LAUTECH Journal of Civil and Environmental Studies e-ISSN: 2714-3988
Volume 5, September, 2020 DOI: 10.36108/laujoces/0202/50(0180)

Dampness Patterns in Halls of Residence in Lagos Metropolis: A case study of the University of Lagos

*Zakariyyah, K. I., Soyingbe, A. A. and Adenekan, J. A.
Department of Building, Faculty of Environmental Sciences,
University of Lagos, Akoka-Yaba, Lagos, Nigeria

*Corresponding Author's Email: kzakriyyah@unilag.edu.ng, 08088136563

Abstract
Studies have established that comfort level, emotional balance, wellbeing and productivity are linked to the functionality of buildings. Functional buildings, however, require less energy for sustainability purposes. To achieve these advantages, there is a need to seek improvement in the existing stock of buildings or procure newer ones. Seeking improvement connotes reducing building defects/failures and improving occupant-comfort. Dampness plagues both new and old buildings and contributes more than 50% of building envelopes' defects, discomfort, or failure. This study, therefore, examined dampness in halls of residence in selected tertiary institutions in Lagos metropolis, using the University of Lagos as a case study. The objectives were to evaluate the incidence and causes of dampness in the halls of residence in the institution. As a preliminary assessment of dampness evaluation in halls of residence, the institution used is the University of Lagos, as a case study. This is selected based on its location and proximity. The study population consists of undergraduate and postgraduate halls of residence while the sample frame is undergraduate male hostels. The four undergraduate male hostels are taken as the sample size, using the census as the sampling technique. From the four male halls of residence; eighty rooms and two maintenance staff per block were selected using a purposive sampling technique. Analyses were done using mean, percentage, and relative importance index. The results revealed the presence of the four types of dampness, with dampness from leaking pipes as the most prevalent. The dampness originated from a combination of a host of factors, with those emanating from the negligence of maintenance culture and lack of materials/workmanship consideration as the top two causes. The study concluded that symptoms of the four dampness types are in existence in the four sampled halls of residence and the factors causing dampness are many and all-encompassing, but if the issue of maintenance and materials/workmanship are professionally handled, dampness will reduce, hence better comfort and building longevity can be guaranteed. The symptoms of buildings deterioration and defects can be minimised with ease of maintenance and through the use of professionals that are apt in the knowledge of materials and components inter-relationship. The study emphasised the significance of a healthy building and recommended that such should be procured with all hands-on deck and handled by the professionals in the built-environment.

Keywords: building, construction, dampness, deterioration, moisture.

Introduction
Buildings by composition are bound to retain a certain percentage of moisture. However, when this limit is exceeded, the comfort level is disrupted (Engvall, Norrby & Norbäck, 2001; Rirsch & Zhang, 2010; Wargocki &Wyon, 2013). Cheung, Fuller and Luther (2005) posit that damp penetration is one of the most serious defects in buildings. This is supported by Heseltine and Rosen's (2009) report that moisture is responsible for over 70 percent of defects in building envelope. According to Seeley (1987), aside from the deterioration of building structure, moisture results in damage to the façade and finishing with severe cases adversely affecting occupants. Sundell (2004) infers that a building system is a potent factor in determining indoor air quality.

This was buttressed by Agyekum, Ayarkwa, Koranteng, and Adinyira, (2013b) as well as Agyekum and Salgin, (2017) that dampness is one of the most severe causative agents of decay and deterioration of old, historic and modern buildings. In the US, the study of Fisk and Rosenfeld (1997) stresses that the characteristics of buildings and indoor environments significantly influence sick building symptoms and workers' performance. The study further establishes that as much as 0.75% of the gross national product (GNP) is lost due to dwindled productivity arising from sick leaves and absenteeism. In Europe, the World Health Organisation guideline (WHO, 2009) stresses that building standards and regulations concerning comfort and health do not sufficiently emphasise the requirements for preventing and controlling excess moisture and dampness.

While buildings in the developed and the developing nations experience dampness, 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, Zuraimi, Koh, Chew & Ooi, 2007). On this note, for improved wellbeing and productivity, emotional and psychosocial balance, dampness and its associated negative effects need to be combated headlong, especially in the tropical regions. This is the awareness this study sought to create. The objectives of the study are to assess the incidence and causes of dampness in the study area.

Dampness is the penetration of water through the elements of a building, wetting of structural elements through moisture rise by capillary action or excessive quantity of moisture contained in building materials/components (Agyekum, Ayakwa, Koranteng & Adinyira, 2013a; Wilkowska, 2017). An ample percentage of building structure or fabrics has deteriorated by the time wetness, dampness, or excessive moisture movements are perceived, visible or become measurable (Soldatova, Sansone, Stephens & Shah, 2011). A building is described as being affected by dampness when there is more moisture in the building than its water-retaining capability such that finishes are stained or discoloured and certain secondary elements are either upturned or lifted (Ishak, Che Ani, Akashah &Kayan, 2013). The primary sources of moisture in buildings according to Sulaiman and Beithou (2011) are liquid water from precipitation or plumbing leaks; water vapour from the building exterior or activities/processes within the building; liquid and vapour from the soil adjoining a building; and moisture built-in with the materials of construction or brought in with goods and people. Young (2007) and Agyekum *et al*. (2013), categorise the primary sources of moisture into four types namely: penetration damp, pipe/plumbing leak, condensation and rising damp.

Condensation is one of the most common forms of dampness in buildings, mainly caused by warm moist air originating from activities such as cooking, washing, bathing or even by just breathing and condensing onto colder surfaces in the homes. Condensation describes moisture formation on a surface as a result of moist air coming into contact with a surface that is at a lower temperature. Factors that contribute to condensation include high humidity of indoor air, low temperature of walls/surfaces and inadequate ventilation. Notable areas such as stair-halls/lobbies, stores, wardrobes/cupboards built against external walls and posterior view of furniture or pictures are prone to condensation due to poor-ventilation tendency which does not allow the walls to fully warm up (Agyekum *et al*, 2013; Karagiannis, Karoglou, Bakolas, Krokida & Moropoulou, 2017). Condensation can be detected with damp patches on outside plaster walls often appearing and disappearing regularly (Agyekum, *et al*., 2013). Excessive condensation frequently results in severe mould growth on walls, ceiling and underneath bay windows which can in turn create health hazards. More than three-quarters of dampness problems in the United Kingdom are due to condensation or man-made moisture (Mumovic, Ridley, Oreszczyn & Davies, 2006).

Straube, (2002) opines that a great amount of water can penetrate a building through defective plumbing components thereby resulting in dampness or moisture problems. For a leak to be effective there must be a presence of water, an active force to aid its transportation through the medium and sufficient time to transport the fluid. When this continues for a long time, a very small drip left unattended to progress into streams saturating building components (Ishak, *et al*. 2013). These problems occur when there is a disruption along with the network of pipes, fittings and appliances, presence of cracks or holes or spills through the openings of the wall (Ishak, *et al*., 2013). Leakages arise when joints are incorrectly made or fail; the pipe material corrodes or a failure of joints integrity due to acidic intrusion/introduction of a foreign object. Dampness due to leakages can also occur due to defective rainwater goods (Ishak *et al*. 2013; Laeirj, Spence & Laycock, 2013). Other sources of dampness due to plumbing works include failures in mains water pipes, heating systems, or foul water. Water seeping or flowing from pipes often results in dampness and damage to finishes which can be detected by staining and algal/fungal growth, localised stains and the presence of moisture that is unrelated to the weather (Trotman, Sanders & Harrison, 2004; Trotman, 2007; Gana, 2015).

Of all the causes of dampness, rising damp is considered the most challenging (Ahmad & Abdul Rahman, 2010; Ahzahar, Karim, Hassan & Eman, 2011). Rising damp occurs when the water rises upwards through the pores of masonries, cracks in buildings, or the floors of buildings, with the water being sourced from the ground, through the pores of masonries or cracks through a process known as capillary suction or capillarity. Capillary suction becomes stronger as the pore size gets smaller; if the pore size is fine enough; damp may rise many inches in a wall until the upward suction is balanced by the downward pull of gravity (Timusk, 2008; Halim & Halim, 2010; Burkinshaw 2010; Agyekum et. al, 2017). The height to which water will rise in a wall is limited by the rate of evaporation of water from the wall surfaces. This rate of evaporation, however, is related to the nature of the masonry materials, surface coatings, climate and wall orientation (Timusk, 2008; Rirsch & Zhang, 2010). With an advanced stage of rising damp, salt deposits become inevitable. As the presence of salts in building components affected by rising damp is not always feasible to a casual observer, thus with a minor height or symptoms of rising damp, substantial damage would have been caused to mortar, blocks and so on as the salts dissolve or disintegrate (Ahmed & Rahman, 2010; Halim & Halim, 2010).

Ground moisture problems are related to the entry of groundwater into a building from drainages below ground surface or standing water. Moisture may enter via upward movement through the bases of walls or floors (Tismuk, 2008). Rising damp differs from groundwater in the sense that rising damp rises through capillary action while groundwater does not depend on capillarity (Trotman, Sanders & Harrison, 2004). Water penetration through a building enclosure depends on the simultaneous occurrence of three things: the presence of water; an opening through which water can enter and a physical force to move the water. This is however influenced by gravity, air currents, capillary suction, surface tension, kinetic energy, air pressure and hydrostatic pressure (Tismuk, 2008; Seller, 2017). Penetration dampness takes place when the forces enumerated re-direct moisture in form of drips from air conditioning, overflows from overhead tanks, rainwater, pipe leakages, or water from other sources in horizontal directions (Agyekum *et al*., (2013a; Laeirj, Spence & Laycock, 2013). Dampness from horizontal penetration produces small localised patches of dampness and decay, whereas rising dampness may affect the base of a whole building. Prolonged dampness is injurious to buildings and the occupants as excessive dampness lead to the growth of microbes such as fungi and bacteria that act as agents of degradation which eventually leads to health problems (Trotman *et al*., 2004; Mumovic, Ridley, Oreszczyn & Davies, 2006; Tham, Zuraimi, Koh, Chew & Ooi, 2007; Kportufe, 2015).

While water molecules are present in the air and absorbed by materials within all buildings, when the materials become sufficiently damp to cause material damage or visible mould growth, such a building is said to have an excess moisture or dampness problem or characterised as a damp building (Burkinsahw, 2010; Becher, Hoei, Bakke, Holos & Ovrevik, 2017). Dampness is the most frequent and main problem in both old and new buildings, contributing more than 50% of all known building defects and failures (Agyekum *et al*., 2013, Ishak *et al*, 2013; Karagiannis, Karoglou, Bakola, Krokida & Moropoulou, 2017). The composite nature of different materials used in the construction of buildings coupled with the forms of construction gives buildings varying performance characteristics (Agyekum &Ayarkwa, 2014). A larger percentage of these materials are porous with the pores filled with air (air pockets), thereby making it possible for water in the form of rain and condensation of air humidity to penetrate through capillary rise causing several physical, chemical and biological problems to buildings (Karagiannis., *et al*, 2017; Seller, 2017). The air pockets are connected through a network of pores; thus, the liquid can pass through the material. The movement of water through these pores (often referred to as capillaries) depends on how hydrophilic (wettable) a surface is, how small or minute the capillary is and the adhesion forces between water and capillary surfaces (Seller, 2017). Thus, water (in the liquid form) rises into the internal structure of a building via the pores due to the tiny nature of the pores and the strong affinity of water to the force of capillarity (Timusk, 2008; Agyekum &Ayarkwa, 2014).

For water in the form of vapour, with humid air on one side of a porous material (such as timber, concrete or plasterboard), water vapour will find its way into the pores. For a hydrophilic material, water sticks to its surface, while a hygroscopic material pulls water out of the air (Timusk, 2008). As most of the conventional materials for the construction of masonry walls are porous to some extent, the more the resistance of the materials to the movement of water and vapour, the more the durability of the component. The general term for describing the difficulty or ease of flow of a liquid through a porous substrate is the permeability. Thus, to reduce dampness, the sorptivity (that is the transport of liquids in porous solids due to surface tension acting in the pores), its porosity and permeability should be understood (Shah & Pitroda, 2013; Yang, Gao, Zhang, Tang & Li,2019).

Despite the importance of water to living, water or moisture resulting in dampness poses a great danger because the water is 'no longer in the free state'. Thus issues such as attack on decoration, building fabrics deterioration, loss of paint adhesion/discolouration of paint/blistering of wallpaper, stains on wall surfaces, dark/yellow-brown patches, loss of plaster, wrot/removal of skirting, cracks, attack of reinforcement, mould and algal growth and unpleasant odour inside the home become evident (Norbäck, Wieslander, Nordström &Wålinder, 2000; Mumovic, Ridley, Oreszczyn & Davies, 2006; Rostron, 2008; Saijo *et al*, 2009; Sauni *et al*, 2013). Consequently, thermal insulation property of building materials and structural integrity becomes undermined thereby leading to an adverse effect on the environmental microclimatic conditions of the buildings with discomfort to the occupants (Trotman, Sanders & Harrison, 2004; Agyekum, *et al.,* 2014; Shah & Pitroda, 2013; Yang, *et al.*, 2019; Kportufe 2015). The study of Olanrewaju, Owolabi & Anifowose (2015) in Nigeria highlight rising dampness in foundation substructure and leaking roofs as the prevalent dampness in the study area. In a related study, Othman, *et al*. (2015) identified fourteen major defects at walls and floor levels originating from water leakages through cracks, through pipe penetration and joints. These are indications that dampness deserves further attention theoretically and practically. Theoretically, it has been established that dampness is a widespread problem that is associated with most types of buildings. Based on the composition of buildings, therefore, there is a need to establish how dampness and its resulted challenges can be minimised to improve the functionality of structures.

Materials and Methods

This study aimed at investigating the prevalent sources of dampness in halls of residence in tertiary institutions in Lagos Metropolis using the University of Lagos as a case study. This is part of a preliminary study to investigating dampness sources, occurrences and implications in halls of residence of tertiary institutions in Lagos state. The assessment of dampness comprises a 4-tier process of visual inspection, investigation using a moisture meter, a more detailed investigation and finally laboratory assessment studies. In his study, the first stage of the 4-tier dampness diagnosis assessment tool, which is a visual observation, is reported. This entailed a survey investigation of selected buildings in the study area, with the aid of a checklist of symptoms that are instrumental in categorising dampness types. The checklist was drawn based on the characteristics of each dampness type collated from the literature. The population was undergraduate and postgraduate halls of residence in the College of Medicine, University of Lagos, Idi-Araba Campus. The sampling frame that comprises the four male hostels is taken as a whole as the sample. Each of the four male hostels has four floors; however, five rooms per floor were purposively selected for observations. The sample size for the rooms thus becomes 80. As the first stage of dampness assessment involved visual observation of the halls, to assess the symptoms or signs of dampness which were used in categorizing the dampness type. A checklist of a minimum of four dampness indicators was developed for each source of dampness; namely condensation, penetration damp, pipe leakage and rising damp. These indicators were graded on a scale of '1-3'ranging from '1' for nil to '2' for moderate and '3' for severe. Two (2) trained research assistants inspected the halls. The indexes for the halls were then computed using an Excel sheet. This was done to reveal the prevalent sources of dampness based on the mean score of the indicators. The indexes for the halls were then computed using an Excel sheet. The scale used for the indexes was 0-0.9 for indicators that were not visible/present, 1.0-1.99 for moderate indicators while 2.0-2.99 was for severe indicators. The computation was done based on an average score of 1.50 which is the mid-way of the Likert scale adopted corresponding to 'moderate' symptom. Frequency count and percentages were also computed.

The second part of the assessment involved getting the view of the students and the hostel maintenance staff on what constituted dampness. Two sets of questionnaires per room were administered on the students in each identified room for their opinions on factors that were responsible for dampness in the halls. For the hostel maintenance staff, two members were selected per hall of residence. The respondents were requested to assess the relative importance of each of the listed causes on a 5-point Likert scale ranging from '1' denoting not at all important to '5' denoting extremely important. The relative importance index (RII) of the causes was computed as $RII = \Sigma W / (A*N)$**,** Where, W is the weighting given to each cause by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case) and N is the total number of respondents. The higher the value of RII, the more important was the cause of dampness.

Results and Discussion

Incidence of dampness in halls of residence

The first objective of this study was to assess the incidence of dampness resulting from primary sources of moisture in the hall of residence in Lagos Metropolis. To achieve this objective, four (4) sources of dampness and their symptoms as identified from previous studies were listed. This objective was achieved through the checklist provided and summarised as presented in Table 1.

Table 1: Frequency of Occurrence of Dampness in Halls of Residence

Dampness Type/ Indicators	Mean	Sum	1(Nil)	2(Mod)	3(Sev)
Plumbing					
Loosening of tiles in bathrooms, kitchen and laundry	2.82	31	0	2	9
Uplifting of components	2.55	28	0	5	6
Stand-alone patches around ducts, pipes/air-conditioners	2.18	24	1	7	3
Pool of water/Constant flooding	1.91	21	2	8	1
Localised stains	1.45	16	7	3	1
Condensation					
Water vapour/mist/condensation drips at window	2.36	26	0	7	4
Wet spot behind furniture	1.91	21	3	6	2
Presence of cold surfaces to external walls	1.82	20	5	3	3
Moisture/mist at floor-to-floor junction	1.82	20	4	5	2
Misty odour in building space	1.55	17	6	4	1
Penetration Damp					
Moss/vegetation growth at roof	2.45	27	1	4	6
Defective roof components	1.91	21	2	8	1
Mould growth at wall beneath roof	1.55	17	6	4	1
Defective cladding details/cracked or detached rendering	1.55	17	5	6	0
Paint discolouration below the roof	1.55	17	6	4	1
Rising Damp					
Pronounced defect at plinth level	1.91	21	2	8	1
Uneven horizontal line at lower level	1.55	17	6	4	1
Discolouration/darkening/patchiness below walls	1.55	17	5	6	0
Falling off /deterioration of skirting, tiles, etc at plinth level	1.55	17	6	4	1

Visual indicators grade: ‘1’ for nil ‘2’ for moderate and ‘3’ for severe; Index: 0-0.9 for indicators that are not visible, 1.0-1.99 for moderate indicators and 2.0-2.99 for severe indicators

The results of the frequency of occurrence of dampness for the four halls based on the scale used are as presented in Table 1. For the symptoms of a pipe leak, the indicators such as uplifting of components like floor and wall tiles in the washrooms, kitchen and laundry as well as stand-alone patches around ducts are above the range of 2.18 and 2.88, indicating that the symptoms are severe. As for condensation, water vapour/mist has an index of 2.36 which also implies that the symptom is severe. This is also the case with penetration damp, whereby moss/vegetation growth reveals severe symptoms. For rising damp, none of the indicators has a severe symptom. These results showed that the most frequently occurring dampness in the hostels is a result of factors that are related to plumbing issues which are followed closely by condensation and penetration damp. This finding is not in agreement with Asamoah, Ankrah, Bannor and Ofei-nyako (2017) study, where the most prominent moisture problems in buildings are through condensation. The result, however, seeks support in the study of Cedeño-Laurent *et al*., (2018) and Agyekum, Salgin and Danso

(2017), that emphasize the health- ignorance of those that live in damp houses. The summary of dampness incidence for the four halls is as presented in Table 2.

Table 2: Summary of Frequency of Occurrence of Dampness in The Halls of Residence

Dampness Types/Halls	Hall1	Hall 2	Hall 3	Hall 4
Pipe/Plumbing leak **(47.5)**	18	21	20	20
Sum 42	43.0	50.0	48.0	48.0
Condensation **(41.08)**	15	19	18	17
Sum 42	35.7	45.2	42.9	40.5
Penetration Damp **(35.45)**	**8**	**9**	**9**	**8**
Sum 24	33.3	37.5	37.5	33.5
Rising Damp **(23.73)**	**15**	**14**	**14**	**14**
Sum 60	25.0	23.3	23.3	23.3
Total	**56**	**63**	**61**	**59**

Visual indicators grade: '1' for nil, '2' for moderate and '3' for severe.

The summary of the frequency of occurrence of dampness for the four halls of residence is presented in Table 2. For pipe/plumbing leak, the index for the symptoms based on the scale used is 18 for Hall 1, 21 for Hall 2, and 20 for Hall 3 and Hall 4. For penetration damp and other forms of dampness, the values for the four halls are as presented in Table 2. Pipe leakage (as characterized by indicators such as softening, crumbling and deterioration of plaster/painting, uplifting of wall components, patches etc.) has the highest frequency of occurrence with a mean percentage of 47.5. This is followed by condensation (with symptoms like water vapour/mist/condensation drips at window levels, misty odour, wet spot behind furniture, etc) and penetration damp (defective cladding details/cracked or detached rendering, defective roof components, moss/vegetation growth) with 41.08 and 35.45 percent respectively. Rising damp has the least frequency of occurrence at 23.73 percent. It is not surprising that rising damp is high in halls of residence on Idi-Araba campus. This is so because Idi-Araba area is always flooded during the rainy season thereby resulting in a high-water table. In overall, the incidence of dampness in the four halls of residence surveyed is noticeable, Further test thus need to be conducted on the moisture content and the relative humidity to know the extent of the wetness and the associated damage.

Prevalent causes of dampness in halls of residence

Based on an extensive review of the literature, some prevailing causes of dampness were selected. The respondents (students in the halls and maintenance staff) were asked to assess the relative importance of each of the listed causes of dampness. The result is presented in Table 3.

Table 3: Prevalent Causes of Dampness in Buildings

Causes of dampness	MS	SD	RII	Ranking
Maintenance culture	**4.18**			
Low budg*et al*location to dampness works	4.43	0.912	0.886	1
Low response to works requiring maintenance	4.21	1.091	0.842	2
Quality of maintenance materials	4.21	1.091	0.842	2
Quality of maintenance workmanship	4.21	1.091	0.842	2
Blocked roof gutter pipes	3.86	1.519	0.772	5

Materials and Workmanship	**4.10**			
Choice of construction methods	4.36	.903	0.872	1
Workmanship/supervision quality	4.29	.889	0.858	2
Choice of material	4.29	.889	0.858	2
Design consideration	4.14	0.923	0.828	4
Choice of drainage system	3.86	1.197	0.772	5
Weather and climate considerations	3.67	1.354	0.734	6
Water penetration/ingress	**3.90**			
Water seepage due to poor material selection	4.43	0.912	0.886	1
Leakages from roofs, faulty pipe-works, air-conditioners	3.64	1.600	0.728	2
Driving rain	3.64	1.600	0.728	2
Raised ground level	**3.83**			
Inadequate slope	4.21	1.091	0.842	1
Sloppy site towards building	3.86	0.999	0.772	2
High water table	3.43	1.412	0.686	3
Habit	**3.68**			
Excessive usage of facilities without adequate maintenance	4.14	1.135	0.828	1
Clogged floor drains	4.00	1.206	0.800	2
Usage pattern	3.43	1.412	0.686	3
Presence of vegetation around building	3.14	1.519	0.628	4

SD=Standard Deviation, MS=Mean Score, N=80 ,1.00-1.49 for 1 (not at all important); 1.50-2.49 for 2 (slightly important); 2.50-3.49 for 3(moderately important); 3.50-4.49 for 4(very important,) and 4.50- 5.00 for 5 (extremely important)

The results in Table 3 reveal that apart from the last two factors (usage pattern and vegetation around buildings) that have 3.43 and 3.14 respectively, all other factors have mean scores higher than 3.50 which corresponds to very important on the scale adopted. This is an indication that the respondents agreed with all the factors as causes of dampness in the halls of residence. A cursory look shows that causes such as low budgeted allocation to maintenance works, the response rate for the maintenance department and the quality of materials/workmanship used in maintenance works are topmost on the list of causes of dampness. These corroborate the fact that as building stock ages, a significant level of maintenance is required for a healthy environment and preservation of the economic value of the buildings (Magutu & Kamweru, 2015). The choice of construction methods, workmanship and supervision are topmost under the materials and workmanship factor. These are precursors to the need for construction to be handled by those that are conversant with the real need for shelter which is to protect the occupants from weather elements while providing comfort. Sub-factors such as the means through which water gets into the halls, the gradient of the ground and habit also have higher values. In all, maintenance and materials/workmanship took the lead. These are indications that the factors leading to dampness are multilevel, interwoven and all-encompassing.

Conclusion

This is a preliminary study evaluating dampness patterns in halls of residence in selected tertiary institutions in Lagos Metropolis, with the University of Lagos as a case study. The findings indicate that the four halls observed showed the presence of the four types of dampness varying conditions. A percentage of over 20 revealed that the four halls are affected in one way or the other by dampness. Though, the symptoms of pipe leak and condensation are more severe while those of rising damp is mild, a linkage can be traced from the interrelationships among the symptoms. For instance, constant flooding will lead to condensation and mould growth, especially when the rate of evaporation is poor. The values of the frequency imply a relationship

or interconnectivity of the dampness problems. Excessive pipe leaks will result in condensation while continuous water from rain penetration and the constant pool of water will lead to water traveling through pores in the walling materials. Blistering of paint, mould signs in obscure spaces, water stains/patches on walls, uplifting of components, crumbling of mortar are already evident, which are typical problems associated with excessive moisture (Galvin, 2010; Franzoni, 2014). Therefore, there is a need for further investigation through other means of dampness assessment to be able to curtail their effect on the halls of residence.
Although, the causes of dampness reveal a host of factors that are related, causes originating from lack of maintenance culture and lack of adequate considerations for materials/workmanship are topmost on the list. Therefore, it can be inferred that most of the dampness problems in the halls are linked to plumbing issues that might have originated from untimely response to faults as well as the use of substandard materials, workmanship or negligence on the part of the users. This is further corroborated through observations that revealed most of the rooms that are seriously affected by damp are the rooms close to the washing areas or kitchen or launderette. In conclusion:

i. all the four dampness types are present in the halls with pipe/plumbing leak and its associated indicators such as the lifting of components, dark patches, clogged drains and dripping pipes taking the lead,

ii. negligence on maintenance and the quality of materials/workmanship are the major causes.

This study provided an insight for the occupants of the halls on the significance of dampness and the need to curb it. On the part of the maintenance section, once the problems or symptoms of dampness are known; efforts will be made on what is required for it to be rectified or nib it in the bud, especially at the initial stage or preliminary stage, when it has not gone out of hand. This study, for the professionals, implies that with the knowledge of dampness, soil terrain, usage pattern and properties of materials; functional halls of residence will be procured.

Based on the foregoing, recommendations are made on:

i. the erection and maintenance of functional and sustainable buildings as *a sine qua non* to wellbeing and productivity. This should be attained with all hands-on deck towards the erection and maintenance of buildings that will not be sick but stand the test of time,
ii. The need to make our buildings and spaces healthy and liveable, this should start with education and awareness of the need to engage professionals in the built environment and remodelling of users' behaviour.

References

Agyekum, K., Ayarkwa, J., Koranteng, C. and Adinyira, E. (2013a), "Preliminary assessment of dampness in walls of residential buildings in four climatic zones in Ghana", *Journal of Sustainable Development*, 6, 51-61.

Agyekum, K., Ayarkwa, J., Koranteng, C. and Adinyira E. (2013b). An overview of the symptoms associated with dampness in walls of residential buildings in major towns in Ghana. *Civil and Environmental Research*, *3*(9), 1–9. https://doi.org/10.5539/jsd.v6n9p51

Agyekum, K., Salgin, B. and Danso, A. K. (2017). Creating awareness on the negative impact of dampness on the health of occupants: A case for inhabitants living in damp buildings in Ghana. *International Journal of Development and Sustainability, 6(8),* 1-18

Agyekum, K. and Salgin, B. (2017). Diagnosing rising damp in residential buildings: Lessons from three cases. *Annals of the Faculty of Engineering Hunedoara*, *15*(3), 159-168.

Agyekum, K. and Ayarkwa, J. (2014). Diagnosing rising damp in the walls of a six-bedroom residential apartment in Kumasi, Ghana. *International Journal of Development and*

Sustainability, *3*(5), 1174–1198.

Agyekum, K.,and Ayarkwa, J. (2014). Dampness in walls of residential buildings: The views of building construction professionals in Ghana. *Africa Developmentand Resources Research Institute (ADRRI) Journal ADRRI Journal (Www.adrri.org)*, *7*(772), 2343–6662. Retrieved from http://www.journals.adrri.org/

Ahmad, A. G. and Abdul-Rahman, H. F. A. (2010). Treatment of salt attack and rising damp in heritage buildings in Penang, Malaysia. *Journal of Construction in Developing Countries*, *15*(1), 93-113.

Ahzahar, N., Karim, N. A., Hassan, S. H. andEman, J. (2011). A study of contribution factors to building failures and defects in construction industry. *Procedia Engineering*, *20*, 249-255.

Asamoah, R., Ankrah, S. J., Bannor, P. J. And Ofei-Nyako, K. (2017). Construction practices contributing to rising damp in Kumasi Metropolitan and Ejisu Municipal Assemblies in Ghana. *Journal of Construction Engineering*, *2017*.1-6.

Becher, R., Hoie, A. H., Bakke, J. V., Holos, S. B. and Ovrevik, J. (2017). Dampness and moisture problems in Norwegian homes. *International Journal of Environmental Research and Public Health*, *14*(10). https://doi.org/10.3390/ijerph14101241

Burkinshaw, R. (2010). The rising damp tests of Camberwell Pier: Potential height of moisture rise in brickwork and the effectiveness of a modern chemical injection cream damp coursing application. *Journal of Building Appraisal*, *6*(1), 5–19. https://doi.org/10.1057/jba.2010.13

Cedeño-Laurent, J. G., Williams, A., MacNaughton, P., Cao, X., Eitland, E., Spengler, J., & Allen, J. (2018). Building evidence for health: green buildings, current science, and future challenges. *Annual Review of Public Health*, *39*, 291-308.

Cheung, C. K., Fuller, R. J. and Luther, M. B. (2005). Energy-efficient envelope design for high rise apartments. *Energy and Buildings*, *37*(1), 37-48.

Engvall, K., Norrby, C. and Norbäck, D. (2001). Sick building syndrome in relation to building dampness in multi-family residential buildings in Stockholm. *International Archives of Occupational and Environmental Health*, *74*(4), 270-278.

Fisk, W. J. and Rosenfeld, A. H. (1997). Estimates of improved productivity and health from better indoor environments. *Indoor Air*, *7*(3), 158-172.

Franzoni, E. (2014). Rising damp removal from historical masonries: a still open challenge. *Construction and Building Materials*, *54*, 123-136.

Galvin, R. (2010). Solving mould and condensation problems: A dehumidifier trial in a suburban house in Britain. *Energy and Buildings*, *42*(11), 2118-2123.

Gana, A. (2015). An Investigation in to dampness in structures (a case study of high-rise buildings *Global Journal of Engineering Science and Research Management*, *2*(5), 17–21.

Halim, A. H. A. and Halim, A. Z. A. (2010). An analysis of dampness study on Heritage Building: A Case Study Ipoh Old Post Office Building and Suluh Budiman Building, UPSI, Perak, Malaysia. *Journal of Sustainable Development*, *3*(4), 171.

Halim, A. H. A., Harun, S. N. and Hamid, M. Y. (2012). Diagnosis of dampness in conservation of historic building. *Journal of Design and Built*, *5*(1), 11-18

Heseltine, E. and Rosen, J. (Eds.). (2009). *WHO guidelines for indoor air quality: dampness and mould*.WHO Regional Office Europe.

Ishak, N. H., Che Ani, A. I., Akashah, F. W.andKayan, B. A. (2013). Identification of dampness due to water leakages in high-rise residential buildings in Malaysia. *The 3rd International Building Control Conference*.

Karagiannis, N., Karoglou, M., Bakolas, A., Krokida, M. and Moropoulou, A. (2017). Drying kinetics of building materials capillary moisture. *Construction and Building Materials*, *137*, 441449.

Kportufe, G. S. (2015). The Devastating effects of rising damp in the construction industry, *5*(10), 28–35.

Laeirj, I., Spence, K. and Laycock, E. (2013). Identification and evaluation of factors influencing penetrating damp in residential buildings in east Libya. In *International Conference on Safety, Construction Engineering and Project Management (ICSCEPM 2013), "Issues, challenges and opportunities in developing countries, Islamabad, Pakistan*.).

Magutu, J., & Kamweru, K. (2015). The phenomenon of building maintenance culture: Need for enabling systems in the crisis of building maintenance in Kenya. *Global Journal of Engineering, Design & Technology*, *4*(5), 8-12.

Mumovic, D., Ridley, I., Oreszczyn, T. and Davies, M. (2006). Condensation risk: comparison of steady-state and transient methods. *Building Services Engineering Research and Technology*, *27*(3), 219-233.

Norbäck, D., Wieslander, G., Nordström, K. and Wålinder, R. (2000). Asthma symptoms in relation to measured building dampness in upper concrete floor construction, and 2-ethyl-1-hexanolin indoor air. *The International Journal of Tuberculosis and Lung Disease*, *4*(11), 1016-1025.

Olanrewaju, S., Owolabi S., and Anifowose, O. (2015). The challenges of building maintenance in Nigeria:(a case study of Ekiti State). *European Journal of Educational and Development Psychology*, *3*(2), 30-39.

Othman, N. L., Jaafar, M., Harun, W. M. W. and Ibrahim, F. (2015). A case study on moisture problems and building defects. *Procedia - Social and Behavioral Sciences*, *170*, 27–36. https://doi.org/10.1016/j.sbspro.2015.01.01

Rirsch, E. and Zhang, Z. (2010). Rising damp in masonry walls and the importance of mortar properties. *Construction and Building Materials*, *24*(10), 1815-1820.

Rostron, J. (2008). Sick building syndrome: A review of causes, consequences and remedies. *Journal of Retail & Leisure Property*, *7*(4), 291-303.

Saijo, Y., Nakagi, Y., Ito, T., Sugioka, Y., Endo, H. and Yoshida, T. (2009). Relation of dampness to sick building syndrome in Japanese public apartment houses. *Environmental Health and Preventive Medicine*, *14*(1), 26-39.

Sauni, R., Uitti, J., Jauhiainen, M., Kreiss, K., Sigsgaard, T. and Verbeek, J. H. (2013). Remediating buildings damaged by dampness and mould for preventing or reducing respiratory tract symptoms, infections and asthma. *Evidence-Based Child Health: A Cochrane Review Journal*, *8*(3),944-1000.

Seeley, I. H. (1987). *Building maintenance*. Macmillan International Higher Education.

Sellers, L. D. (2017). Rising damp evaluation and treatment a quasi-experimental case study. Leslie Dean Sellers submitted in partial fulfilment of the requirements of the degree of doctor of the Built Environment, May 2017, (May).

Shah, R. A. and Pitroda, J. (2013). Effect of water absorption and sorptivity on durability of pozzocrete mortar. *International Journal of Emerging Science and Engineering (IJESE) ISSN: 2319*, *6378*.

Soldatova, L. N., Sansone, S.-A., Stephens, S. M. and Shah, N. H. (2011). WHO guidelines for indoor air quality: dampness and mould. Selected papers from the 13th Annual Bio Ontologies Special Interest Group Meeting. *Journal of Biomedical Semantics*, *2*(Suppl 2), I1. https://doi.org/10.1186/2041-1480-2-S2-I1

Straube, J. F. (2002). Moisture in buildings. *ASHRAE Journal*, *44*(1), 15–19.

Sulaiman, S. J. and Beithou, N. (2011). Residential building walls and environment in Amman, Jordan. *International Journal of Thermal & Environmental Engineering*, *3*(2), 101-107.

Sundell, J. (2004). On the history of indoor air quality and health. *Indoor air*, *14*(s 7), 51-58

Tham, K. W., Zuraimi, M. S., Koh, D., Chew, F. T. and Ooi, P. L. (2007). Associations between home dampness and presence of molds with asthma and allergic symptoms among young children in the tropics. *Pediatric Allergy and Immunology*, *18*(5), 418-424.

Timusk, P. C. (2008). *An investigation of the moisture sorption and permeability properties of mill-fabricated oriented strandboard*. 1-PhD. Thesis University of Toronto, 1-266, available: PCTimusk - 2008 - ui.adsabs.harvard.edu

Trotman, P., Sanders, C. and Harrison, H. (2004). Understanding dampness: E*ffects, causes, diagnosis and remedies*, 1–226. https://doi.org/10.1017/CBO9781107415324.004

Trotman, P. (2007). BRE Digest 245 (Building Research Establishment). Rising damp in walls: Diagnosis and treatment. *Building Research*

Wargocki, P. and Wyon, D. P. (2013). Providing better thermal and air quality conditions in school classrooms would be cost-effective. *Building and Environment*, *59*, 581-589.

WHO. (2009). WHO Guidance for indoor air quality: dampness and mould. WHO.

Wilkowska, A. (2017). Enzymatic production of pectin-derived oligosaccharides from sugar beet pulp as a component of animal feed. *Journal of Biotechnology & Biomaterials*, *7*(4), 2155. https://doi.org/10.4172/2155-952X-C1-080

Young, M. E. (2007). Dampness penetration problems in granite buildings in Aberdeen, UK: causes and remedies. *Construction and Building Materials*, *21*(9), 1846-1859.

Yang, L., Gao, D., Zhang, Y., Tang, J. and Li, Y. (2019). Relationship between sorptivity and a capillary coefficient for water absorption of cement-based materials: theory analysis and experiment. *Royal Society Open Science*, *6*(6), 1-9.