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Towards Safe Cities & Resilient Communities

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DIAGNOSIS ON DEFECT CAUSED BY HUMIDITY IN A UNIVERSITY'S ACCOMMODATION: A LITERATURE STUDY

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Abstract- In Malaysia, buildings are developed strictly according to the Malaysian Standard and the British Standard. However, due to improper maintenance performance, building issues have increased rapidly creating a concern among building users. Building issues such as defects are predominantly raised due to climatic characteristics, for instance, extreme weather, high heat and increased humidity exposure. Due to such issues, buildings are exposed to Building-Related Illness (BRI) which may affect the building users. The aim for this paper is to perform a preliminary work related to the diagnosis work for defect on humidity in university's accommodation in order to allow a proper remedial work towards a more sustainable university. The objectives are to identify the common defect related to humidity found at university accommodation, to diagnoses level of defect related to humidity found at university accommodation and to determine the suitable diagnosis for humidity's defect at the students' accommodation in university. University accommodations in Malaysia are chosen as the subject of research since these accommodations always have to face this issue. If humidity defects in students' accommodation are not treated accordingly, issues may arise on the numbers of occurrence for BRI for these accommodations.
Keywords – Defects, humidity, Building Related Illness (BRI) and university's accommodation.

1 INTRODUCTION

There are numerous challenges facing today's building, mainly due to defect which caused by the surrounding's environment. Building issues, such as defects, are increased due to climatic characteristics, for instance extreme weather, high heat and abundant humidity exposure. Due to such issues, buildings are exposed to Building-Related Illness(BRI),which may affect the comfort of the building users. Many examples of building issues have caused by surrounding's environment, for instance the prominent Malaysian cases of Highland Towers Apartment in Lembah Klang (Utusan Malaysia, 2013) and Sultan Mizan Stadium in Terengganu (Headlines online, 2009). Temperature variations, humidity occurrence and constant exposure on heat leads to many issues on the building structure (Othman, Jaafar, Harun, & Ibrahim, 2015) which allows defect to occur and eventually affect the buildings.

One of the major sources of defect comes from humidity. According to Othman et al., (2015), humidity is defined as the water-vapour content of the air. It is expressed in various ways. Normal atmospheric air in most of the cases is humid. Humid air is also called moist air. The capacity of air to hold moisture increases with temperature. Othman et. al., (2015) mentioned that dampnesscanbedefinedaswaterpenetrationthroughthewallsandcertainelementsofthebuilding where it is near to a water source. In addition, dampness can also be defined as extreme moisture that will lead to dampness problems, for instance rising damp (Othman, et al,2015).

Furthermore, moisture is also known as a main source to poor indoor air quality, unhealthy buildings and the growth of mould (Norback et al., 2013). There are many ways that moisture can enter the buildings such as rainwater penetrating through leaks in walls, floors, roofs, windows and doors (Norback et al., 2013).

Record shown billions of dollars have been spent to rectified defect due to moisture problems in the United States properties (Norback et al., 2013)and study done on 420 buildings in Sweden shows that moisture can cause vivid microbial growth within 65% of the buildings in that country (Vaisala, 2013). Compared to other western countries, Malaysia is heavily exposed to moisture problems due to its climatic characteristic, which lead to adverse effect on health, deteriorate the building faster and affect its functionality.

2 THE ISSUES

One of the concerns on controlling or mitigating defect on humidity is due to the issue of Building Related Illnesses (BRI). Building related illness (BRI), as described in UK/European terminology, isabuildingillnessrelatedsymptomsasitisreferredtointheUnitedStates, and has been described as 'a group of symptoms of unclear aetiology' (Sundin, 2012). Humans are constantly exposed to fungi, or moulds, usually without suffering harm to health. However, in some instances inhalation of sufficient numbers of mould spores can trigger symptoms of asthma, rhinitis or bronchitis (RICS, 2017). Respiratory ill health associated with the built environment is often referred to either as building related illness (BRI) (Healthy Building Science,2015). BRI most clearly recognized in the office environment. However, Healthy Building Science (2015),stated similar problems could occur and have been reported in academic buildings, hospitals or care homes. Figure 1 describes the symptoms of BRI that can occur due to humidity in the building.

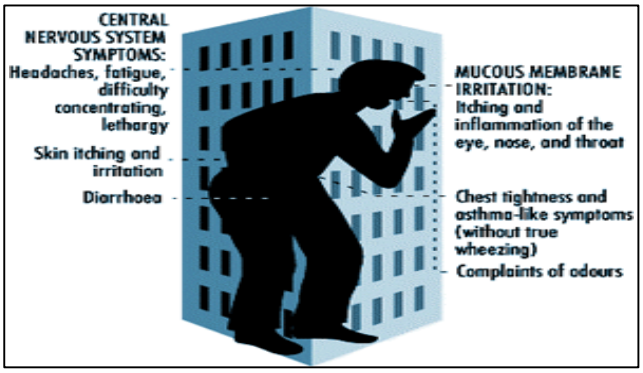

Figure 1 Symptoms of Building Related Illness (BRI) ("Sick Building Syndrome," 2011)

BRI also links to building leakage. Building leaks is a phenomenon of corrosion and material deterioration due to air infiltration and humidity (Kuan, 2017). It penetrates into the building and caused high dampness which links to defect. Defect on damp is generally divided into rising damp and lateral damp (RICS, 2017). Both defects involve a situation of extreme moisture that leaks into building (RICS, 2017). Defect diagnosis process involves the analysis of buildings construction to understand causes of failure or reduction in performance to enable formulation of appropriate repair measures (RICS, 2017).

This issue has occurred in many buildings, including students' accommodation of many universities. For university accommodation in Malaysia there are limited studies on identifying humidity-based defects for university accommodation. If there were diagnosis that can forecast the defect related to humidity for these buildings, building related illness issues can be prevented and building can be sustained for a long period of time.

The moisture problem that occurs at buildings usually takes place on the connection between the floor and the wall of a building. This situation can be seen in Figure 2. Theoccurrence of water seepage that is related to the improper waterproofing installation may lead to mould growth, flaking of paint and water stain (Luca, 2014). The affected area usually occurs on vinyl or carpet floorings.

One of the highest humidity areas in the building is the toilet. 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 outside as shown in Figure 2.

Figure 2 The building defects occur at building due to humidity

This situation can happen to all kind of buildings. For example, academic buildings vastly exposed to all sort of problems due to numerous main factors. Building defects are critical as they can physically affect the building appearance as well as damage the building structure (Hassan, Ismail,Isa,&Takim,2011).This can subsequently affect the safety of the building users. Therefore, appropriate solutions to mitigate building defects in academic buildings should be carried out in order to ensure the buildings do not easily fall into defects (Centersetal., 2017).If the defects were not taken seriously, it may consequently lead to structural failure. In brief, all parties such as local government authorities, the academic authorities, consultants, contractors and public should be involved in the remedial works and work together in order to diminish the occurrences of defects and failures in the academic buildings. They should have a close partnership to work mutually in order to form a strong and sustainable built environment in the academic buildings (Shuib and Baharum, 2015).

The similar situation could also occur in university's accommodation. This is why it is important to carry out this research in order to prioritize the defect diagnosis procedure in order to identify the humidity-based defect in the university's accommodation. At the moment, all kinds of defect are treated in a general way, without prioritisation on the defect procedures (Kuan, 2017). If there were mechanisms that allow defect to be diagnosed through priority process, every defect can be treated accordingly and efficiently.

3 LITERATURE REVIEW

Humidity-based defect can occur in any kind of building that have leakage. To study the context of building defects in Malaysia, there are several defects 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 historical building (Vaisala, 2013).

According to Hassan, Ismail, Isa and Takim, (2011), building defects occur because of design deficiency, or poor quality workmanship, or because the building was not built based on the original design, or because it follows the factors that do not fit with the design requirements. For any universities' accommodation, the common moisture problems in buildings that were identified by Othman et al., (2015) are; (1) rainwater or groundwater leaking in to the enclosure (roof, wall, windows and foundation), (2) plumbing leaks and spill, (3) water wicking from capillary suction through porous building materials (concrete or wood), (4) rainwater, condensation or plumbing water, (5) infiltration of warm or moist outside air, through cracks and holes in the enclosure during warm and humid weather, (6) exfiltration of

warm or moist indoor air through cracks and holes in the enclosure during cold weather, (7) unvented or poorly vented sources such as swimming pools, (8) insufficient dehumidification by heating, ventilating and air-conditioning systems, poor condensate drainage due to heating, ventilation and air-conditioning, system deficiency and (9) enclosure of wet materials in building during construction (Othman*et,al.*,2014).

Kuan (2017) argued that there are generalised condition of dampness associated with buildings, without considering the function of the buildings and proper prioritisation of remedies work order. Little information on the efficacy and impact of prevention strategies is available, perhaps in part because it is easier to study problems than their absence (RICS, 2017). Moreover, minimal practical knowledge acquired and applied by design, construction, and maintenance professionals has been committed to print or subject to validation; thus, this complicates the study and dissemination of best practices (HHS, NIOSH, & CDC, 2013).

3.1 Definition of Moisture and the Problems

Moisture problem can be defined as a situation of "any visible, measurable or perceived outcomecausedbyexcessmoistureindicationindoorclimateproblemsorproblemsofdurabilityin building assemblies that are caused by various leaks of water" (Vaisala, 2013). However, Vaisala (2013) 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. The issues of moisture are linked with humidity that has caused building defects and are mainly recognized by many scholars such as Othmanetal.,(2015);UnitedStatesEnvironmentalProtectionAgency(EPA)(2013). According to Halim, Harun, and Hamid (2012), moisture is known as a major cause of building defect by 76 percent and HH Setal. (2013) has identified that moisture caused 75-80 percent of building envelopes defects.

The main building moisture problems are caused by leakage at building elements such as roof, wall and ceiling. For instance, a study done by Edis, Flores-colen, and Brito (2014) identified that among 14 major defects at walls and floors are water leakages through cracks, water leakages through pipe penetration, and water leakages through joints. According to Edis et al.(2014) 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, Suffian (2013) identified that the flat roof leaky due to waterproofing that was not applied properly by the contractor (Suffian, 2013).

One of the common problems identified due to moisture is the occurrence of Building Related Illness (BRI). Building-related illness is defined as an illness in which a focus of the complaint is usually an office building or school, and not a residence or an industrial building (Healthy Building Science, 2015). Such illness, commonly encountered by family doctors, is an important societal concern, fuel led by media reports of the "sick building syndrome" ("Sick Building Syndrome," 2011). This latter term has been widely criticized as inappropriate, since it falsely suggests that buildings can be categorized as "sick" or "healthy" and diverts attention from a proper evaluation of the patient (Sundin, 2012).

Buildings are described as "sick" when the occupants are exposed to health hazards which in some way derive from the building. This may be because of poor design, poor management and maintenance, or the use of hazardous materials. There are many health problems which are building-related, but these are divided into two classes: reasons. First, no direct, single cause-and- effect mechanism will be evident. Rather the causes are multiple and cumulative and will vary between buildings. Secondly, psychological factors play a significant role in causation" ("Sick Building Syndrome,"2011).

According to Bahaudin et al., (2011), causes of building related illness are temperature, humidity, air movement and ventilation. In general, buildings with high BRI symptom rates, temperatures tend to be consistently higher than the recommended levels. The situation is worsened when the air temperature is

too high but there are low radiant temperatures. These situations create feelings of stuffiness and dryness. The humidification of buildings is a complex issue, since human perceptions of dryness relate to a number of environmental variables other than relative humidity levels.Theseinclude: high temperature, high levels of volatile organic chemicals (VOCs), highdust levels and air movement patterns (Bahaudin et al., 2011). Low relative humidity may be a result of outside weather conditions; alternatively, a building may, in some way, be reducing the relative humidity to levels which are causing health problems:

Building services systems may be inadvertently dehumidifying (reducing the relative humidity of) the air coming into the building. Chillers, for example, may be operating when they are not so designed because of a control problem and, in so doing, they will cool and dehumidify the air (Sundin, 2012).

The air change rate in the building may be high; whilst this has general air quality advantages, it will purge the building of the moisture derived from human occupation (perspiration and breathing); inturn, this will bring in outside air which may be of low relative humidity, thereby reducing the relative humidity within the building (Sundin,2012).

The health problems associated with low relative humidity are predominantly dry skin, dry eyes, and sore throats. In addition, it is possible, though not yet proven, that low relative humidity can increase the likelihood of infections. This is primarily because low humidity may reduce the mucus flow which leads to less adequate rejection of micro- organisms. It is also possible that dry air produces micro-fissures in the upper respiratory tract which act as landing-sites for micro- organisms. Air movement is the third major indoor climate variable. If it is too high this can cause sensations of dryness and create draughts. Alternatively, if air movement is too low there may be stuffiness and stale air may not be dispersed and removed from the occupied areas. Ventilation problems can have many causes (Jayamurugan, Kumaravel, Palanivelraja, & Chockalingam, 2013).

3.2 Types of Dampness

Type of dampness defect is divided into four (4) types. Firstly, due to the type of construction processes. Possible characteristics of construction processes are damp patches on walls, damp smell in newly built or renovated property and the cause of dampness is plaster or concrete slabs not properly dried out (Center et al, 2017).

Secondly is rising damp. Rising damp characteristics is based on the bands of dampness anddiscolorationongroundfloorwallsuptoaheightof18”–36” (Centersetal.,2017).The cause of rising damp is caused by defective or absent damp proof course (DPC). In addition, water logging of the surrounding ground due to inadequate drainage can impact on the rising damp (Centersetal., 2017).

Third dampness defect is penetrating damp. Penetrating damp characteristics is based on the patches of damp and/or mould e.g. in a corner of the ceiling, underneath the windowsill or on the walls. Windows and doors that don’t fit, holes in the roof, old or inadequate pointing to the brickwork, faulty joints in concrete slabs, blocked or leaking gutters are among the effect (Centers et al., 2017).

The fourth cause is condensation. It happens because warm moist air meets cooler wall surface or windows (Jayamurugan et al., 2013). Inadequate ventilation, insulation, heating and/or poor building design and the possible characteristics of condensation which occurs on windows, or puddles gathering on window sills. Mould and dampness, or even drops of water, all over occurs at an outside wall. It can affect bed clothes near that wall or the contents of cupboards (Shuib & Baharum, 2015). Below are examples of dampness:

(a) Rising Damp

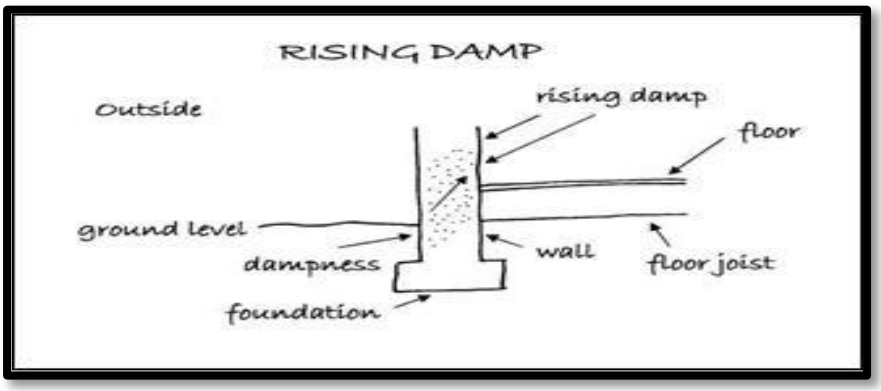

Figure 3 Rising damp (Property Care Association, 2013)

Figure 3 shows rising damp where water is literally drawn up by capillary action into the wall. Typically, although not exclusively, a brick wall will have rising damp to approximately a metre in height. Different types of construction, such as stone construction or where the property sits on a sloping site, may have slightly different readings, but in our experience generally rising damp rises to about a metre (Zhang, 2011).

(b) Lateral damp

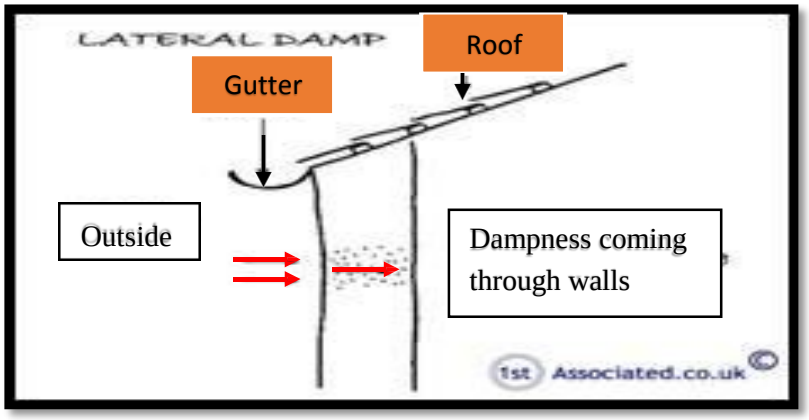

Figure 4 Lateral damp (Property Care Association, 2013)

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 condensation if it is at high level (Zhang, 2011).

(c) Cement pointing and dampness

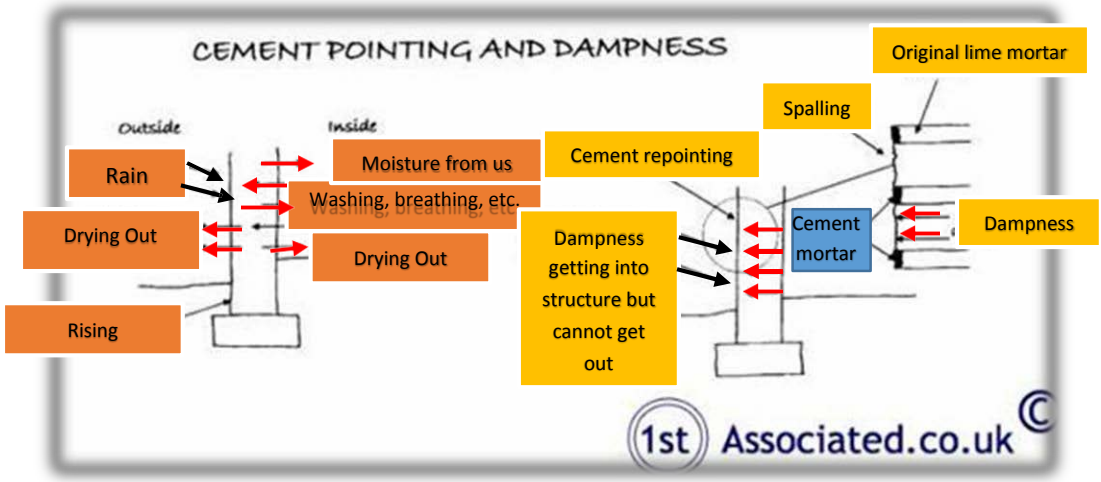

Figure 5 Cement pointing and dampness (Property Care Association, 2013).

One of the most common causes of this defect is repointing with a cement mortar where there was once a lime mortar. This does not only stop the walls from breathing it also causes deterioration to the face of the brick work or stone work. The suitable solution is a lime mortar, both to the pointing externally to the brickwork or stonework but also to the plaster internally together with a suitable emulsion based paint (Zhang, 2011)

4 CONCLUSION

This study will be beneficial to the parties involved such as developer, owner of building, occupants of building and maintenance department of the university. It will improve the idea to constructthebuildingandgetearlypreventionmeasurestoavoidanydefectsandalsotohelpbetter planning. For the owner of building, it will allow less maintenance on the building and get more knowledge about the defects and also alert with the defect of building. It also can help to improve the maintenance performance procedures of the maintenance department of the university by following the guideline in controlling the defect on humidity in university's accommodation.

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