An Overview of the Symptoms Associated with Dampness in Walls of Residential Buildings in Major Towns in Ghana

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Abstract

This study sought to identify and document the symptoms associated with dampness in the walls of 5,800 residential buildings in Ghana through a questionnaire survey in the Dry Equatorial, South Western Equatorial, Tropical Continental and the Wet Semi Equatorial climatic zones. A quantitative approach to data analysis was used in which the symptoms associated with dampness were analyzed using severity index. Majority of the houses surveyed were of lateritic materials and sandcrete block walls. The results showed that the most severe symptoms associated with dampness in the walls of the residential buildings surveyed were hygroscopic salts, decayed skirting, dampness below 1.5m and mold growth on walls up to 1m high. These identified symptoms are indications of the severity of the problem of dampness in residential buildings in Ghana. It is recommended that further studies be conducted to identify the lead source of dampness in the walls of residential buildings as this will assist in the recommendation of appropriate actions to remedy the problem.

Keywords: Buildings, climatic zones, dampness, Ghana, symptoms

1.0 Introduction

Dampness penetration is one of the most damaging faults that can occur, whether a building is old or of a modern type of construction (Hetreed, 2008; Burkinshaw & Parrett, 2004). 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). 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 (World Health Organization, WHO, 2009). Also, damp conditions typically affect the mental health of dwelling occupants, causing depression and anxiety, particularly where there is damage to decoration from mold or damp staining (Nicol, 2006). As the most frequently reported problem associated with buildings, dampness in all its forms has assumed an alarming proportion and countries like the United Kingdom, United States of America, Australia, Denmark, Canada, Japan, Estonia, Iceland, Norway, Sweden, Taiwan, have recorded the enormity of the problem concerning dampness (WHO, 2009; Mudarri & Fisk, 2007; Gunnbjornsdotirr *et al.,* 2006). Ghana also has its share of the problem of dampness. Field surveys carried out have shown that the problem has assumed an alarming dimension in most residential buildings in several parts of the country (Asamoah *et al.,* 2012). The main objective of this study was to identify and document the symptoms associated with dampness in walls of residential buildings in major towns in Ghana.

2.0 Literature Review

2.1 *Dampness in buildings*

Dampness is the penetration of water through the walls and certain elements of a building (Halim *et al.,* 2012). It is an excessive quantity of moisture contained in building materials and components which causes adverse movements or deterioration and results in unacceptable internal environmental conditions (Briffet, 1994). Burkinshaw &Parrett (2004) defined dampness as the amount of moisture content present in a material and can be classified as capillary moisture content, equilibrium moisture content, hygroscopic moisture content, total moisture content and potential moisture content. Dampness is the most frequent and main problem in buildings and contributes more than 50% of all known building failures (Halim *et al.,* 2012). According to Hollis (2000), dampness is inextricably linked to most building deterioration. A source of water close to a building will also be one of the problems associated with dampness. 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).

Sources of dampness can be classified as rising dampness, penetrating dampness and condensation and pipe leakages (Hollis, 2000). Dampness can also be classified as air moisture condensation, penetrating dampness and internal plumbing leaks, below ground moisture or building specific sources (Burkinshaw & Parrett, 2004).

2.2 Sources of dampness and their associated symptoms

2.2.1 Rising Dampness

Rising dampness occurs as a result of capillary suction of moisture from the ground into porous masonry building materials such as stone, brick, blocks, earth and mortar (Halim & Halim, 2010; Ahmed & Rahman, 2010; Riley & Cotgrave, 2005). It is a problem that is very common in older buildings, particularly those constructed without damp proof courses. However, it is gradually becoming a common issue with modern types of buildings as well (Rirsch, 2010).Over the years, many researchers have tried to define rising dampness from their own perspectives and new definitions keep on resurfacing as the years go by. Oxley and Gobert (1989) linked 'rising dampness to the ground and concluded that it occurs from the capillary flow of water from the ground'. Melville and Gordon (1998) explained that 'when ground water reaches the foot of a wall, it tends to rise in the walling materials and continues to do so due to capillary action to various degrees of intensity'. In their book diagnosing damp, Burkinshaw and Parrett (2004) defined 'rising damp more comprehensively as moisture that travels upwards through the pore structure or through small fissures or cracks, or as water vapour against the forces of gravity, typically up a wall or through a floor from a source below the ground'. Trotman *et al*. (2004) in their book '*Understanding dampness*' defined rising damp to 'normally mean the upward transfer of moisture in a porous material due to capillary action'. According to Rirsch (2010), it is caused by ground water rising upwards through a wall, much in the same way as oil would rise through the wick of a lamp. Rising dampness is a strange phenomenon because experts in dampness issues do not agree on exactly what it is and some deny its existence (Burkinshaw, 2012). The visible symptoms of rising damp include dampness on the lower parts of walls, sometimes up to 1.5m in horizontal bands (Rirsch, 2010). Rising damp may also present itself as salty yellowy browny patches of plaster/décor just above the height of skirting boards (Burkinshaw, 2010). It tends to cause many problems to a building with associated health, environmental, social and economic implications. Rising dampness serves as a platform for the growth of fungi in wood which causes rot, deterioration of wall plasters and paints, loosening of wall papers, staining of wall surfaces, crumbling of mortar, rusting of steel and iron fasteners, etc. (Zhang, n.d).

2.2.2 Penetration Dampness

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 (Beall, 2000). Penetration damp is the term applied to the penetration of moisture through the fabric of buildings over a period of time. It is usually characterized by localized areas of damp or saturated wall/ceiling finishes (Latta, 2005; Oliver, 1988). Penetration damp is caused by plumbing issues in a building or where a problem has allowed water to enter a building. Symptoms associated with penetration dampness usually occur during wet weather (Newton, n.d). Though penetration dampness may look harmless, it can cause damages to buildings even if it does not penetrate all the way through the walls of the building. Penetration dampness can lead to moss growth, increased heat loss, frost damage into masonry, etc.

2.2.3 Condensation

Dampness resulting from condensation occurs where water in the air inside a building condenses on a cooler surface (Curtis, 2007). This is usually indicative of cold spots in the building, sometimes called cold bridges (Curtis, 2007). Excessive condensation frequently results in severe mould growth which can in turn create health hazards. Damp patches can appear on plastered walls in odd places, particularly on outside walls, often appearing and disappearing on a regular basis (Burns, 2010). Condensation is mostly accompanied by mold which is black in colour but can virtually be of any colour and is very common on walls and ceiling, underneath bay windows, etc. (Burns, 2010). Running water on windows and walls is the most immediate indication of a condensation problem (Property Care Association, PCA, n.d). This problem can lead to deterioration in the decorative condition of a property, stained curtains and decay in window frames (PCA, n.d). Condensation is also associated with the appearance of moulds on the surface of wall papers and paints in poorly ventilated areas (PCA, n.d).

3.0 Study Areas

Major towns in the ten administrative regions of Ghana were grouped under four climatic zones- South Western Equatorial (SWE), Dry Equatorial (DE), Wet Semi Equatorial (WSE) and Tropical Continental (TC) (Abass, 2009; Fianko *et al.,* 2009; Dickson & Benneh, 1988). The South Western Equatorial Climatic zone is the wettest in Ghana. The rainfall regime is the double maximum type. Mean annual rainfall is above 1900mm and on the average, no month has less than 25mm of rain. The highest mean monthly temperature of about 30°C occurs

between March and April and the lowest of about 26°C in August. A typical station for this climatic zone is Axim (Abass, 2009). The DE has a mean annual rainfall between 740mm and 890mm. This region is the driest in the country with mean monthly temperature of 28°C. The highest average relative humidity does not exceed 75% and the lowest is about 60% (Dickson & Benneh, 1988). The towns which fall within this zone are Accra, Cape Coast, Takoradi and Ho (Abass, 2009). The WSE zone has two rainfall maxima, with a mean annual rainfall of about 200cm. The first rainy season lasts from May to June, and the second from September to October. Relative humidity is normally around 75% (Dickson & Benneh, 1988). The major towns located in this zone are Kumasi, Koforidua and Sunyani (Abass, 2009). The Tropical Continental climate has a single rainy season from May to October followed by a prolonged dry season. The mean annual rainfall is about 1000mm to 1150mm. Mean monthly temperatures vary from 36°C in March to about 27°C in August. The major towns which fall within this climatic zone are Navrongo, Wa and Tamale (Abass, 2009).

4.0 Research Methodology

The study was conducted through field surveys. The main instruments used for data collection were structured questionnaire made up of closed-ended questions. The questionnaires were administered to building occupants of residential buildings in major towns of the four climatic zones in Ghana.

The questionnaires distributed to the building occupants sought information about the type of buildings, the materials used to construct the walls of the buildings and symptoms associated with dampness in walls of the buildings. The respondents were asked to rank the level of severity of the symptoms associated with dampness in walls on the Likert scale of 1-5 (where 1=Not severe and 5= Very severe).

Houses located in eleven major towns in the four main climatic zones were considered in the survey. According to the Ghana Statistical Service, GSS, (2000), the number of buildings located in each of the selected towns are shown in Table 1 (Column 3).

A sample size of 5,800 buildings from the total population of 278,273 buildings in the selected locations was determined for the entire survey using the formula proposed by Yamane (1967) as follows: n= N/1+N (e)^2 Where N = the total population size; e= the standard error of sampling distribution assumed to be 0.013 and n is the sample size. Proportionate or quota sampling technique was used to select the sample size for each location and the convenience purposive sampling approach was then used to select the residential buildings within each location (representing a cross section of buildings within the four climatic regions of Ghana).

A quantitative approach to data analysis was employed. Statistical Package for Social Scientists Version 16 was used to analyze the data by means of frequencies and severity index. The severity index analysis (Idrus *et al.,* 2011) uses weighted percentage scores to compare the relative importance of the criteria under study. The frequency analysis was first carried out to determine the frequency of responses which were then used to calculate severity indices (Idrus *et al.,* 2011): Severity Index (SI) = $[\sum ai.xi/5\sum xi]$ where 'a' is the constant expressing the weight assigned to each response (ranging from 1 for 'not severe' to 5 for 'very severe') and 'x' is the frequency of each response.

5.0 Results and discussions

5.1 Characteristics of buildings

Table 2 shows the characteristics of the buildings surveyed in the four climatic zones in Ghana. The results show that 71% of the respondents interviewed in the South Western Equatorial Zone, 77% in the Dry Equatorial Climatic Zone and 56% in the Wet Semi Equatorial Climate Zone live in detached buildings. In the Tropical Continental Zone, 62% of the respondents live in compound houses.

In the South Western Equatorial climatic zone, 89% of the walls of buildings were constructed with sandcrete blocks and only 11% were constructed with earth. In the Dry Equatorial climatic zone 94% of the walls of buildings were constructed with sandcrete blocks, 3% were constructed with earth and 3% were constructed with concrete. In the Wet Semi Equatorial climatic zone, the walls of buildings were constructed with concrete, earth, burnt bricks and sandcrete blocks. However, sandcrete blocks gained more usage (83%). In the Tropical continental climatic zone, 66% of the walls of buildings were constructed with earth. The results show that the outer walls of buildings surveyed in the four climatic zones of Ghana were mostly constructed with sandcrete blocks and earth, though concrete and burnt bricks were used in fewer cases. These results show that the commonest material used to construct walls of buildings in major towns within the climatic zones surveyed except the TC zone is sandcrete blocks.

5.2 Severity of symptoms associated with dampness

The severity indices of the symptoms associated with dampness are presented in Table 3. From Table 3 it can be seen that *'mold growth (on cold surfaces, windows, etc)'* is the most severe symptom of dampness (with SI of 90%) associated with walls in the South Western Equatorial climatic zone and therefore ranked first on the list of symptoms. In the Tropical Continental climatic zone, *'dampness at the base of walls up to 1.5m in horizontal band* is ranked first on the list (with SI of 84%) as the most severe symptom associated with dampness in the walls of buildings. *Stains, especially in horizontal band* are ranked first (with SI of 97%) on the list of symptoms as the most severe symptom associated with dampness in the walls of buildings in the Wet Semi Equatorial climatic zone. In the Dry Equatorial climatic zone, *'surface efflorescence just above skirting/floor'* is the most severe symptom (with SI of 89%) and therefore ranked first on the list of symptoms associated with dampness.

From the results it is seen that each climatic zone has a unique symptom associated with the walls of buildings. This is a situation likely to be caused by the differences in climatic conditions of each zone. However, these differences do not have much influence on the results obtained. For instance, mold growth highly associated with buildings in the South Western Equatorial climatic zone does not require the presence of standing water: it can occur when high relative humidity or the hygroscopic properties of building surfaces allow sufficient moisture to accumulate (United States Environmental Protection Agency, USEPA, 1991). The relative humidity and temperature levels often vary within a room; therefore, if one side of the room is warm and the other side is cold, the colder side of the room has a higher relative humidity than the warmer side (USEPA, 1991). The highest relative humidity in a room is always next to the coldest surface and this is likely to be the location where the first condensation occurs (USEPA, 1991). In the South Western Equatorial climatic zone, average monthly relative humidity levels (based on figures recorded each day at 12 noon) are highest as compared to the other climatic zones in Ghana and range between 75-80%, a possible reason for walls being affected by mold growth in this zone.

Cyclic wetting and drying brought about by seasonal changes is an important driver of salt attack or efflorescence in walls of buildings (Young, 2008). Changes in the relative humidity of a location can cause efflorescence to occur (Young, 2008). Surface efflorescence in walls is caused by rapid evaporation of water from wall surfaces leaving behind salt crystals (Young, 2008). In the Dry Equatorial Climatic zone, there is that tendency of rapid evaporation of moisture from walls of buildings which could lead to the formation of salt bands on the surfaces of walls. A reason why surface efflorescence is the most severe symptom of dampness associated with buildings in this climatic zone.

The results from this study confirm that *mold growth*, *stains, especially in horizontal band*, *dampness at the base of walls up to 1.5m in horizontal band* and *surface efflorescence* are the most severe symptoms associated with dampness in walls of residential buildings in major towns in Ghana. The results are not different from that reported in literature which lists *mold growth*, *surface efflorescence*, *water run marks*, *blistering of paints*, etc. as symptoms associated with dampness in the walls of buildings (Hetreed, 2008; Burkinshaw & Parrett, 2004; Trotman *et al.,* 2004).

5 Conclusions

The study sought to identify and document the symptoms associated with dampness in walls of residential buildings in four climatic zones in Ghana. The results has shown that the major symptoms associated with walls of residential buildings in the major towns in Ghana are *hygroscopic salts*, *decayed skirting*, *dampness below 1.5m and mold growth on walls up to 1m high*. The evidence of a progressive dampness problem is an indication that a building's condition is most likely to deteriorate overtime. These symptoms that have been identified are indications of the severity of the problem of dampness in residential buildings in Ghana. With the identified symptoms, it is recommended that further studies be conducted to identify the lead source of dampness in the walls of residential buildings. This will assist in the recommendation of appropriate actions to remedy the problem.

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Table 1 Sample size determination of houses surveyed

TOWN	CLIMATIC ZONE	NO. OF HOUSES (GSS, 2000)	NO. OF HOUSES SAMPLED	TOTAL SURVEYED
Sekondi-Takoradi		24,817	517	
Cape Coast		6,847	143	
Accra	DE	131,355	2,738	3,541
Ho		6,853	143	
Axim	SWE	2,694	56	56
Koforidua		7,318	153	
Kumasi	WSE	67,434	1,406	1,689
Sunyani		5,611	117	
Bolgatanga		3,932	82	
Wa	TC	5,539	115	545
Tamale		15,873	330	

Table 2 Characteristics of buildings surveyed

	South Western Equatorial		Dry Equatorial		Wet Semi Equatorial		Tropical Continental	
Characteristics of dwellings	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Type of dwelling								
Detached/separate	40	71%	2,744	77%	946	56%	136	25%
Semi detached	4	7%	485	14%	203	12%	49	9%
Block flat/Apartment	2	4%	208	6%	473	28%	22	4%
Compound	10	18%	104	3%	67	4%	338	62%
TOTAL	**56**	*100%*	**3,541**	*100%*	**1,689**	*100%*	**545**	*100%*
Walling material								
Concrete	0	0%	104	3%	51	3%	0	0%
Earth	6	11%	104	3%	118	7%	360	66%
Burnt bricks	0	0%	0	0%	118	7%	82	15%
Sandcrete blocks	50	89%	3,333	94%	1,402	83%	104	19%
TOTAL	**56**	**100%**	**3,541**	**100%**	**1,689**	**100%**	**545**	**100%**

Table 3 Severity of symptoms associated with dampness in buildings

	South Western Equatorial (SEW)		Tropical Continental (TC)		Wet Semi Equatorial (WSE)		Dry Equatorial (DE)	
Symptom	**S.I.**	**Rank**	**S.I.**	**Rank**	**S.I**	**Rank**	**S.I.**	**Rank**
Decayed skirting	33 %	9th	40%	9th	28%	10th	44%	10th
Dampness around edges of solid floor	32 %	10th	77%	6th	43%	8th	70%	6th
Surface efflorescence just above skirting/floor	88 %	2nd	83%	2nd	84%	4th	89%	1st
Dampness at the base of walls up to 1.5m in horizontal band	86 %	3rd	84%	1st	89%	2nd	86%	3rd
Stains, especially in horizontal band	86 %	3rd	79%	5th	97%	1st	87%	2nd
Mold growth	90 %	1st	81%	4th	85%	3rd	85%	4th
Free surface water, water run marks, etc.	85 %	5th	83%	2nd	84%	4th	77%	5th
Blistering and flaking of paint	49 %	6th	54%	7th	40%	9th	53%	8th
Softening and deterioration of plaster	38%	7th	53%	8th	60%	7th	61%	7th
Dampness on first floor and above	34%	8th	28%	10th	61%	6th	52%	9th

a) Stain in horizontal band   b) stain in horizontal band   c) water run marks on windows

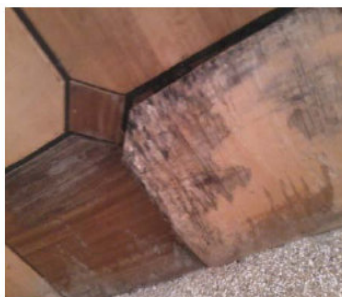d) Surface efflorescence   e) Surface efflorescence   f) Water run marks on window

g) Damp at the base of wall   h) decayed skirting   i) mould growth on wall

Figure 1.Photographs of some symptoms associated with dampness in buildings

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