ASSESSMENT OF DAMPNESS IN WALLS OF RESIDENTIAL BUILDINGS IN FOUR CLIMATIC ZONES IN GHANA

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Abstract
This study sought to identify the most dominant type of dampness associated with walls of residential buildings in Ghana through a questionnaire survey of 5,800 residential buildings in the Dry Equatorial, South Western Equatorial, Tropical Continental and the Wet Semi Equatorial climatic zones. A mixed method of data analysis was used in which the symptoms associated with dampness were analyzed using severity indices and the most dominant types of dampness were analyzed using percentages. Majority of the houses surveyed were of lateritic materials and sandcrete block walls. The results showed that the most dominant symptoms 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 symptoms point to the presence of rising dampness in the walls of these residential buildings. The results provide a platform for addressing the problem of rising dampness in buildings.

Keywords: Buildings; climatic zones; dampness; rising damp; condensation

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 and Parrett, 2004). It can damage brick/block work by saturating it, cause decay and breaking 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). Damp conditions also 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 and 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).

Aim
The aim is to investigate symptoms associated with dampness in walls of residential buildings in four climatic zones in Ghana

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Objectives

- To identify the symptoms associated with dampness in walls of residential buildings.
- To identify the most dominant type of dampness associated with the walls of these buildings.

2.0 LITERATURE REVIEW

2.1 Housing characteristics in Ghana

The official data of the Ghana Statistical Service on the distribution of housing in Ghana reported that there were 3,392,745 houses countrywide.

A house or building is defined as a structurally separate or independent place of abode such that a person or group of persons can isolate themselves from the hazards of climate such as storms and the sun (BOG Report, 2007).

Table 2: Regional Distribution of Stocks of Houses and Households (HH) – 2010 Census

Regions	2010 Population	No. of Houses	No. of Households	% Distribution of Housing Stock	Pop. Per House	Avg. HH size	HH per House
All Regions	**24,658,823**	**3,392,745**	**5,467,136**	**100**	**7.3**	**4.4**	**1.6**
Greater Accra	4,010,054	474,621	1,036,426	14.0	8.4	3.8	2.2
Ashanti	4,780,380	574,066	1,126,216	16.9	8.3	4.1	2.0
Western	2,376,021	380,104	553,635	11.2	6.3	4.2	1.5
Eastern	2,633,154	431,697	632,048	12.7	6.1	4.1	1.5
Volta	2,118,252	399,953	495,603	11.8	5.3	4.2	1.2
Northern	2,479,461	257,311	318,119	7.6	9.6	7.7	1.2
Brong Ahafo	2,310,983	331,967	490,519	9.8	7.0	4.6	1.5
Central	2,201,863	346,699	526,764	10.2	6.4	4.0	1.5
Upper East	1,046,545	114,034	177,631	3.4	9.2	5.8	1.6
Upper West	702,110	82,293	110,175	2.4	8.5	6.2	1.3

Source: 2010 Population and Housing Census Report (GSS, 2012)

In the 2010 population census, the GSS classified occupied dwellings into 10 categories as follows: rooms in a compound; separate house (detached house); semi-detached house; several huts/buildings; improvised house (kiosk/container); living quarters attached to a shop; camps or tents; hotel or hostel; flat or apartment and others. Of these, compound houses accounted for 51.1 per cent and emerged as the most common dwelling unit in both urban and rural areas. Separate or detached houses (28.7%) were found to be the second most common dwelling type in all regions (ranging from 15.9% - 27.2%) except the Volta Region (44.7%) where this type is predominant. Semi-detached house (7.1%) is the third most common type in all regions. Flats or apartments are ranked fourth in the country (4.7%) . Improvised houses (kiosk/container) and living quarters attached to a shop' were found mainly in urban localities of the Greater Accra and Ashanti Regions due to rural urban migration. In Greater Accra, for example, these improvised houses (kiosks and containers) are used for both commercial and residential purposes (Bank of Ghana, 2007).

The type of building material used by individuals and institutions depend on cost, availability and people's ability to pay for these materials. The two main materials for the construction of the outer walls of a house in Ghana are mud /earth brick and cement/concrete, which together account for 89.1 per cent of wall materials of dwelling units (BOG, 2007). The earth/mud brick constitutes 50.0 per cent while concrete/cement is used in 39.1 percent of the cases. The use of these materials as walling materials have seen many problems over the years including dampness, which results from moisture finding its way into the walls of the buildings.

2.2 Dampness in buildings

Dampness can be defined as water penetration through the walls and certain elements of a building (Halim et al., 2012). It can also be defined as 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 and 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). In order to successfully diagnose and make appropriate recommendations for remedial actions, one should understand dampness and its impact on buildings.

The ultimate objective of any dampness study is to identify the lead source of moisture in order to recommend actions to remedy the problem (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 and Parrett, 2004).

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 and Halim, 2010; Ahmed and Rahman, 2010; Riley and Cotgrave, 2005). The moisture evaporates from either face of the wall (inside or outside), allowing more to be drawn from below. The height to which the moisture will rise is determined by the evaporation rate and the nature of the wall (Halim and Halim, 2010; Ahmed and Abdul-Rahman, 2010). The normal limit for rising dampness ranges from 0.5m to 1.5m above ground level (Halim and Halim, 2010; Ahmed and Abdul- Rahman, 2010; Trotman et al., 2004). Rising dampness may show as a high-tide-like stain on wall paper and other interior finishes, and, when it is severe, as blistering of paint and loss of plaster. Damp walls encourage the growth of mold which in conjunction with high humidity, can lead to health problems to occupants (Halim and Halim, 2010).

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). Water can be present as rain, melting snow and soil moisture. Several forces such as gravity, air currents, capillary suction, surface tension, kinetic energy, air pressure and hydrostatic pressure influence the penetration of water into buildings (Beall, 2000). Drips from air conditioning or hot water system overflows, rain water, pipe leakages, water from horizontal directions, etc. can also cause penetration dampness in buildings. These sources tend to produce small, localized patches of dampness and decay, whereas rising dampness may affect the base of a whole building.

According to Curtis (2007), dampness resulting from condensation occurs where water in the air inside a building condenses on a cooler surface. 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 plaster 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).

2.2.1 Diagnosing dampness

Dealing effectively with the problem of dampness requires the adoption of an organized system of investigative procedures to confirm all the sources of dampness and to ensure that the recommended remedial works are appropriate (Halim et al., 2012; Burkinshaw and Parrett, 2004). Such a system must commence with identifying and recognizing symptoms or signs of dampness (Halim et al., 2012). A professional who undertakes any form of building inspections should be aware of information already available (Carillion, 2001). The selection of an effective remedy for any form of dampness must start with a correct diagnosis of the cause (Carillion, 2001). There are four major stages to any dampness investigation. These are visual inspection, investigations using moisture meters/ non-destructive tests, a more detailed investigation/destructive tests and homing in on the problem/assessment study (Halim et al., 2012; Burkinshaw and Parrett, 2004).

2.2.1.1Stage 1-visual inspection

This study was based on stage 1, thus the visual inspection stage. The procedure requires a surveyor to inspect the defect closely and it is the first of the four stages involved in any dampness investigation. This stage may be subjective and based on experience and skill of the personnel involved (Halim et al., 2012). The identification of a dampness problem is dependent on the symptom of defect i.e. staining of water, cracking, rotten timber, decay, blisters, etc.(Halim et al., 2012; Burkinshaw and Parrett, 2004). The diagnosis requires knowledge of the behavior of relevant building materials, construction knowledge and knowledge on the use (past, present and future) of the building. The surveyor needs to record the defect by description, photograph or sketch drawings, etc. (Halim et al., 2012; Burkinshaw and Parrett, 2004).

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 and 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 and 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 and 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 METHOD

The study was conducted through field surveys. The main instruments used for data collection were structured questionnaire made up of closed-ended questions and a checklist for on-site building investigations. The questionnaires were administered to building occupants of residential buildings in 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). A checklist containing symptoms of dampness collected from the literature and modified to suit conditions in Ghana was pre-tested using 50 buildings and used for the study (Burns, 2010; Safeguard Europe Limited, SEL, 2007).

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).

Table 1 Sample size determination of houses surveyed

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

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 of 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.

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%**

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 results of the severity indices of the symptoms associated with dampness are presented in Table 3. The results show 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.

The results show that each climatic zone has a unique symptom associated with the walls in buildings. This is a situation likely to be caused by the differences in climatic conditions of each zone. 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 (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 possible reason why the 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 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 and Parrett, 2004; Trotman et al., 2004).

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*

4.3Identification of the most dominant type of dampness in buildings

Tables 4 presents results on symptoms associated with the various types of dampness studied. Eighty one percent (81%) of buildings (1,370 buildings) in the Wet Semi Equatorial climatic zone were identified with symptoms of *'hygroscopic salts'*, *'moisture in skirtings'*, *'dampness below 1.5m in horizontal band'* and *'mold growth on walls about 1m high'*. These are all symptoms highly associated with rising dampness (Hetreed, 2008; Burkinshaw and Parrett, 2004; Trotman et al., 2004). Fifteen percent (15%) of buildings (275 buildings) in this climatic zone were identified with symptoms associated with water penetration (Burns, 2010; SEL, 2007). These symptoms include *‘water droplets or free flowing water on surfaces’* and *‘moisture above 1.5m’*. Furthermore, 4% of buildings (69 buildings) were identified with *‘mold on ceilings and top of walls’* which is a symptom associated with condensation (Burns, 2010; SEL, 2007).

In the Tropical Continental climatic zone, 69% of buildings (375 buildings) were identified with symptoms highly associated with rising damp. They include *‘hygroscopic salts’*, *‘moisture in skirtings’*, *‘dampness below 1.5m in horizontal band’* and *‘mold growth on walls about 1m high’* (Hetreed, 2008; Burkinshaw and Parrett, 2004; Trotman et al., 2004). Nineteen percent of the buildings (19%) (105 buildings) were also identified with symptoms associated with water penetration. These include *‘water droplets or free flowing water on surfaces’* and *‘moisture above 1.5m’*. Twelve percent (12%) of the buildings (69 buildings) were identified with *‘mold on ceilings and top of walls’* which is a symptom associated with surface condensation (Burns, 2010; SEL, 2007).

Ninety two percent (92%) of buildings (3,541 buildings) in the Dry Equatorial climatic zone showed symptoms of *‘hygroscopic salts’*, *‘moisture in skirtings’*, *‘dampness below 1.5m in horizontal band’* and *‘mould growth on walls about 1m high’*. *‘Water droplets or free flowing water on surfaces’* and *‘moisture above 1.5m’*, were identified with 6% of the buildings and *‘moulds on ceilings and top of walls’* was identified with 2% of the buildings in this climatic zone.

In the South Western Equatorial climatic zone, 46% of the buildings showed symptoms of *‘hygroscopic salts’*, *‘moisture in skirtings’*, *‘dampness below 1.5m in horizontal band’* and *‘mould growth on walls about 1m high’*. Thirty six percent (36%) of the buildings were identified with *‘water droplets or free flowing water on surfaces’* and *‘moisture above 1.5m’*. Eighteen percent (18%) of buildings were identified with *‘mold on ceilings and top of walls* which are associated with surface condensation.

Table 4 Dominant types of dampness in buildings based on symptoms

	WET SEMI EQUATORIAL (KUMASI, KOFORIDUA AND SUNYANI)			TROPICAL CONTINENTAL (TAMALE, WA, BOLGATANGA)			DRY EQUATORIAL (ACCRA, CAPECOAST, TAKORADI, HO)			SOUTH WESTERN EQUATORIAL (AXIM)		
	1, 689 BUILDINGS SURVEYED			545 BUILDINGS SURVEYED			3,541 BUILDINGS SURVEYED			**56 BUILDINGS SURVEYED**		
Type of dampness / Symptoms	RISING DAMPNESS	CONDENSATION	WATER PENETRATION	RISING DAMPNESS	CONDENSATION	WATER PENETRATION	RISING DAMPNESS	CONDENSATION	WATER PENETRATION	RISING DAMPNESS	CONDENSATION	WATER PENETRATION
Water droplets/free flowing water on surface	0	0	50	0	0	30	0	0	100	0	0	10
Hygroscopic salts	180	0	0	55	0	0	2,000	0	0	2	0	0
Moisture in skirting	90	0	0	20	0	0	150	0	0	4	0	0
Moisture above 1.5m	0	0	200	0	0	75	0	0	100	0	0	10
Dampness below 1.5m in horizontal band	1,000	0	0	200	0	0	1,000	0	0	10	0	0
Mold on walls about 1m high	100	0	0	100	0	0	116	0	0	10	0	0
Mold on ceilings and top of walls	0	69	0	0	65	0	0	105	0	0	20	0
TOTAL NO. OF BUILDINGS	***1,370***	***69***	***250***	***375***	***65***	***105***	***3,266***	***75***	***200***	***26***	***10***	***20***
RANKS	1^{ST}	3^{RD}	2^{ND}	1^{ST}	3^{RD}	2^{ND}	1^{ST}	3^{RD}	2^{ND}	1^{ST}	3^{RD}	2^{ND}

Figure 2 provides a summary of the most dominant types of dampness in the walls of buildings in the four climatic zones in Ghana. From Figure 2, it can be seen that the most dominant type of dampness in walls of buildings in the four climatic zones is most probably rising dampness. This is because majority of buildings surveyed in the four climatic zones showed symptoms associated with rising dampness. Thus, 1,370 out of 1,689 (81%) buildings in the WSE climatic zone, 375 out of 545 (69%) buildings in the TC climatic zone, 3,266 out of 3,541 (92%) buildings in the DE climatic zone and 26 out of 56 (46%) buildings in the SWE climatic zone all showed symptoms associated with rising dampness.

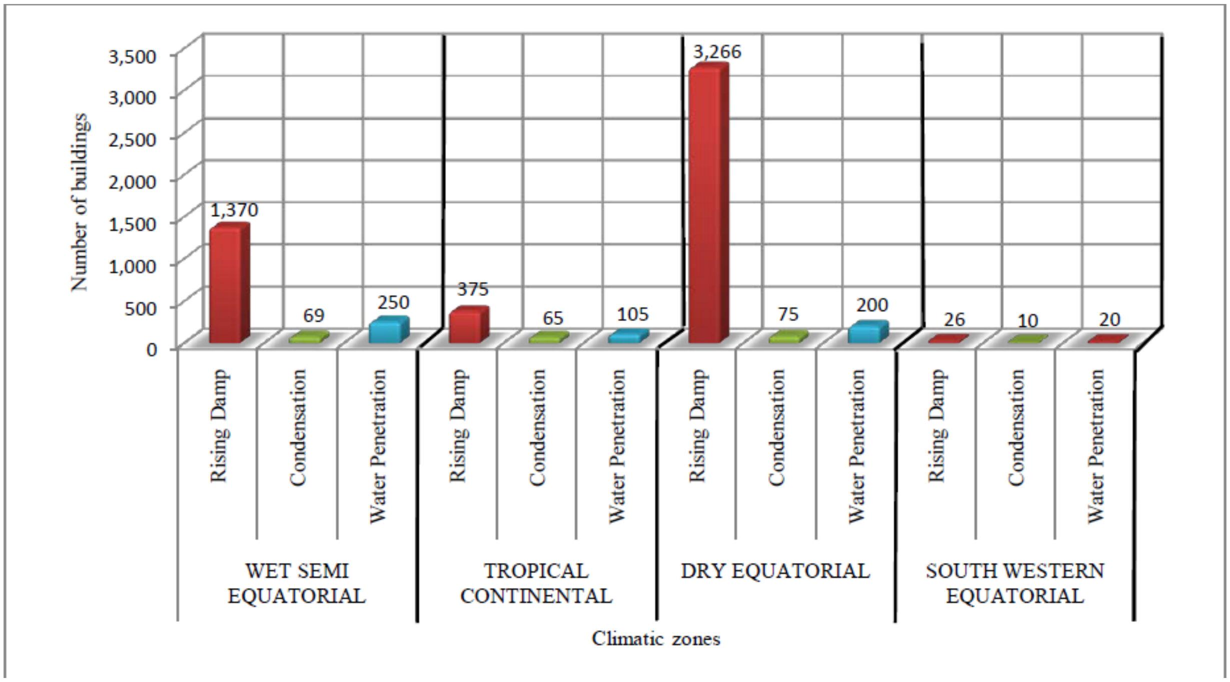

Figure 2.Number of buildings identified with rising dampness, condensation and water penetration in the four climatic zones

6. CONCLUSION

The study sought to identify the symptoms associated with dampness in walls of residential buildings and to identify the most dominant type of dampness associated with the walls of these buildings. The results has shown that the major symptoms associated with walls of residential buildings are *hygroscopic salts*, *decayed skirting*, *dampness below 1.5m and mold growth on walls up to 1m high*. The results have further shown that the most dominant type of dampness in the walls of buildings in the four climatic zones is raising dampness. This was confirmed in the survey when 81% of buildings in the WSE, 69% in the TC, 92% in the DE and 46% in the SWE climatic zones showed symptoms such as *hygroscopic salts*, *moist timber skirting*, *damp base of walls*, etc associated with rising dampness. As a recommendation for further study, the authors suggest that a more detailed laboratory diagnosis be conducted of the problem of rising dampness in the masonry walls of residential buildings to aid in the recommendation of appropriate treatment mechanisms to address the problem.

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