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An Introduction to Thermal Bridge Assessment and Mould Risk at Dampness Surface for Heritage Building

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Abstract. The dampness is a significant threat in the heritage building and a leading factors to the degradation and dilapidated building. The scientifically measured need to be implemented in mitigating such issues. Advance understanding of heritage building condition is a must in mitigating to prolong the building life cycle. The study purpose is to measure surface temperature, ambient temperature and relative humidity at the dampness point of the heritage building. The measurement calculation technically reveals the dew point temperature and indicates the prediction of thermal bridge and mould risk. In situ test conduct using natural infrared heat radiation to the same relevant surface. The preliminaries finding indicates the average temperature pattern at the surface in four (4) heritage building with nineteen (19) spot at (24.5-25.7)℃, dew point temperature (23.7-24.3)℃, ambient temperature (25.78-27.0)℃ and relative humidity (85.5-89.6)%. The preliminaries finding leads to the identification of no thermal bridge treat but with highly mould risk.

1. Introduction

A study on the threat of humidity on heritage buildings is still at a new level. Most reviews and research are made to touch on the mechanisms that cause the danger of building moisture. The building's dampness[1–3] and humidity[4] study focus only on identifying the location of the defects and recommending the conservation work without taking into account the current situation and surrounding areas. Therefore this study will pay particular attention to the dampness point and surrounding humidity in the affected building using the thermal and moisture approach. Thermal assessment[5,6] using thermal detector indexes namely surface temperature, dew point temperature, ambient temperature and relative humidity used to identifies actual moistures content in accessing material study.

2. Literature Reviews

2.1 Dampness

Generally, the dampness[2,7] refers to the situation where there is moisture in the air or on the surface of something. This situation will cause damage to the environment and surface of its building material in the building envelope. Parallel it will affect the building structure adversely and will create an unhygienic condition for the persons living in that building. Signs of rising damp can usually detect at the base of the masonry walls, where crumbling plaster and peeling paint are evident[8]. Generally, dampness caused by falling or rising damp, condensation, infiltration and leaking pipes or dysfunction of material or services in the building. The cause of dampness categories in five (5) significant pillars [9] namely;

1. Dampness emanates from the top(including parapet) of the building wall and penetrates or absorb into the wall.
2. Moisture by capillary action
3. Humidity by leaking pipes such as plumbing, sanitary and any others mechanical equipment in the building
4. Dampness trough condensation and vaporisation due to the internal activity such as cooking and temperature control
5. Dampness results in poor restoration and maintenance of the building.

Dampness in heritage building [2]leads to structural and mechanical damages, architecture defect, mould and fungus attacked that leads to the health issue and the worst lead to the building dysfunction. The technical approach to diagnosing [10] the affected location by formative visual assessment and scientific method such as using the moister meter. The moister meter with standard reading indicates the level of humidity in the compound, target surface and inside layer (mostly at the wall, column, beam and floor area).Dampness treatment [7,11] mechanism is crucial to avoid any retaliation damage and defect to the heritage building. Prediction and identification of the affected and potential location within the building components ensuring the minimum defect problems. [3,10,12] indicates that six (6) techniques used to treat walls or floor with rising damp by creating a physical or chemical barrier, creating a potential against the capillary potential, applying atmospheric drainage, applying a coating with controlled porosity, concealing the anomalies, and last but not list by ventilating the wall base. The detection of the accurate method of remediation is vital to make sure no repeated defects occur. All defected area caused by dampness prevent via accurate repair methods, compelling design and proper planned maintenance.

2.2 Ambient temperature

Ambient temperature defines technically as a surrounding temperature of the study material or object of study. In this case, it refers to the indoor and outdoor environmental temperature of the building. These measurements are essential for physical functions and longevity, particularly on extending material durability. Ambient temperature plays a vital role in human performance, material, chemical processes or any other activity where the temperature is a relevant factor.

2.3 Relative Humidity

The relative's humidity[13,14] provides the information on how intensive the air saturates water vapour. It is state as percentages of the maximum amount of water that the air can absorb. The maximum amount of water vapour depends on the temperature. The higher the temperature, the more amount of water vapour the air can consume. Too low humidity can lead to health impairment.

2.4 Thermal Bridge

A thermal bridge[15,16] is an object that undesirable transmit heat outwards on inwards. Therefore differing temperature from the rest of the wall as the surface temperature at the thermal bridge is lower than in the rest of the room.

The risk of the mould increases significantly at these locations point thermal bridge measurement base on a different temperature in the surface area, and ambient temperature indicates in table 2 below:

Table 1. Thermal bridge measurement indicators.

Coding	Deferent in temperature	Statement
Green	< 3.5	No thermal bridge present
Yellow	3.5 - 6.5	Possibility of thermal bridge in the measuring area. The insulation is maybe inadequate at this position
Red	> 6.5	There is a thermal bridge in the measuring area, indication of poor insulation

Source: Authors 2018

3. Methodology

3.1 Framework

The study is divided into two main stages namely the detection level of building defects associated with dampness and the second to take a temperature reading on the detected area of the fault. The visualisation approach is used to determine the associated sign.

Table 2. Instrument and specification.

	Tool	Specification
No 1	GIS 1000 C Infrared Thermal Detector.	Measurement range -40 °C up to 1000 °C Measuring accuracy of IR ±1.0 °C Optics (Ratio of measuring distance : measuring sp 50:1 : Resolution 0.1 °C : Measuring accuracy of relative humidity ± 2 % : Laser diode Laser class 2, 635 nm Frame buffer (number of images) > 200: Operating temperature -10 - 50 °C: Storage temperature -20 - 70 °C: Working range 0,1 - 5 m

Source: Authors 2018

After verification and list of marking is made and verified, the second stage of the study is carried out using the instrument of research, which is a thermal detector to obtain the temperature reading surrounding and within the mark area that exists on the signs of moisture. Table 2, above indicates the mitigating instrument in successions the study.

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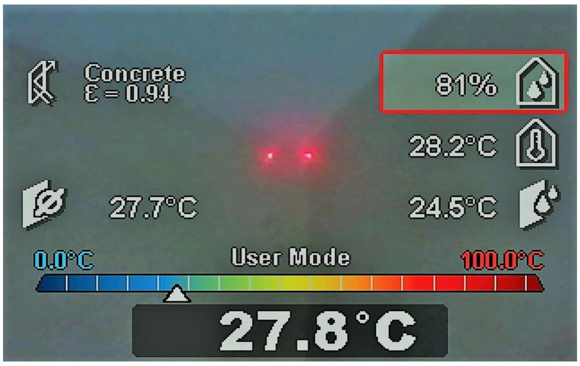

Figures 1: Reading sample output from marking surface

27.7°C : Surface Temperature (ST)

24.5°C :Dew Point Temperature (DPT)

28.2°C :Ambient Temperature (AT)

81% : Relative Humidity (RH)

Source: Authors 2018

Figures 1. above indicates a reading sample using thermal dictator in the specifically required spot for the assessment.

3.2 Limitation
This study has its limitation, especially which involves the privacy and confidentiality of the building. Therefore it only focuses specifically on the outside of the building that does not require the specific permission to carry out a study. Technically it does not touch the physical envelope and structure.

4. Analysis and Finding
The study divides into four main sections, namely building envelope with total dampness location with visualisation technic, calibration reading on surface temperature and humidity, thermal bridge detection and calibration pattern in surface temperature and relative humidity learning at the buildings studied.

4.1 Building Profiles
A total of eighty-eight (88) dampness locations were found in nine buildings as shown in table 3 below. The buildings surveyed are between ninety-nine (99) years to 368 years old and classifies as the heritage building under rules of laws in Heritage Act 2005 (Act xxx). Due to financial dan time limitation constrain the thermal assessment only conduct to four (4) heritage building namely Municipal Town Hall (B1), City Council Building (B3), Stadhuys Building (B4), and Immigration Office (B8).

Table 3. Building profiles and dampness point

	State	Building Ages	Building Component	Dampness point
B1.Municipal Town Hall	Penang	145	EW,CB	4
B2.Dato Jaafar Building	Johor	125	EW,CB,EFSA	11
B3.City Council	Penang	114	EW,CB, EFSA	5
B4.Stadhuys Building	Melaka	368	EW,CB, EFSA	4
B5.Pejabat Daerah dan Ukur, Seremban	N. Sembilan	168	R,EW,CB, EFSA	31
B6.Pejabat Kerajaan Kuala Lipis	Pahang	99	EW,CB, EFSA	7
B7.Larut District Building	Perak	162	R,EW,CB, EFSA	16
B8.Immigration Office	Penang	128	R,EW, EFSA	6
B9.Historical Union Building	Terengganu	109	R,EW,CB, EFSA	4

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Note: R: Roof, EW: External Wall, CB: Colum and Beam,
EFSA: External Floor, Stairs and apron

Source : Authors 2018

Due to time and financial constraint, four (4) building choose to access the study approach, namely Municipal Town Hall (B1), City Council (B3), Stadhuys Building (B4) and Immigration Office (B8).
4.2 Calibration Reading at building component. A total of 19 Calibration reading took from four (4) above mention building with four (4) typical indexes namely surface temperature, dew point temperature, ambient temperature and relative humidity.

Table 4. Summary of calibration.

	Surface Temperature (ST)	Dew Point Temperature (DPT)	Ambient Temperature (AT)	Relative Humidity (RH)(%)
B1.EW_{p1}	24.5	24.1	26.7	85
B1.EW_{p2}	24.8	23.6	25.6	89
B1.EW_{p3}	25.4	23.6	25.7	89
B1.CB_{p4}	24.5	23.5	25.3	89
B3.EW_{p1}	26.2	23.6	25.2	91
B3.EW_{p2}	24.8	24.0	25,4	92
B3.CB_{p3}	25.8	24.7	27.4	85
B3.CB_{p4}	25.9	23.8	25.4	90
B3.$EFSA_{p5}$	25.9	23.8	25.5	90
B4.EW_{p1}	24.2	24.9	27.5	86
B4.CB_{p2}	26.2	24.2	27.2	84
B4.$EFSA_{p3}$	25.8	24.1	26.9	85
B4.$EFSA_{p4}$	25.8	24.0	26.4	87
B8.EW_{p1}	26.2	24.0	26.2	88
B8.EW_{p2}	24.2	24.1	26.7	87
B8.EW_{p3}	24.6	23.6	25.9	86
B8.$EFSA_{p4}$	24.2	23.6	25.6	89
B8.$EFSA_{p5}$	24.0	23.6	25.8	88
B8.$EFSA_{p6}$	25.1	24.2	26.8	86

Note :R: Roof, EW: External Wall, CB: Colum and Beam,
EFSA: External Floor, Stairs and apron

Source: Authors 2018

4.2 Calibration pattern on each building

Table 5 revealed from four (4) building with nineteen (19) spot indicates that surface temperature is ranging between a minimum at 24.0°C to the maximum at 26.2°C. The dew point area slightly lower with a minimum at 23.5°C and maximum at 24.9°C. Followed by ambient temperature from 25.2°C to 27.5°C initiates the potential values in thermal bridge activity. Support by highly consistent relative humidity at minimum 85.% to 92°C. The measurement indicates hugely high humidity for the study area.

Table 5. Summary of calibration. By building overall

	Average Surface Temperature (AST)	Average Dew Point Temperature (ADPT)	Average Ambient Temperature (AAT)	Average Relative Humidity (ARH)(%)
B1.A_{p1-4}	24.8	23.7	25.81	88
B3. A_{p1-5}	25.72	23.98	25.78	89.6
B4. A_{p1-4}	25.5	24.3	27	85.5
B8. A_{p1-6}	24.72	23.85	26.17	87.33

Source: Authors 2018

4.3 Average calibration in each building

Table 6 revealed from four (4) building indicates that average surface temperature is ranging between a minimum at 24.8℃ and maximum at 25.72℃. Average dew point area slightly lower with a minimum at 23.7℃ and maximum at 24.3℃. Followed by average ambient temperature from 25.78℃ to 26.17℃ with highly consistent average relative humidity at minimum 85.5%. The calculation initiates the potential treat in thermal bridge activity.

4.4 Thermal Bridge Prediction

Scientifically thermal bridge exists in two (2) circumstances namely heat bridge and cold bridge. It is the situation whereby the component or area significantly has high values thermal conductivity compares to surrounding material, creating resistance for heat transfer. The case continually results in the reduction of thermal resistance to the object.

Table 6. Summary of Thermal Bridge Prediction

	Average Surface Temperature (AST)	Average Ambient Temperature (AAT)	Different temperature and colour coding	Average Relative Humidity (ARH)(%)
B1.A_{p1-4}	24.8	25.81	1.01: Green	88
B3. A_{p1-5}	25.72	25.78	0.05: Green	89.6
B4. A_{p1-4}	25.5	27	1.50: Green	85.5
B8. A_{p1-6}	24.72	26.17	1.45: Green	87.33

Source: Authors 2018

As for table 7, Overall the building studies indicate a small number of temperature differences between 0.05℃ to 1.5℃ and fall under the green zone. According to thermal bridge measurement indicators at table 1, the buildings are free from thermal bridge treat. Minor repair work suggestion to the spot in preventing the future severe damages to the place due to the constant pressure from relative humidity calibration reading at above 80%

4.5 Mould Risk Prediction

Mould risk assessment [17–19] relies on the humidity condition of the area. The result from relative humidity and average relative humidity indicates that all study area point is potential to a possible formation of the mould. Even though the building is free from thermal bridge treat but the humidity measurement indicates otherwise. The pressure overcomes by consistent measure at the required spot to monitor any dramatic changing in humidity calibration.

5. Concluding Remark

The research explains essential issues to look out for, and it should narrow down to undertake a precise analysis of a building's condition and, in particular, how moisture moves along the building fabric. The acknowledgement of thermal and moisture movement in building envelope technically will prolong the building life cycle by consistency in monitoring both thermal bridge and relative humidity calibration.

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