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Prevalence Symptoms of Wall Dampness in Buildings within Jos Metropolis

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Abstract

Dampness revealed itself through visible symptom such as damped wall, presence of microbial growth, presence of efflorescence and presence of missing mortar e.t.c. The prevalence of the symptoms is damaging, may cause different health effects to the occupants and lead to costly refurbishments, if it is not perceived in time or when one is ignorance of it or lack of knowledge of it. Therefore, the study aimed at investigating the prevalence symptom of wall dampness in buildings within Jos metropolis. Jos is consisting of Jos North, South and East LG.C. Six clusters of Angwan Rukuba, Farin Gada, Tudun Wada, Bukuru, Rayfield and Lamingo area were selected from within the metropolis. Data were collected randomly through three hundred administered questionnaires, 50 in each cluster, while onsite building inspections in the six selected clusters were also conducted within Jos metropolis. Question as regards to the age of buildings were posed to the owner of a building. Relative humidity and temperature were measured and recorded. SPSS Statistics V26 was used to analyzed the data using percentage frequency of occurrence/response. The results show that there is presence of more damp height and microbial growth of 94.7 and 93.6% ; while there is presences of lesser efflorescence and missing mortar/plaster of 23.7 and 24.1% respectively. It is found that about 60% of the houses investigated have damping symptoms at various percentage frequencies. The study recommends detail investigation should be conducted to determine the leading cause of dampness within Jos metropolis.

Key words: *Water, SPSS statistics V26, Relative humidity, Temperature, Percentage Frequency.*

I. Introduction

Dampness in buildings is moisture that should not be present in a building. When the materials in a building become sufficiently damp to cause material damage or visible mold growth, it is often said that the building has a dampness problem or the building is characterized as a damp building (Burkinshaw & Parrett, 2004). Water plays a major role in the deterioration of masonry materials and often has a negative and devastating influence on buildings. The penetration of water is one of the most damaging defects that can occur in both old and modern constructions (Burkinshaw & Parrett, 2004; Hetreed, 2008). According to Hollis (2000), sources of dampness can be classified as rising dampness, penetrating dampness, condensation and pipe leakages. Rising dampness results from the capillary suction of moisture from the ground into porous masonry building materials (Halim & Halim, 2010 ; Ahmed & Abdul Rahman, 2010). Though rising damp is a problem common in older buildings, it is gradually becoming a common issue with modern types of buildings as well (Rirsch & Zhang, 2010). Penetration damp is the term applied to the penetration of moisture through the fabric of buildings over a period of time and is usually characterized by localized areas of damp or saturated wall/ceiling finishes (Latta, 2005; Oliver, 1988). The simultaneous occurrence of the presence of water, an opening through which water can enter and a physical force to move the water are the three main issues that underpin water penetration through a building enclosure (Beall, 2000). Condensation occurs when water in the air inside a building condenses on a cooler surface (Curtis, 2007). Severe mould growth which creates health hazards and damp patches on plastered walls in odd places are some of the symptoms associated with severe condensation (Burns, 2010). Moisture in buildings can cause deterioration of buildings by damaging brick/block work, cause decay and breaking up of mortar joints, fungal attack in timber and corrosion in iron and steel as well as stained wall surfaces internally and externally (Trotman, et al., 2004). Accumulation of moisture or dampness in buildings or components of a building leads to physical, biological or chemical deterioration of the building or its materials (Haverinen-Shaughnessy, 2007). Dampness is one of the most serious structural defects in walls of buildings and causes damages to both structural and building materials and reconstruction efforts can be enormous. In many instances, dampness in building may not be present all year round and, depending on the source, may only become evident after a change in weather conditions, usually during the colder or wetter months or after periods of heavy or extreme rainfall (Kalada & Janet, 2017). Damages to buildings caused by dampness pose serious risks to the performances of those buildings (Oliver, 1997). Of all defects associated with buildings, moisture or dampness is the most frequent and dangerous, and contributes more than 50% of all known building failures (Halim et al., 2012 ; Watts. Et al.,2001). Dampness encourages the formation of mold, and the consequent spread of mold and mites in conditions of high relative humidity is associated with ill health (WHO, 2009). Changes in the relative humidity of a location can cause efflorescence to occur. Surface efflorescence in walls is caused by rapid evaporation of water from wall surfaces leaving behind salt crystals. Cyclic wetting and drying brought about by seasonal changes is an important driver of salt attack or efflorescence in walls of buildings (Young, 2008). To deal effectively with the problem of dampness, an organized system of investigative procedures should be undertaken to confirm all the sources of dampness and to ensure that the recommended remedial works are appropriate . Such a system must begin with the identification and recognition of symptoms or signs associated with dampness. The selection of an effective remedy for any form of dampness must start with a correct diagnosis of the cause (Burkinshaw & Parrett, 2004). There are four major stages to any dampness investigation. These are visual investigations, non-destructive testing, destructive testing and laboratory assessment study (Halim et al., 2012 ; Burkinshaw & Parrett, 2004). In practice, however, surveyors do not firmly stick to these four stages. At times parts of a property exhibit symptoms of a dampness problem for which there is no obvious cause (Burkinshaw & Parrett, 2004). When this happens, the investigation may be intensified from stage 2 to stage 3 and sometimes from stage 3 to stage 4 as the surveyor seeks to identify the cause (Hamid & Ngah, 2010; Burkinshaw & Parrett, 2004). The first stage which is the visual investigation requires the surveyor to inspect the defect closely. It acts as a basis for further investigation and confirmation of the defect assessed (Halim et al., 2012 ; Burkinshaw & Parrett, 2004). During the stage two investigation, the moisture meter is the most widely used instrument for the diagnosis of dampness in buildings (Halim et al., 2012). The moisture meter is used to inspect materials or elements of construction in place without causing modifications, damages or destruction to the fabric of the building. The destructive testing stage, which is stage three offers a specific set of measurements or data in response to a known or suspected dampness conditions. This assessment requires the assembly of techniques that may be used to inspect or observe materials or elements of construction in place. It also involves causing modifications, damages or destruction to the fabric of the building. The tools and techniques used at this stage include drilling of samples (mortar, bricks/blocks), salt test, carbide meter, electronic-thermo hygrometer and mechanical hygrometer . The final stage may apply to a whole building or to the further investigation of a damp zone identified from a Stage two or three investigation (Halim et al., 2012 ; Burkinshaw & Parrett, 2004). During this stage, destructive tests and examinations that require opening up are conducted. More emphasis is placed on the sampling which aims at confirming moisture conditions within structural elements by drilling out masonry samples. The decision on where samples should be drilled depends on the purpose of the investigation conducted and prevailing site conditions (Burkinshaw & Parrett, 2004).

Although, it is the symptoms that indicate the presence of dampness problem in buildings. From previous study of Kofi et al., (2013), in their study of Preliminary Assessment of Dampness in Walls of Residential Buildings in Four Climatic Zones in Ghana. The results show that the four climatic zones in Ghana have the same dominant type of dampness and concluded that the most dominant type of dampness in the wall of buildings is rising dampness and it is usually associated with symptoms such as hygroscopic salts, moist timber skirting, damp base of wall e.t.c. Kofi & Joshua (2014), have conducted a study on Dampness in Walls of Residential Buildings: The Views of Building Construction Professionals in Ghana. Part of the conclusion drawn was that surface efflorescence just above skirting/floor(80.988%), stains especially in horizontal band(78.899%), dampness at the base of walls up to 1.5m in horizontal band(77.032%), softening and deterioration of plaster' and 'blistering(76.593%) and flaking of paint(75.935%) are the five main symptoms associated with dampness. John et al., (2017), have concluded from their study on Damp and Its Effects: Insights from Tal that Peeling of plaster and paint, mould growth, wetting of floors and walls and decay of skirting were the effects identified from the study. Also, Zakariyyah et al., (2020), have concluded from their study on Dampness Patterns in Halls of Residence in Lagos Metropolis: A case study of the University of Lagos that symptoms of the four dampness types are in existence in the four sampled halls of residence. Kalada & Janet (2017), have identified in their study on the Causes of dampness in residential building walls in Jos Metropolis, Plateau State, Nigeria: Emphasis on microbial concentrations, biodegradation and health hazards in Jos that about 80% of the houses investigated had damping defects at various degrees.

The effects of dampness are more pronounced in the developing countries as a result of a higher population of low-income earners whose homes are poorly constructed and maintained (Tham, 2007). These problems include symptoms such as dirty spots on the building, biological plants like the growth of fungi, mosses and creeping plants, paint flaking, blistering etc. (Halim et al., 2012). Nigeria as a developing country with Jos a capital city of plateau state has its own share of the effect of dampness. There is no or little works on symptoms of dampness within Jos metropolis. Few available literatures concentrated more on health hazard, considering the level of microbial growth on damp wall. Hence, there is the need to have a broader view of the symptoms of wall dampness, which may or may not reveal the symptoms of the four dampness types, to include measurement of damp height, presence of efflorescence, presence of missing mortar e.t.c. and some other factors such as measurement of building temperature, measurement of building humidity and knowledge about the age of buildings, which may influence the symptoms of wall dampness. Therefore, this study aims at investigating the prevalence symptom of wall dampness in buildings within Jos metropolis.

II. Materials and Method

A. Materials

The following are equipment used in carrying out the research work: Humidity Meters, Digital Thermometers, Measuring Tape, Note Pad, safety Boots, Questionnaires, SPSS Software, and Computer Set.

B. Method

Jos is the capital city of Plateau State in Nigeria. It falls within Nigeria's North-central geopolitical zone. Jos metropolis comprises Jos North, Jos South and Jos East Local Government Area (LGA). Three hundred (300) questionnaires including onsite inspection and measurement was adopted and used to generate data by the research team. Cluster sampling method was used and Jos metropolis which is the study area was divided into six (6) cluster of Angwan Rukuba, Farin Gada, Tundu Wada, Bukuru, Rayfied and Lamingo. The 300 questionnaires was divided evenly over the 6 clusters of 50 each. Data were collected randomly through onsite inspection, physical measurement and administered questionnaires in the six selected cluster within the Jos metropolis. Questions were posed to the respondent as regard to his/her age of building. And through the onsite inspection/measurements of affected area on the buildings as shown on plate 1-3, the following parameter were determined: wall damp height using measuring tape, missing mortar, microbial growth, and efflorescence. The outdoor/indoor temperature and relative humidity were measured using Humidity Meters and Digital Thermometers respectively. The data generated from the questionnaire, onsite inspection/measurement which consists of temperature and relative humidity, age of buildings, wall damp height, missing mortar, microbial growth and efflorescence was analysed. All analysis were done using SPSS Statistics V26 to determine their percentage frequency of response/occurrence.

Plate 1.0 Presence of dampness at the base of the building

Plate 2.0 Presence of efflorescence on the wall and peeling of mortar

Plate 3.0 Staff measuring the height of dampness and presence of mould growth

III. Results and Discussion

A. Results

The results of some factors associated with dampness and Symptoms of Wall Dampness are as shown below on Table 1 and Table 2:

Table 1. Summary results of some factors that influences the symptoms of Wall Dampness

Cluster (%)	**Relative Humidity** (%)	Percentage Frequency (%)	**Temperature** **(ºC)**	Percentage Frequency (%)	**Age of Buildings** (Years)	Percentage Frequency (%)	**Height of Dampness** (Meters)	Percentage Frequency
Bukuru	0-19	20	20-29	69	0-9	8	None	-
	20-39	78	30-39	31	10-19	44	0.1-0.5	18
	40-69	2			20-29	22	0.6-1.0	66
					30-39	10	1.1-1.5	16
					40-49	6	1.6-2.0	-
					50 and above	6		
Farin Gada	0-19	30.4	20-29	75	0-9	22	None	10
	20-39	69.6	30-39	25	10-19	42	0.1-0.5	22
	40-69	-			20-29	22	0.6-1.0	42
					30-39	8	1.1-1.5	16
					40-49	2	1.6-2.0	10
					50 and above	4		
Lamingo	0-19	26	20-29	78.3	0-9	12	None	6
	20-39	74	30-39	21.7	10-19	44	0.1-0.5	22
	40-69	-			20-29	28	0.6-1.0	48
					30-39	8	1.1-1.5	20
					40-49	8	1.6-2.0	4
					50 and above	-		
Rayfield	0-19	12	20-29	96.7	0-9	24	None	-
	20-39	88	30-39	4.3	10-19	34	0.1-0.5	16
	40-69	-			20-29	16	0.6-1.0	54
					30-39	10	1.1-1.5	24
					40-49	-	1.6-2.0	6
					50 and above	14		
Tudun Wada	0-19	-	20-29	84.1	0-9	14	None	8
	20-39	100	30-39	15.9	10-19	26	0.1-0.5	8
	40-69	-			20-29	22	0.6-1.0	64
					30-39	20	1.1-1.5	18
					40-49	14	1.6-2.0	2
					50 and above	4		
Ungwan Rukuba	0-19	36	20-29	89.1	0-9	8.5	None	16
	20-39	64	30-39	10.9	10-19	21.3	0.1-0.5	14
	40-69	-			20-29	8.5	0.6-1.0	32
					30-39	42.6	1.1-1.5	30
					40-49	32.8	1.6-2.0	8
					50 and above	6.4		

Table 2. Summary results of symptom of dampness in Jos metropolis

Presence of Microbial Growth (%)	**Presence of Efflorescence** (%)	**Presence of Missing Mortar** (%)	**Presence of damp height** (%)
93.6	23.7	24.1	94.7

B. Discussion of Results

Table 1 shows that the outdoor relative humidity, same as indoor, ranging between 0-19, 20-39 and 40-59% having one or two symptoms of wall dampness in Jos metropolis as shown in Table 2. And 20-39% gave the highest average percentage frequency of 78.93% as measured from buildings within the metropolis. Despite the highest percentage frequency of 20-39%, the relative humidity is low which may not be unconnected with proper ventilation of the buildings in the metropolis. According to Burns, (2010), warm moist air formed from cooking, washing, bathing or even by just breathing, condensing onto colder surfaces in the homes where the relative humidity is high and having poor ventilation. According to Dick, (1997), relative humidity which is the ratio of the absolute humidity to the saturated humidity at a given temperature, is temperature dependent being the larger the higher the temperature. Also, Table 1 shows that the outdoor temperature, same as indoor, ranging between 20-29 and 30-39^{o}c are having one or two symptoms of wall dampness in Jos metropolis as shown in Table 2. And 20-29^{o}c gave the higher percentage frequency of 82.03% while between 30-39 gave the lower percentage frequency of 18.13%, as measured from buildings within the metropolis. The low temperature range between 20-29^{o}c, within the metropolis at the time of this research work, having higher percentage frequency may not be unconnected, despite being in the tropic, with the time of the research conducted (January, mostly cold period) and unique climatic condition of Jos having alternate seasons of more cold than hot weather conditions. According to Australian Building Codes Board, ABCB.(2011), tropical climates typically have high outdoor temperatures combined with high relative humidity and this result in high outdoor vapour pressure. Further more, Table 1 shows that the age of building ranging between 0-9, 10-19, 20-29, 30-39, 40-49, greater than 50 and unknown years are having one or two symptoms of wall dampness in Jos metropolis as shown in Table 2. And 10-19 years gave the highest percentage frequency of 35.22% and this may not be unconnected to poor design, construction and supervision. It is also found that symptoms of dampness occurred in all ages of building, thus as mention by Kofi, et al., (2013); Zakariyyah, et al., (2020); Ishak, et al., (2013); Karagiannis, et al., (2017), that dampness problem occurred in both new and old building. Dampness penetration is one of the most damaging faults that can occur, whether a building is old or of a modern type of construction (Burkinshaw & Parrett, 2004; Hetreed, 2008). It can damage brick/block work by saturating it, cause decay and breake up of mortar joints, fungal attack in timber and corrosion in iron and steel as well as stained wall surfaces (Trotman, et al., (2004). More over, Table 1 shows that the damped height ranging between 0.1-0.5, 0.6-1.0, 1.1-1.5 and

1.6-2.0m are having one or two symptoms of wall dampness in Jos metropolis as shown in Table 2. And 0.6-1.0m has the highest percentage frequency of 51.0%.

Table 2 shows that the Microbial Growth, Efflorescence, Missing Mortar and damp height are some of the visible symptoms on wall of buildings within Jos metropolis. The presence of damp height(94.7%) and presence of Microbial Growth(93.6%) are greater than the non-presence of damp height and microbial growth of 5.4% and 6.4% respectively; while presence of missing mortar(24.1%) and efflorescence(23.7%) are less than non-presence of missing mortar and efflorescence of 75.9% and 76.3% respectively. These prevalence symptoms of dampness may not be unconnected to the existence of one of the four types of dampness. Kofi, et al., (2013), categorizes the primary sources of moisture into four types namely: penetration damp, pipe/plumbing leak, condensation and rising damp. In addition, there is higher percentage frequency of heights of dampness of 94.7% which means there is more wetting of the wall of buildings in Jos metropolis mostly at the base of buildings, evidently on plate 1. According to World Health Organisation, WHO (2009), damp surfaces encourage the formation of mold, and the consequent spread of mold and mites in conditions of high relative humidity is associated with ill health. Also, according to Nicol, (2006), it typically affects the mental health of dwelling occupants, causing depression and anxiety, particularly where there is damage to decoration from mold or damp staining. Also, there is higher percentage frequency of mould growth of 93.6% on the wall of buildings within Jos metropolis, as evident on plate 3. This may not be unconnected to the climatic condition or hygroscopic properties of building surfaces in Jos metropolis. According to U.S. Environmental Protection Agency.(1991), mould growth can occur when high relative humidity or the hygroscopic properties of building surfaces allow sufficient moisture to accumulate. Moreso, there is lower occurence of efflorescence of 23.7% on the wall of buildings within Jos metropolis. This may not be unconnected to less evaporation of water from the wall of buildings in Jos metropolis (plate 2.0). According to Young, (2008), Surface efflorescence in walls is caused by rapid evaporation of water from wall surfaces leaving behind salt crystals; cyclic wetting and drying brought about by seasonal changes is an important driver of salt attack or efflorescence in walls of buildings; and changes in the relative humidity of a location can cause efflorescence to occur. Moreover, there is lower occurrence of missing mortar/plaster of 24.1% on the wall of buildings within Jos metropolis (plate 2.0). This may not be unconnected to less expansion and shrinkage/contraction of mortar/plaster due to cyclic absorption and drying of moisture from the wall of building. According to Rishabh & Deepak, (2017), most of the building materials with pores in their structure in the form of intermolecular space expand on absorbing moisture and shrink on drying. These movements are cyclic in nature and are caused by increase or decrease in inter pore pressure with moisture changes. Initial shrinkage occurs in all building materials that are cement/lime based such as concrete, mortar, masonry and plasters. Overall, from the results it is found that 59.03% of the houses investigated have damping symptoms of various percentage frequencies.

IV. Conclusion

In conclusion, Microbial Growth, Efflorescence, Missing Mortar/plaster and damp height are some of the symptoms associated with dampness in buildings within Jos metropolis, which are having one or two of it's presence in each building. There is presence of more damp height and microbial growth of 94.7 and 93.6%; while there is presences of less efflorescence and missing mortar/plaster of 23.7 and 24.1% respectively. It is found that about 60% of the houses investigated had damping symptoms at various percentage frequencies..

V. Recommendations

The study recommends detail investigation, using moisture meter, surrounding soil testing and destructive testing, should be carry out in order to determine the leading cause of wall dampness within Jos metropolis.

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