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SUSTAINABLE BUILT ENVIRONMENT

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IDENTIFICATION OF POSSIBLE CAUSES OF MOULD GROWTH IN QUANTITY SURVEYING BUILDING

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ABSTRACT

This research paper discusses mould growth in Malaysian institutions, focusing on the Faculty of Quantity Surveying building in particular. Mould, a common type of fungus, is ubiquitous and plays an essential role in the decomposition of organic matter. Institutions in Malaysia, including office buildings and schools, have reported an increase in mould growth as a result of factors such as hot weather and high humidity in the tropical region. As students spend a considerable amount of time in classrooms and labs, the presence of mould in academic settings is concerning. The purpose of this paper is to identify the causes of mould growth in the classrooms of the Faculty of Quantity Surveying through qualitative research methods, including visual inspection and non-destructive instruments. Analyzing mould growth observations, infrared thermography images, and data analysis tables constitutes data collection. The findings reveal extensive mould growth both inside and outside the building, which is primarily attributable to high humidity and moisture sources such as leaks. In conclusion, the paper emphasizes the significance of implementing preventive measures, such as ongoing maintenance and moisture control, to create a healthier learning environment for students and faculty.

Keywords: *Mould growth, classroom, external*

INTRODUCTION

The most common type of fungus that can be found on earth is called moulds. Yeasts and mushrooms are two examples of other types of fungi. Moulds are an essential component in the decomposition of organic matter, which is required for the continuation of plant and animal life. Hyphae, which look like thin filaments, can be found in large numbers within moulds. If the conditions were right, the hyphae would develop into long strings that would eventually intertwine to form the mycelium, which is the primary body of the fungus. (DOSH, 2019).

Malaysian institutions are also affected by the mould growth problem. Due to a lack of public awareness, the number of reported cases of mould growth in office buildings, institutions, automobiles, and other locations has been increasing (DOSH, 2019). Malaysia, being in a tropical region, has hot weather and high humidity (Wahab, Khamidi, & Ismail, 2013). This environment introduces moisture and humid air, which promotes mould growth inside and outside Malaysian buildings, including institutional buildings.

Because of today's hectic lifestyles, we spend hours working in the same area. This poses a serious problem. Additionally, the majority of the learning process takes place inside the building. A regular human breathes 10,000 to 30,000 litres of air daily (Zainal Abidin et al., 2013). If there is a Mould growth in faculty academics, it should be a major concern for students who study in the classroom and lab based on the fact that written by Zainal Abidin. Therefore, we must protect and ensure that the air we breathe is free of dangerous pollutants. The term sick building syndrome (SBS) is used when IAQ causes health issues (Ross et al., 2004). This paper aims to review the possible cause of mould growth at the faculty academic.

LITERATURE REVIEW

Definition of Mould Growth

Mould is the term used to describe a large and diverse group of fungi that grow in filaments, giving them a cottony, fuzzy appearance, and reproduce by producing spores. Mould grows when it is allowed to spread beyond where it started. Mould growth can be like a snowball because as more mould grows, it sends out more spores. The cycle can keep going until the mould has grown on every surface that can hold it. (Corrosion Pedia 2018). This statement is supported by (the Government of Western Australia. Department of Health, 2015) Mould includes all species of microscopic fungi that grow in the form of multicellular filaments, called hyphae. Although the terms ‘mould’ and ‘fungi’ are often used interchangeably mould is only one of the many organisms that make up the kingdom of fungi. The number of mould species is large and diverse.

Survival and Proliferation of Mould

Moulds propagate via spores. Spores are like seeds; when they land in a favourable environment (damp area), they germinate and generate a new mould colony. They have a relatively basic structure and never contain an embryo or other manufactured progeny, unlike seeds. Spores are formed in several ways and occur in a range of sizes and forms.

Mould Growth Germination

- Presence of Mould Spore

  Mould spores remain in the air indefinitely. Mould spores remain latent in the air until they come into touch with wet or moist surfaces, at which point they may begin to proliferate and become apparent. (Green Orchard Group, 2021). To germinate, spores need access to both water and oxygen, and this process is characterised by fast enlargement as a result of hydration (Chandler, 2017) (Microbial Control of Insect and Mite Pests, 2017).

Figure 1: Typical Sources of Indoor Microbacteria

  There are mould spores both indoors and outdoors. Mould spores can enter a house through open doors, windows, vents, and HVAC systems. Mould spores in the outdoor air can stick to clothing, shoes, and animals and be brought inside. (National Center for Environmental Health 2022). As shown in figure 1.5 are the diagram show how spore enter the building.

- Source of nutrients

Mould growth requires proper nutrients, which are self-provided by the enzymatic digestion of organic materials. Due to its organic nature and hygroscopic properties, wood is highly susceptible to mould providing sufficient nutrients for spore germination and mycelium growth. (Kuka, Cirule, Andersone, Andersons, & Fridrihsone, 2022)

- Adequate Moisture

Moisture is defined by the EPA as the presence of liquid, particularly water, in buildings or building materials. Moisture can come from both internal and external sources, such as leaks or condensation. There are 4 sources of moisture (John Carmody; Brent Anderson; and Richard Stone, Extension educator, 2018) e) Human Activities (Angell, 1988) which are:

a) Rainwater (Lstiburek, 2001).
b) Plumbing (Lstiburek, 2001).
c) Condensation (J Lstiburek, 1996)
d) Ground water .

- Conducive Temperature for a Particular Mould

It is well known that air temperature and humidity have a substantial impact on the development and spread of mould in building environments. (Almeida R. Barreira E, 2018) When the temperature and relative humidity (RH) are above threshold levels, mould development is encouraged. For instance, moisture and/or mould issues seem to be more prevalent in warm climates. (Haverinen, Shaughnessy U, 2012) 20 to 30 °C is the appropriate range of air temperature for the growth of mould. (Sedlbauer K, 2012) The growth rate of filamentous fungus was shown to be enhanced when the temperature neared favourable ranges between 25 °C and 30 °C. (Aihara M, Tanaka T, Ohta T, Takatori K, 2012).

Possible Causes of Mould Growth

- Unwanted Moisture

  Water leaks in plumbing and roof, flooding, excessive humidity, and condensation are all sources of moisture for mould to thrive and spread. Moist environments are ideal for mould growth, which is why leaking plumbing or other sources of water damage can quickly expand a mould problem. (Leak Masters 2022). According to the Environmental Protection Agency and the Centers for Disease Control and Prevention, mould can begin to grow on surfaces within 24 to 48 hours of exposure to water. At this stage, however, the mould spores are not visible to the naked eye. Mould spores typically take between 18 and 21 days to colonise and become visible. Mould can start to develop in as little as a few hours under ideal conditions. Therefore, it is crucial to act swiftly in the event of a water leak or flood.

- Limited Air Circulation

Mould growth may result from insufficient airflow. If users combine wetness with restricted air circulation, it will create a humid and damp atmosphere, which is ideal for the growth and spread of mould. It is crucial for classrooms to have outdoor vents so that dirty air can escape, and fresh air can enter. Inadequate vents can reduce airflow and increase the volume of contaminated air in a residence, hence increasing the risk of respiratory illness. There must be a balance between the quantity of air intake and the quantity of exterior venting. Inadequate ventilation is also linked to an increased risk of airborne infectious disease transmission, as well as the accumulation of indoor pollutants and humidity, all of which contribute to the development of major health problems. (Mold solution 2017) According to ASHRAE Standard 62, classrooms must have 15 cubic feet per minute (cfm) of outside air per person, while offices must have 20 cfm per person. This standard provides guidelines for acceptable ventilation rates and air quality inside buildings.

- Poor Maintenance

Poor building maintenance can result in moisture concerns. Mould can thrive in an atmosphere where moisture concerns are undiscovered or disregarded. Mould is typically related to moisture concerns in temporary constructions, such as portable classrooms. If the mechanical ventilation is not well assisted after a retrofit, the improved thermal insulation of buildings may cause an insufficient air change volume indoors. (Fisk WJ, Singer BC and Chan WR.2020), (Földváry V, Bekö G. Langer S, Arrhenius K, Petráša D.2017). If the heating was not available and the indoor wall surfaces were not sufficiently heated, the risk of condensation would occur (BS 5250,2011). Mould growth in indoor environments would be controlled by all of these factors. Other than that Mechanical ventilation, failure of the roof and plumbing without proper maintenance are the causes of contribute to mold growth.

- Crawl Maintenance

High relative humidity (RH) in a crawl space, along with a bare earth floor, is a recipe for mould growth. Capillary motion causes water to move through the soil from wet to dry areas. Moisture from the earth will evaporate in the crawl space's warmer air, contributing to the crawl space's already humid environment and encouraging mould growth. Additionally, groundwater may enter a crawl space if the water table is high, and the conditions are right. The mould problem in a building may not be limited to the crawl space where it originated. Cracks in the walls, floors, and ceilings allow moisture to seep up from the crawl area and into the rest of the building.

DATA ANALYSIS

In this study, the research presents an innovative approach to data collection by combining visual inspection techniques with Non-destructive tools. The data will be analyzed and compared using acceptable standards, mould germination standards from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHREA), Jabatan Kerja Raya (JKR) and Department of Occupational Safety and Health (DOSH) of findings. This design and strategy allow for a comprehensive understanding of the research topic by examining both qualitative trends and observation insights from the perspectives of guidelines by JKR, ASHRAE and DOSH. As shown in Table 1 is an Acceptable standard by ASHREA and OSHA in classroom while Table 2 is Mould Germination Standard.

Table 1: Acceptable standard by ASHREA/OSHA in classroom

Relative Humidity %	Temperature	Moisture meter	Lighting Lux
ASHRAE	ASHRAE	ASTM F2170	Illuminating Engineering Society
30-60%	20^{o}C – 24^{o}c	<75 (concrete)	300-500 (for task like reading and writing)

Table 2: Mould Germination Standard

Relative Humidity (%)	Temperature	Moisture Meter	Lighting Lux	Source of Nutrient	Source Moisture
ASHRAE	ASHRAE	ASTM F2170	JKR	JKR	Journal Article
<60 %	20^{o}C – 30^{o}c	>75% - 80% (concret e)	<50	Dirt Dust Cellulose Starch	Rainwater Plumbing Condensation Ground water Human activities

RESEARCH METHODOLOGY

Research Design and Strategy

The research design and strategy employed in this study are an observation approach and a qualitative method. This paper aims to identify the possible causes of mould growth in the Faculty of Quantity Surveying Building in the UiTM Perak Branch.

Qualitative Method

Qualitative and Observation data will be collected in 2 phases, phase 1 is by visual Inspection and phase 2 by Non-destructive tools.

Case Study

Quantity Surveying building is being constructed in early 2008. The building finished construction on 30/10/2010. It takes about 1 year and a half to complete the construction of the building which has 3 floors. The building cost is RM 4 million building own. The building spaces at UiTM Seri Iskandar's Quantity Surveying building serve a variety of critical functions to support the academic programme. Classrooms for lectures and tutorials, laboratories for practical exercises, faculty offices for staff, meeting rooms for collaboration, computer labs for specialised tasks, and exhibition spaces for student projects and research are among the spaces available. The Quantity Surveying building at UiTM Seri Iskandar utilizes metal deck roofing, a construction method that combines metal decking with a waterproofing membrane, ensuring a durable and watertight flat roof system.

Data Collection

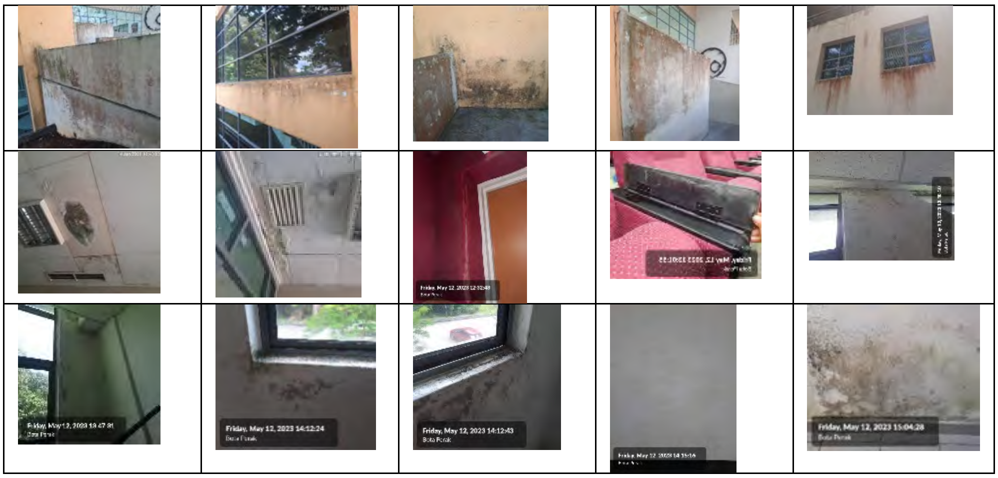
This study employs a qualitative methodology. In the initial phase, the Visual Inspection technique is utilised. In the second phase, non-destructive tools, including a 4 in 1 meter, moisture metre, hygrometer, anemometer, and infrared thermography, are utilised. For phases 1 and 2, the Royal Institute of Surveyors Malaysia has provided guidelines. The objective is to achieve objectives 1 and 2, which are to identify the causes of mould growth in the college.

Table 3: Instrument tools

No.	Instrument tools	To Measure
1.	4 in 1 meter	Temperature (°c) Lighting (lux) Relative Humidity % Wind speed m/s
2.	Hygrometer	Measure the humidity, or amount of water vapour in the air.
3.	Infrared Thermography	To detect any hot spots where equipment may weaken or fail. To detect any hot spots in were damp area. - To identify hidden areas.
4.	Moisture meter	To measure the percentage of the moisture content in wood and concrete materials.

FINDING

Finding Visible Mould



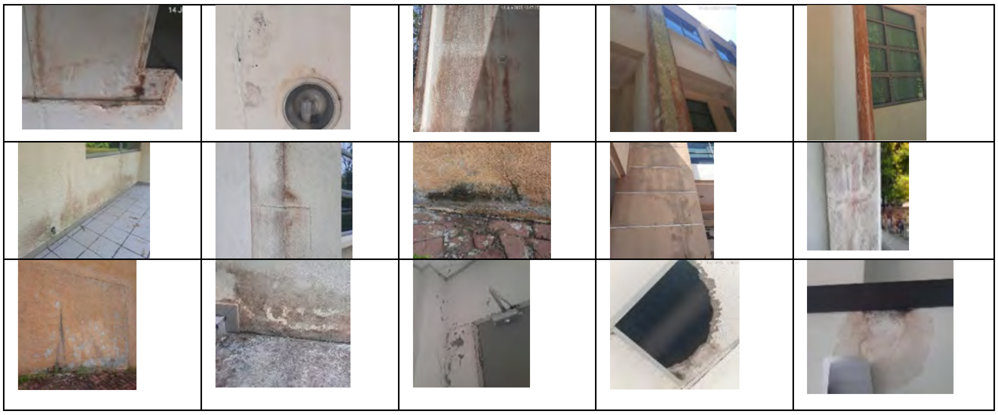


Figure 2: Visual Mould found on Quantity Surveying Building

As shown in Figure 2 are all the mould growths observed during a visual inspection. There are a total of 30 mould growths outside and inside the classroom.

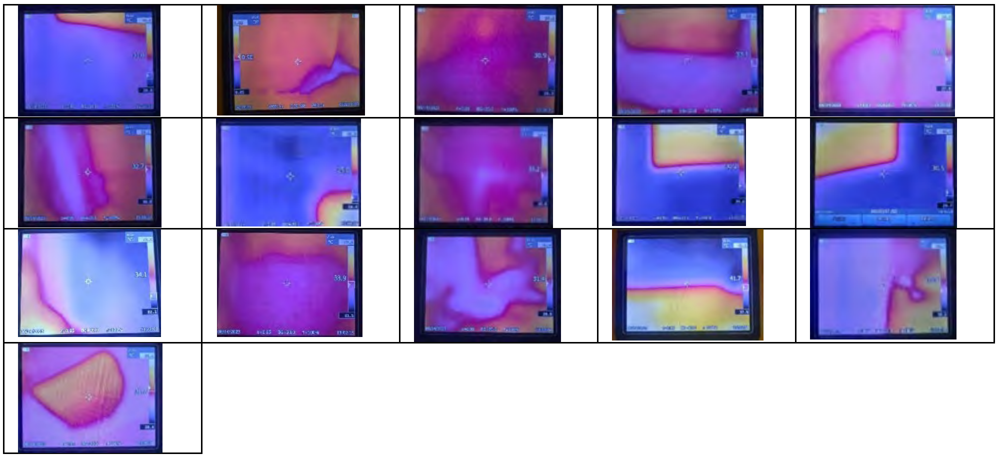


Figure 3: THERMOGRAPHY IMAGE

As shown above are infrared thermography images. The infrared image reveals a purple and blue colour range, which indicates that the area is damp.

Data Record on Measurement of Temperature, Relative Humidity and Moisture

Table 4: Data Analysis for External Level G

Area	Visible mould	Relative humidity (%)	Moisture Meter (%)	Temperature (ºC)
Front Left Elevation	/	72.6	22.1 (Concrete)	30.2
	/	72.3	13.8 (Concrete)	31.8
	/	70.8	22.4 (Concrete)	32.3
	/	67.2	27.2 (Concrete)	32.6
Front Right elevation	/	74.6	24.8 (Concrete)	29.2
Rear Left elevation	/	54.3	20.8 (Concrete)	36.8
	/	74.6	24.8 (Concrete)	29.2
Rear Right elevation	/	70.9	13.8 (Concrete)	30.9
	/	54.3	20.8 (Concrete)	36.8
	/	73.3	43.0 (Concrete)	30.9

Table 5: Data Analysis for External Level 1

Area	Visible mould	Relative humidity (%)	Moisture Meter (%)	Temperature (ºC)
Front	/	71.2	16.03	31.0
Left Elevation			(Concrete)	

	/	73.8	13.3 (Concrete)	30.4
	/	75.9	39.6 (Concrete)	30.1
	/	72..3	38.3 (Concrete)	30.6
Front Left elevation	/	73.3	-	30.0
Rear Right elevation	/	78.2	-	28.1

As shown in Table 4 is data analysis for external level G area and Table 5 is data analysis for external level 1. The data from the quantity surveying faculty's external level G and level 1 led to these conclusions. The above table indicates that mould can be found on nearly all of the building's surfaces. This is because of the high humidity levels outside the structure. Mould thrives in damp environments, so it's important to keep outdoor spaces dry. This can happen when there's too much moisture in the air, it rains, or there aren't enough drains. In addition, climatic conditions also one of the possible causes of mould outside the building which is certain climates with high humidity, frequent rainfall, or damp weather conditions provide a conducive environment for mould growth.

Table 6: Data Analysis for Internal Level G

Area	Visible mould	Lighting lux	Relative humidity (%)	Moisture meter (%)	Temp (ºC)	Causes
Class 019/0B	/	1090	64.0	48.6 (Concrete)	29.7	condensation
Class 018/0B	/	709	53.5	-	28.3	Leaking of plumbing
Class 015/0B	/	463	54.2	-	28.6	Leaking of plumbing

Class 019/0B does not meet the acceptable standards for relative humidity and temperature, as shown by the Table 6. The room's humidity level is 64%, exceeding the recommended maximum of 60%. Additionally, the temperature exceeds the comfortable range for classrooms. These conditions create an environment conducive to mould growth. Due to the high humidity and condensation moisture, it is possible that mould is already present in the room. Classes 018/0B and 015/0B, on the other hand, meet the acceptable standard for relative humidity but have temperatures that exceed the optimal range for a classroom. In addition, the conditions in these rooms are conducive to mould growth. Class 018/0B has a plumbing leak that contributes to moisture, while class 015/0B has information board leakage issues. These elements contribute to the mould growth in these classrooms.

Table 7: Data analysis for internal level 1

Area	Visible mould	Lighting lux	Relative humidity (%)	Moisture meter (%)	Temp (°C)	Causes
Student pathway	/	30	75.4	-	28.1	Leaking & condensation
Dewan Al Khawar izmi	/	18	64.0	-	23.8	Leaking & condensation
	/	224	51.3	-	22.2	Condensation & organic material
Class 011/OA	/	40	78.1	20.5 concrete	25.9	Condensation
	/	42	75.3	19.2 concrete	25.3	Condensation
Class 010/0A	/	2050	67.2	29.1 concrete	25.9	Condensation & water intrusion
	/	1023	60.1	31.7 concrete	26.0	Condensation & rainwater intrusion
	/	403	58.6	-	25.5	Dirt

Based on Table 7 and the data presented, it is evident that several areas within the university building do not meet the acceptable standards for relative humidity and temperature, making them conducive to mould growth. Classrooms such as 019/0B, the pathway, Ibnu Sina hall, and classes 011/0A and 010/0A have humidity levels exceeding the recommended limit of 60% and temperatures outside the comfortable range. These conditions create a potential for mould presence, with moisture sources including condensation and leaks. Additionally, the presence of mould in different areas, such as wooden chairs or window corners, indicates existing mould growth. The combination of high humidity and suitable temperature provides a favourable environment for mould development in these spaces.

Table 8: Data Analysis for Internal Level 2

Area	Visible mould	Lighting lux	Relative humidity (%)	Moisture meter (%)	Temp (^{o}C)	Causes
Path to lecture room	/	301	68.6	-	31.8	Leaking of roof

As shown in Table 8 are comparison table between finding data and acceptable standard and mould germination standard. Based on the provided tables and data, it is evident that path to lecture room fails to meet the acceptable standards for relative humidity and temperature according to ASHRAE. The humidity level in the room exceeds the recommended limit of 60%, with a measurement of 68.9%. Additionally, the temperature in at the pathway is 31.8°C. The combination of high humidity and suitable temperature creates an environment favourable for mould growth. This indicates that there is already mould present at the ceiling due to the leaking. The leaking issue from the roof, contributing to the moisture problem.

CONCLUSION

The conclusion of this paper is complete Based on the findings presented in the tables and analysis of the data, mould growth is a significant problem within the university building, both inside classrooms as well as external areas. The high levels of humidity, especially outside the building, contribute to the prevalence of mould on various surfaces. In addition, several classrooms, including 019/0B, 018/0B, and 015/0B, do not meet the acceptable standards for relative humidity and temperature, thereby fostering mould growth. In addition, leaks, such as the one observed in the hallway leading to the lecture hall, contribute to the moisture issue and subsequent mould growth. Universiti Teknologi MARA (UiTM) must implement comprehensive mould remediation and prevention strategies to address this issue. Implementing prevention, UiTM can create a healthier, more conducive learning environment and ensure the health of its students and employees. To prevent future mould growth and preserve a safe and comfortable indoor environment, it is crucial to prioritise the ongoing maintenance and management of moisture levels.

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Sekian, terima kasih.

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Saya yang menjalankan amanah,

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

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Setuju.

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