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A REVIEW OF THE DAMPNESS-RELATED FACTORS THAT AFFECT BUILDING STRUCTURES. CASE STUDY: UNIVERSITY FACILITY BUILDINGS

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Abstract:

Dampness, which is frequently caused by water ingress from heavy rainfall, building usage, maintenance practice, condensation, or insufficient ventilation, can manifest in a variety of ways, ranging from visible damp patches on walls to less visible but equally insidious effects below the surface. Understanding the factors contributing to dampness is critical for architects, builders, and maintenance professionals looking to protect structures from damaging effects. This paper reports on a finding of unwanted dampness in university facility buildings. The primary goal is to highlight significant issues and propose potential solutions, as well as to raise building owners' awareness of building condition surveys and their relationship to building maintenance management. The condition assessment will bring a wide range of non-destructive equipment to four facility buildings of university. This paper contributed to a better understanding of dampness factors in building structures. It also looks at ways to improve the building's maintenance strategies.

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Dampness, Roof Leakage, Condensation, Maintenance, Structures, Defects, Facility

Introduction

A facilities building is commonly defined as a building or place that accommodates a variety of essential facilities or amenities required for the operation of a community or organisation. The strength and appearance of building structures are critical factors that influence the overall quality, functionality, and durability building. While structural strength assures safety and durability, aesthetic considerations are critical in determining the character and visual effect of buildings. Malaysia receives an abundance of rain, especially in the monsoon seasons. Too much rain can cause dampness in structures by allowing water to seep through the foundation, walls, or roof. Buildings that are not properly maintained or waterproofed may experience serious problems with water intrusion. Understanding dampness-related issues is essential for producing, constructing, and maintaining resilient, healthy, and efficient buildings. It requires taking into consideration a variety of factors such as temperature, building materials, ventilation strategies, and maintenance procedures to ensure that buildings function properly and provide safe and comfortable living or working environments for people. In certain cases, confirming the potential source of moisture may necessitate additional laboratory testing (Johansson et al. 2020; Wahab and Hamid 2011). The surveyor could then advise the customer on the impact of the property's condition and circumstances based on their thorough inspection and research of the property's construction and services. The building condition survey was conducted by researchers and students with prior experience in building maintenance management and building condition surveys. A total of four facility buildings were inspected and the resulting reports were presented during a one-month period. This paper presents a compilation of prevalent building defects that arise from moisture in University facilities buildings. The straightforward diagnosis and suggested remedy for these shortcomings are also addressed.

Literature Review

The importance of university facility buildings having an attractive design, efficient performance, and usefulness with minimal problems is essential for various reasons. The visual aesthetics of these buildings play a crucial role in establishing an exciting and favourable learning environment for both students and lecturers, hence promoting a pleasant attitude on campus. Furthermore, guaranteeing the highest level of efficiency guarantees that the interior areas of the buildings successfully serve their intended functions, be it classrooms, labs, libraries, or administrative offices. This feature has a direct impact on the effectiveness and efficiency of academic and administrative tasks. Additionally, it is essential to minimise defects such as structural issues, maintenance problems, or safety concerns in order to ensure the safety, comfort, and well-being of all individuals utilising these facilities (Hauashdh et al. 2022). Building owners and facilities managers have identified that complaints about building defects have increased in recent years, with common issues including leaky roofs and walls, dampness and water penetration from the upper toilet, cracks in the floor slab, and others (Wahab and Hamid 2011). Deferred maintenance, or maintenance that is not executed at the designated time or as planned, can worsen these issues by

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postponing necessary repairs until a later time. These factors have a direct impact on the effectiveness and efficiency of academic and administrative tasks within the university (Hamid et al. 2010). Prioritizing aesthetics, functionality, and defect control in university facility buildings helps create a supportive and environmentally friendly campus atmosphere. This, in turn, enhances the educational experience and overall satisfaction of students, lecturers, and staff.

Dampness in facility buildings is a common and serious problem that can occur because of different factors, including rainwater seepage, plumbing leaks, or condensation (Mattsson et al. 2024). When there is moisture and management are slow paced to acknowledge or publicly address it, various adverse outcomes can arise. Many facility buildings have issues with dampness problems and face a major challenge because of tenant or the owner negligence and improper maintenance and management. Starting with, moisture can result in the growth of mould and mildew, causing harm to construction materials and perhaps threatening the health of individuals by causing respiratory problems and allergies (Mendell, Macher, and Kumagai 2018). In addition, extended periods of moisture can diminish the strength of structural components such as wood and metal, possibly jeopardising the stability of the building (Wahab and Hamid 2011). In addition, moisture can generate an uncomfortable and disagreeable interior atmosphere, impacting the general welfare and efficiency of students, lecturers, and staff. Hence, it is imperative for management to swiftly tackle moisture issues by conducting thorough investigations, implementing effective mitigation measures, and carrying out regular maintenance to guarantee a secure, wholesome, and operational facility environment.

Building dampness can be attributed to several factors and is caused by different mechanisms. Disadvantages resulting from defective agents are typically classified into four primary categories: Leaky Roofs, Environmental Conditions, Building Material Vulnerability, Plumbing Leaks, Poor Drainage and Landscaping and Poorly Sealed. Water is the main factor causing building degradation in general and in the historic setting in particular, according to (Yacob, Ali, and Au-Yong 2019). An increase in rainfall brought on by climate change may saturate soils and overwhelm gutters and downspouts, raising the possibility that moisture could seep into old materials like masonry walls. Another element that might lead to water penetrating through porous materials and by capillary action when the soil is damp is condensation (Batty, O'Callaghan, and Probert 1984; Lourenço, Luso, and Almeida 2006). By causing salt crystallisation, which speeds up material deterioration, water infiltration also promotes biological activity, sub florescence, and corrosion (Agu and Ajaelu 2022)

As shown in table 1, which addressing the influenced of climate patterns includes precipitation (rainfall) and require careful consideration of material selection, construction techniques and maintenance practices to mitigate the impact of dampness and preserve the aesthetics and integrity of building materials in different environmental conditions.

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Table 1: Climate Sensitivity of Generic Materials

Material Type	Durability Issues	Climate Dependence
Brick and ceramics	• Frost damage	Freeze-thaw cycles
	• Shrinkage of unfired materials	Precipitation and drying
	• Salt staining	Precipitation and drying
Stone	• Weathering & erosion	Temperature, precipitation
	• Acid deposition	Precipitation (with pollution)
	• Salt attack	Precipitation and drying
Wood	• Biological deterioration	Temperature and precipitation
	• Warping and structural movement	Uneven drying
Metals	• Various corrosion mechanisms	Temperature, precipitation
Plastics/Polymers	• UV deterioration	UV exposure, temperature
	• Thermal ageing	Temperature
Concrete	• Corrosion of reinforcement	CO_2, temperature, drying
	• Chemical and salt attack	Precipitation, Temperature and drying
Glazing	• Failure of double glazing seals	Precipitation and humidity

Scope and Methodology

This paper aims to conduct a thorough examination of the various elements connected to moisture that affect both the structural integrity and environmental performance of university facility buildings. The review will specifically concentrate on various forms of moisture infiltration. An analysis will be conducted on several types of moisture, including rising damp, penetrating damp, and condensation, present in university buildings. The examination of building defects commences with the site planning phase, which requires understanding the arrangement and surroundings of the building. Data related to the building, such as building plans and historical records, is gathered to provide information for this process. A checklist form was created to systematically discover possible errors. Various tools and equipment, including cameras, moisture metres, hygrometer and 4 in 1 meter, get prepared for the inspection. The task entailed examining the fundamental factors and processes that contribute to moisture, such as the composition of building materials, construction techniques, weather conditions, and maintenance procedures. Additionally, it is necessary to assess the impact on building structures. Evaluating the impact of moisture on different building elements such as walls, floors, foundations, and roofing systems, with a focus on possible structural damage and material decay. The next step is to discover the causes and mechanisms that occur. Defects are carefully recorded during the assessment, and a plan is put together to visually represent the issues. The identification of the condition and priority level for each problem is done to help to determine which are the necessary corrective measures. The present state is assessed to analyse the building's condition throughout a period.

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The precise locations of defects are properly identified, and specific corrective measures are suggested to solve the difficulties. Eventually, planned maintenance schedules are implemented to prevent possible defects and ensure the building's ongoing state of soundness. Investigating the secondary consequences of moisture, including indoor air quality, growth of mould, and the related health hazards to individuals residing in the building. It is essential to develop plans for minimising the impact of dampness-related issues in university buildings by investigating current and proposed techniques for prevention, management, and remediation. The assessment of the Four Facility University buildings will require a wide range of specialised equipment used by Building Surveyors. The study was conducted by researcher and undergraduate students from UiTM specialising in Building Surveying. The report will provide comments on the findings along with general recommendations regarding the subject matter for the benefit of all parties involved. The prioritisation of tasks is based on the severity of the problems. Figure 1 Show phases of building defects assessment process.

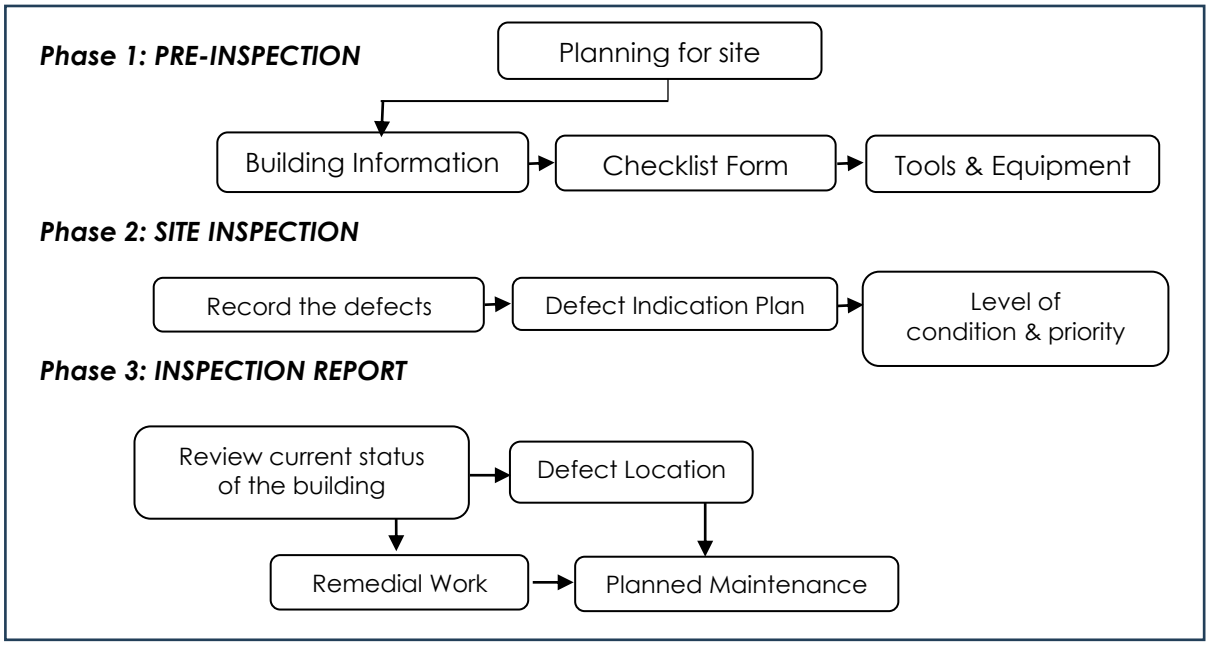

Figure 1: Building Inspection Phase

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Figure 2: A View of the Four Facility University Buildings.

Figure 2 provides a comprehensive perspective of the four Facility buildings that have been surveyed.

Findings On Common Defects

The facility buildings, all constructed on site, range in age from 16 to 28 years. Reinforced concrete frames combine concrete with steel reinforcement structure design with solid brick walls, probably on deep foundations and with solid ground floors. Two of the buildings feature entirely pitch roofs, whereas the other two have a combination of pitch and flat roofs. The subjects are primarily made up of aluminium frame design, which includes sliding sash and casement opening portions, for the windows and doors. Glazing typically consists of a single pane of clear transparent or tinted glass. The floors on both the ground and upper levels are mostly made of solid concrete, with a thickness of 150 mm. The floor covering typically consists of a cement screed and ceramic/mosaic tiles in all bathrooms. The study identified leaky roofs, rising dampness, water stain marks, rusting of steel structures and chipped and cracked tiles and finishes as the most frequent building defects. Possible causes of dampness-related building defects include:

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a) Roof Leakage. The causes and possibilities of roof leakage include age and wear.
b) Poor Installation. Inadequate placement of roofing materials, flashing, and sealants throughout the construction process can result in weaknesses that enable water to infiltrate the roof structure.
c) Defective roofing materials. The waterproofing capabilities of roofing materials, including membranes, shingles, or tiles (in the case of flat roofs), may be weakened by damage to them. Inadequate or damaged roofing, cracked tiles, or perforated membranes may serve as infiltration sources of water.
d) Clogged Gutters and Drains. Accumulated debris such as branches, leaves, or dirt in gutters and downspouts may block the movement of rain, resulting in water pooling on the roof. The stagnant water has the potential to penetrate the roofing components, leading to the occurrence of leaks.
e) Condensation: It occurs when there is inadequate ventilation or insulation in the roof voids, causing moisture to accumulate in the roof structure. Over a period, the presence of this moisture can contribute to the development of mould and the decay of wood, which might potentially result in the occurrence of leaks.
f) Rainwater Exposure: Inadequate slope or drainage systems on the stairs might lead to water pooling and potential moisture.
g) Corrosion of Handrails. Staircases situated in partially outdoor areas are susceptible to moisture from rainfall and humidity. Prolonged contact with water may cause corrosion processes, especially on metal handrails.
h) Presence of water or dampness on the floor and wall. Inadequate roof overhangs or eaves can result in direct rainwater splashing on external walls and nearby ground surfaces, leading to the pooling of water, and splashing onto floors near doors or openings.

The following section provides a concise overview of the discoveries on dampness-related issues that affect the durability of building structures:

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Roof Leakage

Figure 3 shows that water penetration was most common during rainfall periods. The roof leak occurred in the sports complex, library, and multipurpose building, resulting in water stain marks on the ceiling boards and walls. Poor installation or broken flashing around roof edges and valleys can lead to water ingress. The roof also broke down because of the extended dampness. It not only gives an unpleasant impression, but it may also endanger any person passing by the roof.

Figure 3: The Dampness Symptoms Caused by Roof Leakage.

Clogged Downpipe

Figure 4 illustrates how a clogged downpipe on the roof led to water intrusion, allowing rainfall to flood over the ceiling or soffit. This scenario occurs at Sport Complex, where during rainfall, water collects on the roof's surface and runs down via the gutters to the downpipe for drainage. Debris like leaves, twigs, or dirt clog the downpipe, obstructing the normal water flow. This obstacle prevents water from draining properly down the downpipe and away from the structure. As the downpipe becomes clogged, water accumulates in the gutters. With nowhere else to go, water may overflow over the gutter's surroundings or back up onto the roof.

Figure 4: The Dampness Symptom Due to Clogged Downpipes

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Condensation and Unwanted Plant Growth

Stain marks develop on the library's fascia boards. Poor ventilation and insulation in roof spaces can lead to condensation. Condensation can accumulate in roof spaces, causing moisture and perhaps encouraging mould growth. Continuous condensation on ceiling or soffit surfaces can lead to moisture accumulation over time. Moisture can seep into ceiling or soffit materials, making them moist. Unwanted plant or vegetation growth is another indicator of dampness in the library. Moisture accumulated on building surfaces as a result of rainfall, condensation, or insufficient drainage, providing an excellent habitat for plant growth. Moisture can accumulate in cracks or poorly ventilated areas, encouraging plant germination and growth. This is shown in Figure 5.

Figure 5: The Dampness And Vegetation Growth Symptom On Fascia Boards Due To Condensation Or High Moisture

Rainwater Exposure (Driving Rain)

Staircases are subject to rainfall, which can result in water standing on the steps or infiltrating through cracks and joints, as shown in figure 6. The wind's energy causes this form of rain to fall horizontally or at an angle rather than vertically. Because of its powerful nature, driving rain can have a considerable influence on buildings and outdoor spaces, posing many problems and dangers. It takes place at the Pusat Islam and Annex buildings.

Figure 6: The Standing Water and Mould Growth on Staircases

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Corrosion of Handrails

Figure 7 shows the deterioration of handrails due to corrosion. Staircases located in partially exposed areas are subject to dampness from rain and humidity. Extended exposure to water can lead to corrosion, particularly on metal handrails.

Figure 7: Corrosion of Handrails Due to Dampness

Strategies for Dampness Prevention and Control

As we aim to improve the lifespan, convenience, and eco-friendliness of university facility buildings, it is necessary to prioritize the solution to moisture problems. Dampness, which refers to high amounts of moisture in building materials and indoor spaces, presents considerable difficulties, including structural deterioration (Faqih, Zayed, and Soliman 2020) and adverse health effects (Wahab et al. 2015). This study investigates the common causes of dampness in university buildings. Therefore, this study explores effective methods to prevent and manage dampness, emphasizing proactive measures that managers or facility managers can implement to safeguard buildings against these problems. To effectively prevent moisture, a comprehensive approach must be taken, incorporating architectural design, building material selection, construction procedures, and continuous maintenance (Hauashdh et al. 2022). The study investigates a variety of solutions, including moisture-resistant building envelope design and the setup of ventilation systems and moisture management measures. By addressing moisture proactively and completely, stakeholders can reduce risks, improve building performance, and provide healthier indoor environments for inhabitants.

As described in the findings section, the issue of ceiling moisture caused by roof leakage must be resolved. Frequent roof inspections, prompt repairs, good maintenance (such as gutter cleaning and providing sufficient ventilation), and the use of high-quality roofing materials installed by skilled specialists are all necessary for preventing roof leaks (Morgado et al. 2017). Immediate repair of roof problems is essential for maintaining the building's structural integrity and preventing water damage and mould formation in interior areas.

The next discovery is the stain mark on the soffit and vegetation growth caused by condensation. To avoid condensation, ventilation systems such as ridge vents and soffit vents should be improved to promote air circulation and reduce moisture buildup (Haverinen-Shaughnessy et al. 2008). Unwanted vegetation growth on structures can gradually cause damage to the building materials. Periodically cleanse the surfaces of the structure, gutters, and roof areas to eliminate biological material and prevent the collection of moisture (Morgado et al. 2017).

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Furthermore, it is necessary to deal with the issue of stagnant water on the stairs and the presence of water stains on the walls. Implement an appropriate slope and drainage system to effectively divert water away from the stairs. Perform routine inspections and maintenance on drainage systems to avoid the accumulation of water (Au-Yong, Ali, and Chua 2016). For the next design, architects should ensure that the roof slope is appropriate to prevent rainwater from standing on the floor and splashing on the wall.

Another discovery is the degradation of railings caused by corrosion. Conduct regular inspections of handrails to detect any symptoms of corrosion and immediately act by cleaning, repairing, or replacing the affected portions. Universities can extend the lifespan of staircase handrails, assure user safety, and decrease maintenance costs by implementing proactive ways to safeguard and maintain them (Hauashdh et al. 2022), thereby mitigating damage caused by corrosion.

Conclusion

Based on a review of dampness-related concerns affecting university facility buildings, these issues present major threats to the structural integrity, aesthetics, and indoor air quality of these critical educational spaces. The study discovered that variables such as prolonged roof leaking, lack of maintenance, insufficient ventilation, poor design, and localised climate conditions all contribute to moisture accumulation, which leads to mould growth and material degradation. Furthermore, the study emphasised the need of proactive maintenance tactics and new building approaches in addressing moisture issues. Overcoming these difficulties needs a comprehensive approach that includes effective design, periodic inspections, and immediate repairs to ensure the longevity and functionality of university facility buildings in the face of increasing environmental demands.

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References

Agu, Henry Chikodili, and Henry Ajaelu. 2022. “Appraising the Unconventioal Exploitation of Construction Materials and Solid Minerals in Enugu North Local Government Area, Enugu State, Nigeria.” in *Enugu State University of Science & Technology, Agbani Faculty of Environmental Sciences (Fes)*, edited by D. E. Nnadi and D. C. E. D. C. Ezekezie.

Au-Yong, Cheong Peng, Azlan Shah Ali, and Shirley Jin Lin Chua. 2016. “Interval of Routine Maintenance and Maintenance Performance: A Literature Review.” *MATEC Web of Conferences* 66. doi: 10.1051/matecconf/20166600007.

Batty, W. J., P. W. O’Callaghan, and S. D. Probert. 1984. “Energy and Condensation Problems in Buildings.” *Applied Energy* 17(1):1–14. doi: 10.1016/0306-2619(84)90036-9.

Faqih, Faisal, Tarek Zayed, and Ehab Soliman. 2020. “Factors and Defects Analysis of Physical and Environmental Condition of Buildings.” *Journal of Building Pathology and Rehabilitation* 5(1). doi: 10.1007/s41024-020-00084-0.

International Journal of Innovation and Industrial Revolution
IJIREV
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DOI 10.35631/IJIREV.617010

Hamid, Yusof, Keith Alexander EuroFM, Keith Alexander, and David Baldry. 2010. "The Cause and Effects of Deferred Maintenance on Higher Education Buildings Usability View Project PhD Project: Innovation and Facilities Management View Project The Cause And Effects Of Deferred Maintenance on Higher Education Buildings." (January 2010):78–88.

Hauashdh, Ali, Junaidah Jailani, Ismail Abdul Rahman, and Najib Al-Fadhali. 2022. "Factors Affecting the Number of Building Defects and the Approaches to Reduce Their Negative Impacts in Malaysian Public Universities' Buildings." *Journal of Facilities Management* 20(2):145–71. doi: 10.1108/JFM-11-2020-0079.

Haverinen-Shaughnessy, Ulla, Anne Hyvärinen, Tuula Putus, and Aino Nevalainen. 2008. "Monitoring Success of Remediation: Seven Case Studies of Moisture and Mold Damaged Buildings." *The Science of the Total Environment* 399(1–3):19–27. doi: 10.1016/j.scitotenv.2008.03.033.

Johansson, Pernilla, Lukas Lång, Gunilla Bok, and Carl Magnus Capener. 2020. "Threshold Values for Mould Growth: Critical Moisture Level of 21 Different Building Materials." *E3S Web of Conferences* 172:1–6. doi: 10.1051/e3sconf/202017220002.

Lourenço, Paulo B., Eduarda Luso, and Manuela G. Almeida. 2006. "Defects and Moisture Problems in Buildings from Historical City Centres: A Case Study in Portugal." *Building and Environment* 41(2):223–34. doi: 10.1016/j.buildenv.2005.01.001.

Mattsson, Christian, Birgitta Nordquist, Dennis Johansson, Hans Bagge, and Petter Wallentén. 2024. "A Quantitative and Qualitative Literature Review of Water Damage in Buildings Occurring in Building Service Systems, Appliances and Wet Rooms." *Indoor and Built Environment* 0(0):1–17. doi: 10.1177/1420326X241248331.

Mendell, M. J., J. M. Macher, and K. Kumagai. 2018. "Measured Moisture in Buildings and Adverse Health Effects: A Review." *Indoor Air* 28(4).

Morgado, J., I. Flores-Colen, J. de Brito, and A. Silva. 2017. "Maintenance Planning of Pitched Roofs in Current Buildings." *Journal of Construction Engineering and Management* 143(7):05017010.

Wahab, S. N. A., and M. Y. Hamid. 2011. "A Review Factors Affecting Building Defects of Structural Steel Construction. Case Study: Student Accommodation in UiTM Perak." *Procedia Engineering* 20:174–79. doi: 10.1016/j.proeng.2011.11.153.

Wahab, Suriani Ngah Abdul, Nurul Izma Mohammed, Mohd Faris Khamidi, and Nazhatulzalkis Jamaluddin. 2015. "Qualitative Assessment of Mould Growth for Higher Education Library Building in Malaysia." *Procedia - Social and Behavioral Sciences* 170:252–61. doi: 10.1016/j.sbspro.2015.01.035.

Yacob, Syamilah, Azlan Shah Ali, and Cheong Peng Au-Yong. 2019. "Establishing Relationship Between Factors Affecting Building Defects and Building Condition." *Journal of Surveying, Construction & Property* 10(1):31–41. doi: 10.22452/jscp.vol10no1.3.