iv. Lower RH (%) occur during the afternoon due to high temperature, and the area is far from the sink and shower areas.
v. Types of dampness for every area are lateral dampness since there are leakages from the piping system.
vi. Average temperatures found are between 29-30°c °C

Average relative humidity (%) found is from 15%- 60%.

Table 4: Data Collected for Anggerik Block 1 (Defect Matrix)

Transmission (T) = 100% Emissivity (ع) = 0.95% Dewpoint (◦C) = Automatic Wheather = Sunny Day

TIME	INFO	Grid Code Area: G1A	INFO	Grid Code Area: G1B	Remarks
8.00am – 10.00am	1) Room Name: A1003 2) Temperature: a. Normal: 28.8 b. High: 29.7 c. Low: 28.7 3) Relative Humidity (RH) :55.6%	 Types of dampness – G1A: Rising damp, condensation, and lateral/Penetrating damp	1) Room Name: A1003 2) Temperature: a. Normal: 29.4 b. High: 30.2 c. Low: 29.3 3) Relative Humidity (RH): 33.5%	 Types of dampness: G1B: Rising damp and Condensation damp	G1A: Have high RH due to the location of exposure near to the sink. G1B: Lower RH since the area is far from the sink and shower areas
10.00am-12.00pm	1) Room Name: A1003 2) Temperature: a. Normal: 30.4 b. High: 29.7 c. Low: 28.7 3) Relative Humidity (RH) :33.5%	 Types of dampness - G1A: Rising damp, condensation, and lateral/Penetrating damp	1) Room Name: A1003 2) Temperature: a. Normal: 30.4 b. High: 30.2 c. Low: 29.3 3) Relative Humidity (RH): 32.7%	 Types of dampness - G1B: Rising damp and Condensation damp	G1A: Have high RH due to the location of exposure near to the sink. G1B: Lower RH since the area is far from the sink and shower areas
12.00pm-2.00pm	1) Room Name: A1003		1) Room Name: A1003 2) Temperature:		G1A: Have high RH due to the location of

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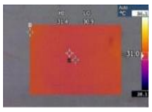
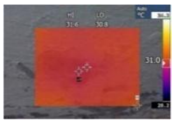
	2) Temperature: a. Normal: 30.6 b. High: 31.1 c. Low: 30.5 3) Relative Humidity (RH): 32.7%	Types of dampness - G1A: Rising damp, condensation, and lateral/Penetrating damp	a. Normal: 31.3 b. High: 31.7 c. Low: 31.1 3) Relative Humidity (RH): 29.5%	Types of dampness - G1B: Rising damp and Condensation damp	exposure near to the sink. However, the RH (%) decreased since it is afternoon. Temperature starts to increase. G1B: Lower RH since the area is far from the sink and shower areas, even drier during afternoon due to high temperature.
2.00pm-3.00pm	1) Room Name: A1003 2) Temperature: a. Normal: 31.0 b. High: 31.4 c. Low: 30.9 3) Relative Humidity (RH) :30.5%	 Types of dampness - G1A: Rising damp, condensation, and lateral/Penetrating damp	1) Room Name: A1003 2) Temperature: a. Normal: 31.0 b. High: 31.4 c. Low: 30.9 3) Relative Humidity (RH): 12.6%	 Types of dampness - G1B: Rising damp and Condensation damp	Conditions are almost the same for both grids (G1A and G1B) during the evening.

Source: Author

Building Assessment Rating System (BARIS) Data

Table 5 below is the data collected by using the BARIS schedule which compiled the defects found at the case study. For this paper, only the worst condition of defect that have been found in this case study are shown in this section. This study will not report on the remedial works. Therefore, for this BARIS schedule, the remedial works section will not be discussed.

Table 5: Building Assessment Rating System (BARIS) Data

Defect Sheet No: 1/19	**Level**	**Ground Floor (G6A-A1)**		
Photo:	**Location:**	Internal		
 (a) Interior side (student's room)	**Element**	Wall Finishes		
	Component			
	BARIS			
	Condition	**Priority**	**Matrix**	**Colour**
	3	2	6	
	Defect Description			
	Peeling of paint, water marks pattern (interior side) and mould growth (exterior side)			
	**Possible Causes**			

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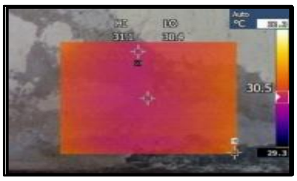
The Damp Proof Course was malfunctioning. There is a sign of lateral/penetrating damp above the wall.

(b) Exterior side (Toilet)



(c) Thermal Imager reading

Figure 16: Interior side (student's room), Exterior Side (Toilet), Thermal Imager Reading

Source: Author

Result Analysis 1- Correlation Temperature and Relative Humidity (RH)

After data have been collected using the NDT tool, known as the Thermal Imager, the data are then analysed using the Radar chart (Spider web graph) in order to identify the trends of each variable (Temperature and RH). It has been categorised into normal, high, and low range temperature readings. For temperature range through thermal imager tools it explains, the highest, normal, and lowest temperature that encounter in observation determines the temperature range which needed from thermal imager tools. Besides that, it also can select a camera picture with a wide temperature range that automatically selects the range based on the scene appeared at thermal imager.

High temperature is usually considered to be 38°c and above. When the reading temperature from thermal imager tools has achieved 38° and above, it is will considered as a high temperature. While, when temperature around 37°c and 36°c categorized in normal temperature.

The average normal temperature is generally accepted as 98.6°F (37°C). Some studies have shown that the "normal" temperature can have a wide range, from 97°F (36.1°C) to 99°F (37.2°C). Then, low temperature is when thermal imager reads 96°F (35.55°C), low temperature be a symptom the humidity causes. When the humidity is low reading temperature. It means has humidity beside the wall.

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Result Analysis for Anggerik Block 1

Normal Range Readings

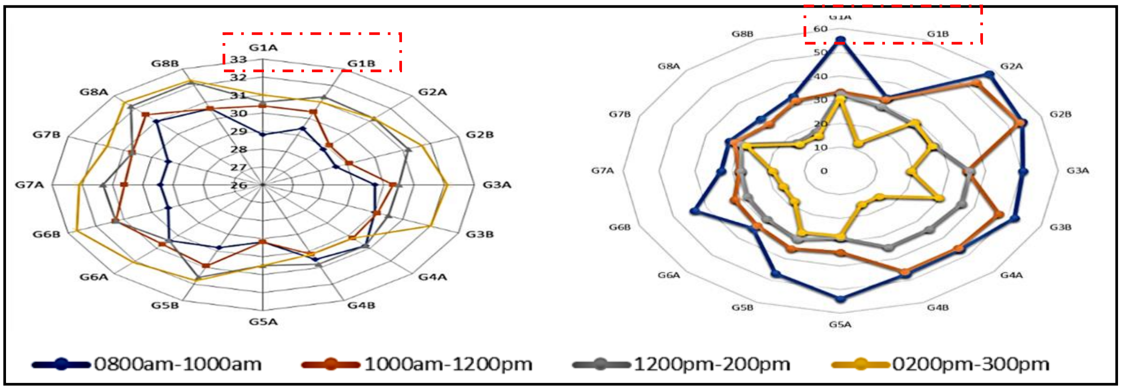

Figure 17: Result Analysis for Temperature and Relative Humidity for Normal Range Readings

Source: Author

Table 6: Normal Temperature at Anggerik Block 1

	G1A	G1B	G2A	G2B	G3A	G3B	G4A	G4B
0800am-1000am	28.8	29.4	28.8	28.6	29.7	30	30.8	30.5
1000am-1200pm	30.4	30.4	29.1	29.1	30.3	30.1	30.2	30.2
1200pm-200pm	30.6	31.3	31.2	31.2	30.5	30.5	30.8	30.8
0200pm-300pm	31	31	31.2	31.7	32.1	32	30.2	30.2

Table 7: Relative Humidity For Normal Temperature at Anggerik Block 1

	G1A	G1B	G2A	G2B	G3A	G3B	G4A	G4B
0800am-1000am	55.6	33.5	58.1	54.2	50.3	52	46.8	47.1
1000am-1200pm	33.5	32.7	52.9	53.5	35	47.3	46	46
1200pm-200pm	32.7	29.5	28.3	27.9	35.7	36.1	34.7	34.7
0200pm-300pm	30.5	12.6	29.1	27.3	19.4	29.4	15.2	15.2

Source: Author

For normal range readings at grid code defect area (G1A), the temperature is recorded between 28.8◦c (morning session) which is 8.00 am – 10.00 am to 30.5◦c (evening session) which is 200pm-300pm, and relative humidity (RH) is recorded between 15% (evening session) which is 200pm-300pm to 55.6% (morning session) which is 8.00 am – 10.00 am. The correlation data can be seen in Figure 18, where it indicates that when the temperature is lower (28.8◦c), the RH % will be higher (55.6%) (Morning session) which is 8.00 am – 10.00 am and when the temperature is higher, the RH% will drop at 30.5% (evening session) which is 200pm-

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300pm. It proves that the humidity in air is colder during the morning time which may accumulate the damp during this time.

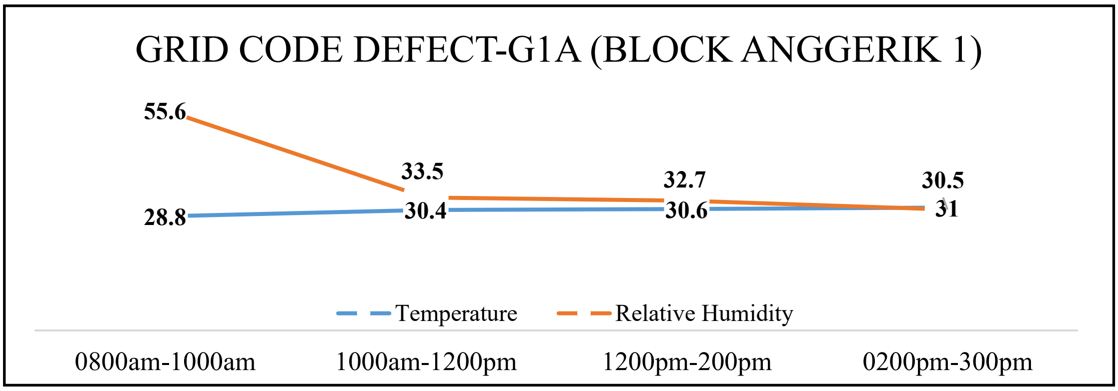

Figure 18: Correlation between Temperature and Relative Humidity for Normal Range-grid code area-G1A

Source: Author

For normal range readings at grid code defect area (G1B), the temperature is recorded between 28.8◦c (morning session) which is 8.00 am – 10.00 am to 31.2◦c (evening session) which is 200pm-300pm, and relative humidity (RH) is recorded between 12.6% (evening session) which is 200pm-300pm to 33.5% (morning session) which is 8.00 am – 10.00 am. The correlation data can be seen in Figure 19, where it indicates that when the temperature is lower (28.8◦c), the RH % will be higher (33.5%) (Morning session) which is 8.00 am – 10.00 am and when the temperature is higher, the RH% will drop 12.6% (evening session) which is 200pm-300pm. It proves that the humidity in air is lower during morning time which may accumulate the damp during this time.

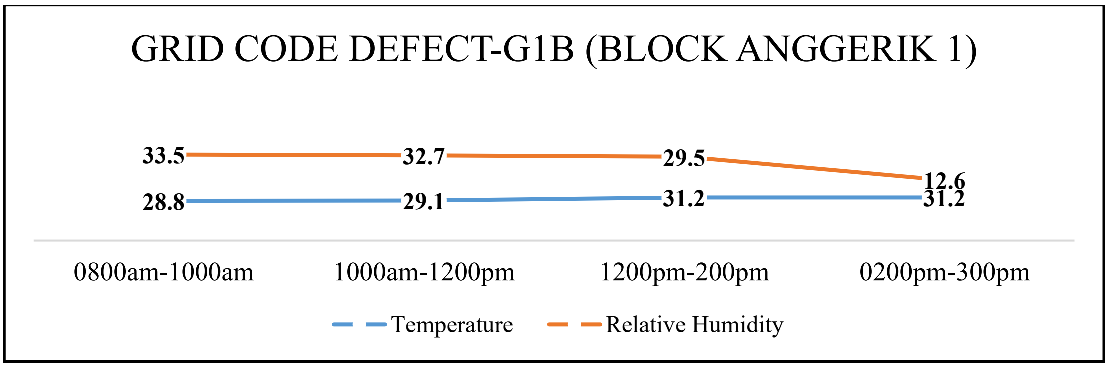

Figure 19: Correlation between Temperature and Relative Humidity for Normal Range-grid code area-G1B

Source: Author

Conclusion

This study aimed to investigate the impact of climatic factors, specifically temperature, relative humidity, transmittance, emissivity, and dew point, on the occurrence of dampness in university accommodations. The findings from the case study conducted at Cempaka Sari College, UiTM Perak, clearly demonstrate that lateral or penetrating dampness is the most prevalent defect, primarily due to leakage from upper-wall plumbing, especially in rooms located adjacent to toilets. Using a combination of visual inspection, Building Condition Assessment (BCA) via the BARIS system, and Non-Destructive Testing (NDT) with a thermal

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imager, the study successfully identified the correlation between climatic conditions and dampness severity. It was observed that relative humidity levels were highest during the early morning when temperatures were lower, and these levels decreased as temperatures increased throughout the day, indicating a strong inverse relationship between temperature and RH in influencing damp conditions.

The use of BARIS effectively quantified the defect conditions and provided a reliable system for monitoring and prioritizing maintenance needs. The results emphasize the necessity for proactive maintenance practices that take into account climatic factors and defect-prone locations, particularly around wet areas.

In conclusion, the study achieves its objectives by establishing that climatic factors significantly influence dampness levels and that targeted assessments using BARIS and thermal imaging can support more efficient and responsive maintenance strategies in university accommodations.

The Significance of This Study

The evidence gained from the data collection and data analysis has been processed to benefit the parties involved in the construction of buildings. Especially, to the developer, owner of the building, occupants of the building, and the maintenance department of the university. It will improve the work process in all sectors in order to establish early prevention measures to avoid any defects occurring in the future.

It will also help to improve planning for other construction parties. In addition, it will also help the maintenance department of the universities to improve their performance on the procedures of the maintenance by following the guidelines for controlling the defect on dampness in universities' accommodation.

In this way, the maintenance team should follow the schedule of maintenance schedule to maintain the building to make sure the building is always in good condition, and it can also avoid building failures in the future.

From this research, it also helps the management to hire suitable workers to perform repair and replacement works, such as leaking pipes. Finally, all parties such as management, local authorities, the academic authorities, consultants, contractors, and the public should be involved in the remedial works and work together to diminish the occurrences of defects and failures in the academic buildings. They should have close monitoring to work mutually to form a strong and sustainable built environment in the academic buildings.

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