Level of practice and effectiveness of damp remediation measures in walls of residential buildings in Ghana

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Abstract

Damage caused by dampness may pose serious risks to the performance of a building structure. A structured questionnaire survey involving a convenience purposive sampling of 5,800 residential buildings in the Dry Equatorial, Wet Semi Equatorial, Tropical Continental and the South Western Equatorial climatic zones was conducted to assess the level of practice and the level of effectiveness of damp remediation measures adopted by building occupants, using the weighted average and the coefficient of variation criteria.The findings showed that construction of aprons at the base of walls, using damp proof courses and membranes, tiling of wall bases, patching of wall bases and repainting are all damp remediation measures frequently practiced by building occupants to address the problem of dampness.The Average Effective Scores of all the measures showed that they are highly ineffective in addressing the problem of dampness in residential buildings. However, the rankings of these measures based on their Effective Index Values showed that using damp proof courses and membranes, construction of aprons at the base of walls, tiling of wall bases, etc. possess some level of effectiveness in their application to address the problem of dampness in residential buildings in Ghana. Despite these findings, there is still the urgent need for concerted efforts at finding effective remediation measures to address the problem of dampness.

Keywords: Ghana, dampness, damp remediation, measures, residential buildings, building occupants.

Introduction

The accumulation of dampness in building structures, structural components or on the surfaces of building materials may lead to physical, biological or chemical deterioration of the components or the materials (Haverinen-Shaughnessy, 2007). Damages caused by dampness may also pose serious risks to the performance of building structures (Oliver, 1997). In epidemiological population studies, dampness damage has been associated with a number of respiratory diseases such as asthma, etc. (Haverinen-Shaughnessy, 2007; Bornehag et al., 2001). The health effects associated with dampness damage seem to be consistent in different climates and geographical regions (Zock et al., 2002). Studies have shown that the technical causes of damages caused by dampness are often closely connected to the climate (Haverinen-Shaughnessy, 2007). According to Palomaki and Reijula (2008), despite the notable amount of research to remedy the problem of dampness, the mechanisms causing the symptoms and diseases associated with dampness still remain unresolved. Problems with dampness and mold seem to have existed even in buildings constructed over 2000 years ago. In *Leviticus,* chapter 14, verses 35–48

(1), the earliest written instructions are given for evaluating microbial contamination in housing environments. The following four aspects are identified in this scripture: inspection (*Lev* 14:36), remediation (*Lev* 14:40–42), evaluation: criteria for failure (*Lev* 14:43–45), evaluation: criteria for successful remediation (*Lev* 14:48) (Palomaki and Reijula, 2008). The best way for people to protect themselves against symptoms and diseases due to dampness and mold is to avoid such exposure. The best means is to see that damaged structures and contaminated materials are removed from the building in question (Palomaki and Reijula, 2008). The prevention and control of moisture problems should be addressed in early phases of building design and construction, and in the sustained maintenance of buildings (Haverinen-Shaughnessy, 2007; Burkinshaw and Parrett, 2004). This study seeks to assess building occupants' knowledge on the level of practice and the level of effectiveness of damp remediation measures in residential buildings in Ghana.

2.0 Literature Review

2.1 Problem of dampness in buildings

Dampness is one of the subject areas littered with misconceptions and confusions over terminology and thinking (Halim et al., 2012; Burkinshaw and Parrett, 2004). According to the Oxford Dictionary, 'dampness is a condition contained with little water'. Seeley (1994) also defined dampness as the wetting of structural elements through moisture rise by capillary action. Dampness can be described as excessive moisture contained within building materials and components which has the tendency to cause adverse movements or deterioration and which can result in unacceptable internal environmental conditions (Halim et al., 2012). Dampness in a building also involves an excess of moisture that causes cosmetic problems, spoils decorations, deteriorates building fabrics and creates conditions that have adverse effects to the health of occupants (Oxley, 2003; Briffet, 1994). It is one of the most serious structural effects and can occur in the walls of both old and modern types of construction (Hetreed, 2008; Burkinshaw and Parrett, 2004; Massari and Massari, 1993). Dampness in walls spoils paints and interior decorations, encourages mold and rots growth, hampers aesthetics, poses a threat to the health of occupants through providing breeding conditions for mosquitoes, bacterial and fungal growths, undermines structural integrity of wall elements, reduces the thermal insulation property of building materials as well as affects the comfort of the occupants (Trotman et al., 2004; Mbachu, 1999).Dampness in buildings can arise from a number of different sources and can cause a variety of effects such as wall staining, mold growth, impairment of air quality and respiratory problems in humans (Ahmed and Rahman, 2010; Riley and Cotgrave, 2005; Trotman et al., 2004).

Dampness in the elements of a structure can arise from rainwater penetration in exterior walls, ground water intrusion into basements and crawl spaces, condensation and indoor moisture sources (Douglas and Noy, 2011; Ahmed and Rahman, 2010; Trotman et al., 2004; Riley and Cotgrave, 2005).

2.2 Reported cases of dampness in buildings

Damp conditions in a home can occur for a variety of reasons (Ryan, 2002). According to the Building Research Establishment (BRE), between 80-85% of dampness problems arise due to condensation or manmade moisture (Ryan, 2002;

Allen, 1995). The 1991 house condition survey in the UK found that 10.4 million homes were affected by mold growth (Ryan, 2002; Wheeler and Critchley, 1998) and the Northern Ireland House Condition Survey in 1996 also found that 16% of homes experienced some form of dampness or mold growth (Ryan, 2002). In Canada, USA and other European countries, studies have shown that about 20% of buildings had one or more signs of dampness (WHO, 2009). This estimate agreed with those of a study of 16,190 people in Denmark, Estonia, Iceland, Norway and Sweden, which gave an overall prevalence of indoor dampness of 18% (Gunnbjornsdottir et al., 2006). In the study undertaken by Gunnbjornsdottir et al. (2006), dampness was defined on the basis of self-reported indicators, such as water leakage or damage, bubbles or discoloration of floor coverings, and visible mold growth indoors on walls, floors or ceilings. A study of 4,164 children in rural Taiwan and China showed that 12% of the parents or guardians considered their dwellings to be damp, 30% reported the presence of visible mold inside their houses, 43% reported the appearance of standing water, water damage or leaks and 60% reported at least one of these occurrences (WHO, 2009; Yang et al., 1997). In Singapore, of 4,759 children studied, the prevalence of dampness in each child's bedroom was estimated to be 5% and that of mold was 3% (WHO, 2009; Tham et al., 2007). In Ghana a study carried out by Coral Ghana (n.d) showed that the problem of dampness in buildings is on the rise.

2.3 Remediation of dampness in buildings

When investigating a dampness problem, it is most essential for the surveyor to understand the construction of the building and be certain of the cause before attempting a remedy (Douglas and Ransom, 2013; Douglas and Noy, 2011; Burkinshaw and Parrett, 2004). According to Haverinen-Shaughnessy (2007) and Bornehag et al. (2001), dampness/moisture damage in buildings does not have a homogenous appearance but each building needs to be examined individually. Some dampness problems are straightforward and fairly easy to diagnose, whereas others are more complex and may consist of several damp areas in a more complicated pattern, often at some distance from the original source of trouble (Douglas and Noy, 2011; Oliver, 1988). It is important to know that moisture can travel a considerable distance before revealing itself inside the building (Douglas and Noy, 2011). Although there are uniform phenomena seen in the microbial contamination of the indoor environment and health effects on the occupants, the original causes of moisture problems and the possibilities of eliminating them vary (Haverinen-Shaughnessy, 2007; Bornehag et al., 2001). There are a lot of remedial measures that have been employed to address all sorts of dampness situations worldwide. Tamas and Tuns (2008) tried to provide a solution to eliminate capillarity moisture from brick walls using the Comer Method. The findings from their study showed that this method provided a radical solution to the upward moisture problems in brick walls. Another method (The Dry Zone Technology) was employed by Tamas and Tuns (2010) to remove moisture from the capillary walls of buildings, a problem which appeared due to the lack of a horizontal insulation layer in those buildings or poor ventilation of interior spaces within such buildings. As part of larger test programmes regarding rising dampness in Danish masonry construction, Hansen and Frambol (2006) performed laboratory tests to evaluate the effects of chemical injection methods in treating rising dampness in masonry walls. The study showed that such agents had a braking but no stopping effect on rising dampness. Torres and de Freitas (2007) felt that many of the techniques used to minimize rising dampness were not effective, particularly, in dealing with walls of considerable thickness and heterogeneous materials. Experiments were performed at the Building Physics Laboratory (LCF) of the Faculty of Engineering of Porto University to validate a new technology for treating rising dampness in walls of historical buildings, using a wall base ventilation system. At the end of the experiment, the results showed that implementing this new treatment technology (wall base ventilation system) reduced the level of rising dampness but did not eliminate the problem. In a study in Denmark, Brandt et al. (2012) explored several measures taken to improve basements, i.e. getting them drier and explored new measures to stop rising dampness in the basements of structures. These methods as described by Brandt et al. (2012) included diversion/drainage of surface water away from buildings, sloping of terrain at least 1:40 away from the building and use of capillary braking layer underneath floors to avoid rising dampness in the floors, etc.In their study, all the tested methods proved usable, however, not all of them were considered suitable for commercial use either because of their safety implications or because they were very expensive in use (Brandt et al., 2012). Brooks (2008) in his study 'home moisture problems' outlined some solutions to home moisture problems and they included: adequate drainage around the house; repair and redesign of rain water downpipes; checking and replacing all leaking pipes; ceasing all moisture generation activities in buildings like cooking without lids, drying of wet clothing indoors, etc. Most of these methods proved to be effective in addressing some dampness problems like condensation and water penetration, however, where the problem originated from another source such as rising dampness, other methods were needed to assist in the remediation action (Burkinshaw and Parrett, 2004). According to Hutton (2012), the control of moisture movement using either damp-proof or hydrophobic materials to create a relatively less permeable 'moisture barrier' is not necessarily a cost effective option in controlling dampness problems and may even be counter-productive (Hutton, 2012). This is because a damp proof barrier is always vulnerable to local failure and will tend to concentrate moisture and dampness problems at those points. This is a general characteristic of all impermeable materials, including those used in tanking systems, which are generally found to fail at some point or after some time (Hutton, 2012).

3.0 Materials and methods

Between the months of November 2012 and March 2013, a questionnaire survey was conducted to assess building occupants' level of practice and effectiveness of some damp remediation measures in residential buildings in Ghana. A total of 5,800 building occupants living in 5,800 residential buildings in the four climatic zones of Ghana were selected for the study. Four main climatic regions are distinguished in Ghana; South-Western Equatorial (SWE), Dry Equatorial (DE), Wet Semi-Equatorial (WSE) and Tropical Continental or Savanna (TC) (Abass, 2009).

The South Western Equatorial Climatic zone is the wettest climatic region 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 region is Axim (Abass, 2009).The Dry Equatorial climatic zone has two rainfall maxima: but the dry seasons are more marked and the mean annual rainfall is considerably less-between 740 and 890mm. This region is the driest in Ghana. Temperatures are almost the same as in the south-west equatorial climatic region, and average monthly relative humidity is higher in the rainy seasons than during the rest of the year. A typical station for this climatic region is Accra. Cape Coast, Sekondi Takoradi and Ho also fall within this climatic region (Abass, 2009).The Wet Semi Equatorial Climatic zone has two rainfall maxima, but the mean annual rainfall is between 1250 and 2000mm. Some of the wetter areas include the Akwapim-Togo ranges and the SouthernVoltarian plateau where annual rainfall sometimes exceeds the second rainy season (from September to October). A typical station for this climatic region is Kumasi. Other towns include Sunyani and Enchi (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 1000 to 1150mm. Mean monthly temperatures vary from 36°C in March to about 27°C in August. A typical station for this climate is Zuarungu. Among the other towns in this zone are Navrongo, Bawku, Wa, Tamale, Salaga and Yendi (Abass, 2009).

Houses located in the major towns in the four main climatic zones were considered in the survey. This resulted in the survey being conducted at eleven locations in ten administrative regions in Ghana: According to the Ghana Statistical Service (GSS) (2000), the number of buildings located in each town are as follows: Sekondi-Takoradi in the Western region (with 24,817 buildings), Axim in the Western region (with 2,694 buildings), Cape Coast in the Central region (with 6,847 buildings), Accra in the Greater Accra region (with 131,355 buildings), Ho in the Volta Region (with 6,853 buildings), Koforidua in the Eastern Region (with 7,318 buildings), Kumasi in the Ashanti Region (with 67,434 buildings), Sunyani in the BrongAhafo Region (with 5,611 buildings), Tamale in the Northern Region (with 15, 873 buildings), Bolgatanga in the Upper East Region (with 3,932 buildings) and Wa in the Upper West Region (with 5,539 buildings). 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 $n = {}^{N}/_{1 + N(e)^2}$ *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 as follows: Sekondi-Takoradi (517 buildings), Axim (56 buildings), Cape Coast (143 buildings), Accra (2738 buildings), Ho (143 buildings), Koforidua (153 buildings), Kumasi (1,406 buildings) Sunyani (117 buildings), Tamale (330 buildings), Bolgatanga (82 buildings) and Wa (115 buildings). 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). In all, 1% of the buildings (56 out of 5,800) were selected from the South Western Equatorial, 61% (3541 out of 5,800) were selected from the Dry Equatorial, 29% (1,689 out of 5,800) were selected from the Wet Semi Equatorial and 9% (545 out of 5,800) were selected from the Tropical Continental Climatic Zones respectively.

Seven damp remediation measures which have been extensively studied were collected from the literature to form the basis of the questionnaire (Brandt et al., 2012; Hutton, 2012; Brooks, 2008; Haverinen-Shaughnessy, 2007). These measures were pre-tested in a multiple pilot study using interviews and questionnaire involving occupants in 50 selected buildings in Kumasi to evaluate their applicability to the current study. Most of the interviewees demonstrated in-depth understanding of the seven damp remediation measures but suggested additional remediation measures like the construction of aprons at the base of walls, repainting and patching of wall bases affected by dampness. These three additional measures were added to the seven measures from the literature, making a total of 10 damp remediation measures.

A structured questionnaire was prepared to seek the views of building occupants on the issues under consideration in the study. The questionnaire was divided into three sections. The first section sought information about the respondents' profile, the second part assessed respondents' knowledge on the level of practice of the ten damp remediation measures by scoring the measures on the Likert Scale of 1 to 5, (where 1= rarely practiced and 5=frequently practiced). The third part of the questionnaire sought the views of the respondents on the level of effectiveness of the practiced damp remediation measures by scoring on the Likert Scale of 1-5 (where 1= highly ineffective and 5=highly effective).

The study used the Weighted Average Model (WAM) (Ayarkwa et al., 2011) to assess the relative levels of practice and the levels of effectiveness of the damp remediation measures as perceived by the building occupants. The WAM based on the Average Practice Score (APS) and the Average Effective Score (AES) was calculated as:

$$APS_i = \frac{\sum_{i=1}^{5} X_j N_{ij}}{N}; \quad AES_i = \frac{\sum_{i=1}^{5} X_j N_{ij}}{N}$$

where APS_i is the average practice score of the damp remediation measure *i*, AES_i is the average effective score of the damp remediation measure *i*, X_j the damp remediation score assigned (on a Likert scale of 1 to 5). N_{ij} = the number of respondents who assigned the score X_j for the measure *I* and N is the total number of respondents. The WAM was further used to assess the level of practice of the damp remediation measure. To rank the level of practice of the damp remediation measures, the study employed the combined values of the weighted average and standard deviation. The coefficient of variation, measured as Practiced Index Value (PIV), was calculated using the model (Ayarkwa et al., 2011):

$$PIV_i = \frac{APS_i + APS_i}{\delta i}$$

Where PIV_i is the practiced index value of the damp remediation measure *i*, APS_i is the average practice score of the damp remediation measure *i* and δi is the standard deviation of the average practice score for the measure *i*.

The WAM was further used to assess the level of effectiveness of the damp remediation measures. To rank the level of effectiveness of the DRMs, the combined values of the weighted average and standard deviations were used and the coefficient of variation measured as the Effective Index Value was calculated using the model:

$$EIV_i = \frac{AES_i + AES_i}{\delta i}$$

Where EIV_i is the effective index value of the damp remediation measure *i,* AES_i is the average effective score of the damp remediation measure *i* and δi is the standard deviation of the average effective score for the measure *i.*

Although the ASS and AES are weighted average measures and could be used to rank all the damp remediation measures, they do not consider the degree of variation between individual responses. Since a smaller variation between individual responses gives better quality to the weighted average value, when two factors carry the same or very close weighted values, the factor carrying the smaller variation is given a higher ranking. Thus, the effective assessment of ranking attributes should consider both the weighted average and the coefficient of variation measured by the practice and effective index values.

4.0 Results and discussions

4.1 Respondent profile

The results of the survey (Table 1) show that 59% of the respondents who live in residential buildings in the four climatic zones were owners and 39% were tenants. A critical look at Table 1 shows that the proportion of buildings aged 1-4 years were 9%, 5-10 years were 24%, 11-20 years were 26% and greater than 20 years were 41%. Studies have shown that the age of buildings is very significant to any dampness study and the older the building, the more susceptible it is to dampness (Halim and Halim, 2010; Ahmed and Rahman, 2010; Trotman et al., 2007; Riley and Cotgrave, 2005). Since 91% of the buildings surveyed in all the climatic zones were 5years and above, they were susceptible to dampness attacks, hence, considered reliable for the study.

The results (Table 1) further show that the four major types of buildings surveyed in the study were detached/separate houses (66%), block flat/apartment (16%), semi detached houses (13%) and compound houses (5%). According to GSS (2000), compound houses constitute the largest proportion of building types in all regions in Ghana (45%) except Volta Region, where separate houses are predominant. For the other regions, the proportions range from 42% in Western Region to 56% in the Upper East Region (GSS, 2000). Separate/detached houses are the next major type of buildings in Ghana constituting 25% of all building types (GSS, 2000). Despite compound houses being the majority of building types in Ghana, the results from the study showed that most of the buildings that were surveyed were the detached type of buildings. This study was purpose oriented and was conducted irrespective of the findings from the GSS.

Table 1. Respondents' profile

CHARACTERISTIC OF RESPONDENT	FREQUENCY	PERCENTAGE
Designation of respondent		
Owner	3,514	61
Tenant	2,286	39
TOTAL	**5,800**	**100**
Age of building		
1-4 years	545	9
5-10 years	1,382	24
11-20 years	1,457	26
Greater than 20 years	2,416	41
TOTAL	**5,800**	**100**
Type of building		

Detached/separate	3,821	66
Semi detached	740	13
Block flat/Apartment	951	16
Compound house	288	5
TOTAL	**5,800**	**100**
Walling material		
Concrete	44	1
Earth/mud bricks	342	6
Burnt bricks	305	5
Sandcrete blocks	5,109	88
TOTAL	**5,800**	**100**

Table 1 also shows that the major type of material for the construction of walls of the buildings surveyed were sandcrete blocks which constituted 88% of all walling materials of building units. The earth/mud bricks constituted 6%, whiles concrete and burnt bricks constituted 1% and 5% respectively in all cases. This finding confirms that of GSS (2000), who identified the two main materials for the construction of the outer walls of buildings in Ghana to be mud brick/earth and cements which together accounted for 89.1% of walling materials of buildings. In this study, earth/mud bricks and sandcrete blocks accounted for 94% of the walling materials in buildings in the four climatic zones.

4.2 Level of practice of damp remediation measures

Table 2 shows a summary of the Average Practice Scores (APS), Practiced Index Values (PIVs) and rankings of the levels of practice of the damp remediation measures among building occupants. A factor is deemed important if it has an APS of 3 or more.

The results show that construction of aprons at the base of walls is the most frequently practiced damp remediation measure (ranked 1st with an APS of 4.02 and a PIV of 12.18 by the building occupants). Patching of wall bases, using damp proof courses and damp proof membranes, tiling of wall bases and repainting are ranked 2nd, 3rd, 4th and 5th respectively. Sloping of ground around the base of walls to allow easy run-offs of water, reduction of moisture generation activities in buildings and repair and redesign of new rain water down pipes and gutter systems were ranked 7th, 8th and 9th respectively (all three had their APS below the APS value of 3), indicating lowest level of practice among building occupants.This finding does not correspond to that identified in literature (Hutton, 2012; Brandt et al., 2012; Brooks, 2008; Haverinen-Shaughnessy, 2007). Whereas in the UK and other European countries measures such as ‘adequate drainage around the house’,‘repair and redesign of rain water downpipes’, ‘checking and replacing all leaking pipes’, etc. are frequently practiced to address the problem of dampness, building occupants in Ghana prefer the use of measures such as ‘construction of aprons at wall bases’, ‘patching of wall bases’, ‘repainting’ and ‘tiling of wall bases’ to address dampness problems in their buildings.The use of DPMs and DPCs were also among the measures practiced by building occupants to address dampness problems in their buildings. The results further show that the measure ‘repair and redesign of new rain water down pipes and gutter systems’was the least frequently practiced by building occupants in Ghana. However, this measure is one of the most frequently practiced damp remediation measures among building occupants in the UK and other

European countries (Brandt et al., 2012; Brooks, 2008, Haverinen-Shaughnessy, 2007).

Table 2 Level of practice of dampness remediation measures among building occupants

Damp Remediation Measure	**Average Practice Score (ASS)**	**Standard Deviation (δi)**	**Practice Index Value (PIV)**	**Rank of Practiced Index Value (RPIV)**
Patching of wall bases	4.13	0.69	11.97	2nd
Tiling of wall bases	4.08	0.82	9.95	4th
Construction of aprons at wall bases	4.02	0.66	12.18	1st
Reduction of moisture generation activities in buildings like cooking without lids, etc.	2.80	1.34	4.18	9th
Sloping of ground around the base of walls to allow easy run-offs of water	1.92	0.91	4.22	8th
Checking and replacing all leaking pipes	1.90	0.84	4.52	7th
Redesign and projections of roof structures to reduce the effects of driving rain and direct sunlight	1.78	0.78	4.56	6th
Repainting	3.01	1.30	4.63	5th
Repair and redesign of new rain water down pipes and gutter systems	1.62	1.04	3.12	10th
Using damp proof courses (DPCs) and damp proof membranes (DPMs)	3.65	0.66	11.06	3rd

4.3 Level of effectiveness of dampness remediation measures

Table 3 shows a summary of the AES, Effective Index Values (EIVs) and ranking of the EIVs (REIVs) of the ten damp remediation measures. For a damp remediation measure to be effective it should have an AES value of 3.0 or more, otherwise, it is considered ineffective.Table 3 shows that all the measures have AES values of less than 3, and therefore considered by building occupants as ineffective measures for controlling dampness in residential buildings. These measures were therefore ranked based on their Effective Index Values (EIVs).The EIVs made use of the AES and the standard deviations of the measures, hence, the measure with the highest effective index value was ranked first followed by the others.

Although none of the ten measures was considered effective per the analysis (thus, all have AES values less than the mean value of 3), the ranking of the effective index values show that ‘using damp proof courses and membranes’, ‘construction of aprons at wall bases’, ‘tiling of wall bases’, ‘patching of wall bases’, and ‘repainting’, have shown some level of effectiveness in addressing the problem of dampness in buildings.

Table 3 Summary of Average Effective Score, Effective Index Value and Rank of Effective Index Values

Dampness Remediation Measure	Average Effective Score (AES)	Standard Deviation (δi)	Effective Index Value (EIV)	Rank of Effective Index Value (REIV)
Construction of aprons at wall bases	1.14	0.35	6.51	2nd
Sloping of ground around the base of walls to allow easy run-offs of water	1.77	0.74	4.78	7th
Redesign and projections of roof structures to reduce the effects of driving rain and direct sunlight	1.39	0.75	3.71	9th
Repainting	1.38	0.56	4.93	5th
Tiling of wall bases	2.06	0.79	5.22	3rd
Checking and replacing all leaking pipes	1.96	0.87	4.51	8th
Repair and redesign of new rain water down pipes and gutter systems	1.61	0.98	3.29	10th
Patching of wall bases	1.90	0.77	4.94	4th
Using damp proof courses (DPCs) and damp proof membranes (DPMs)	1.83	0.43	8.51	1st
Reduction of moisture generation activities in buildings like cooking without lids, etc	1.91	0.79	4.84	6th

The results from this study have shown that with the exception of the worldwide notion of the effectiveness of damp proof courses and damp proof membranes in addressing dampness problems, other measures, which have also shown some level of effectiveness in addressing the same problem in residential buildings in Ghana include the 'construction of aprons at wall bases', 'tiling of wall bases', patching of wall bases' and 'repainting of the affected areas'. Measures such as 'adequate drainage around the house','repair and redesign of rain water downpipes', 'checking and replacing all leaking pipes', etc. which have shown to be effective in addressing various types of dampness like condensation and water penetration in most European countries (Brandt et al., 2012; Brooks, 2008; Young, 2007; Haverinen-Shaughnessy, 2007) have been less effective in Ghana. The reason behind this is that most of these measures are very effective in treating certain types of dampness like condensation and water penetration which are common but not very severe in Ghana. In Ghana, rising dampness appears to be the commonest and the most severe type of dampness and some of these measures have not been effective in addressing such a problem.

a) Patching of wall bases against damp

b) Tiling of wall bases against damp

Fig. 1 a) b)

c) Construction of aprons at wall bases
d) Replastering/ aprons at base of wall

Fig. 1 c) d)

Figure 1 a, b, c, and d show some of remedial measures applied by building occupants in addressing dampness in the walls of their buildings.

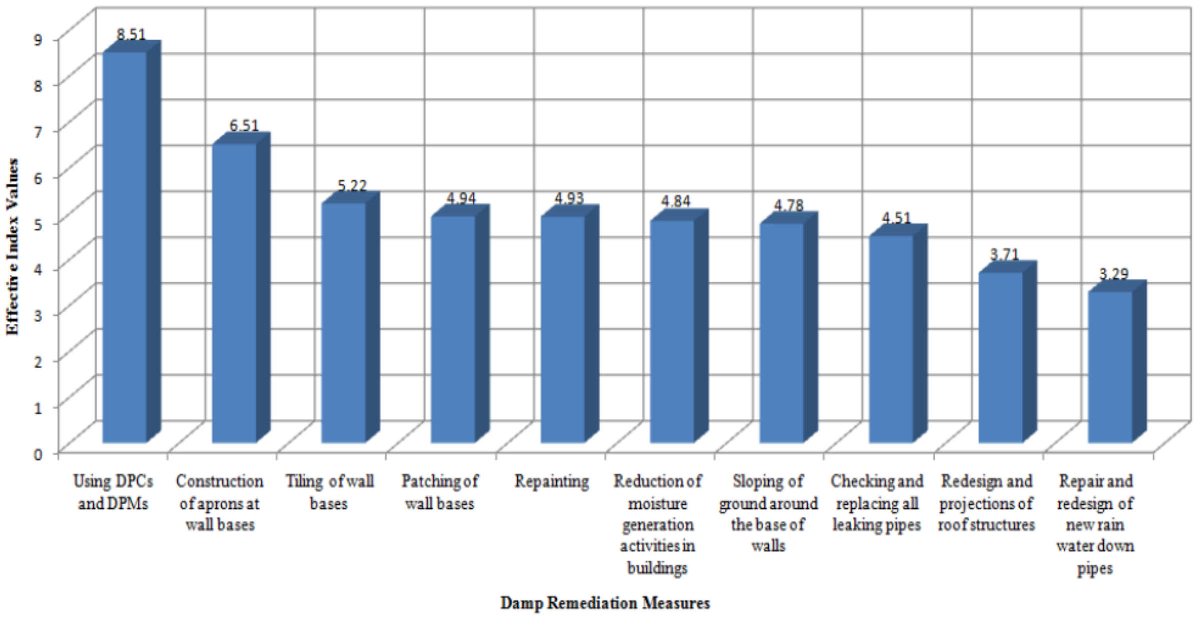
Fig 2 a b) c)

From Figure 2 ‘a’, ‘b’ and ‘c’ it can be seen how the dampness is still rising after the application of some of the remedial measures.

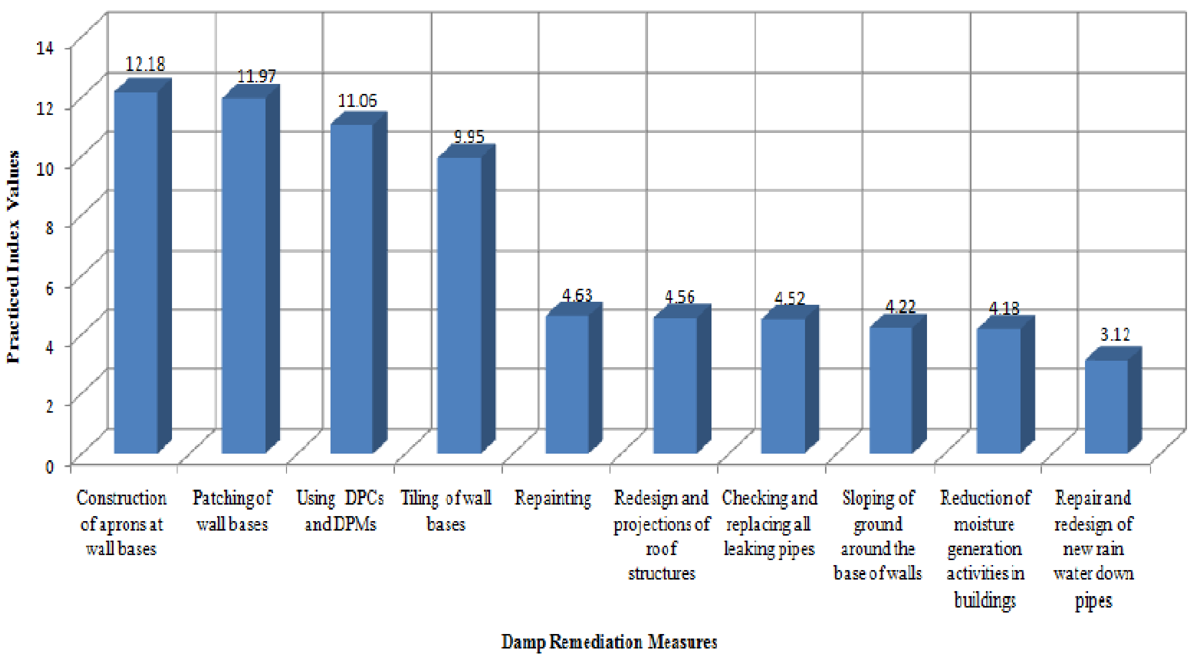
Figure 4 Ranking profile of the levels of effectiveness of damp remediation measures

The results from the ranking profile (Figure. 3) show that the five most frequently practiced damp remediation measures in Ghana are‘construction of aprons at wall bases’, ‘patching of wall bases’, use of damp proof courses and membrane’,‘tiling of wall bases’ and repainting.Though using DPMs and DPCs is the third most practiced damp remediation measure among building occupants in Ghana (Figure 3), it is the most effective of all the measures (Figure 4). Figure 4 also show that ‘construction of aprons at the base of walls’, ‘tiling of wall bases’, patching of wall bases’ and repainting of affected areas’ have all shown some level of effectiveness in addressing dampness problems in Ghana.

5.0 Conclusions



This study sought to assess the level of practice and level of effectiveness of damp remediation measures adopted by building occupants in Ghana. The results from the study have shown that 'construction of aprons at the base of walls', 'use of damp proof courses and membranes', 'tiling of wall bases', 'patching of wall bases', and 'repainting the affected areas' are the five out of ten damp remediation measures most frequently practiced to address the problem of dampness in Ghana. The results have also shown that all the ten damp remediation measures studied have been ineffective (because their Average Effective Scores were less than 3) in addressing the problem of dampness in Ghana. However, when the ten measures were ranked based on their Effective Index Values, 'use of DPCs and DPMs', 'construction of aprons at wall bases', 'titling of wall bases' etc. were among the measures which showed some level of effectiveness in their application to address the problem of dampness in buildings. The results also showed that with the exception of the DPCs and DPMs already known worldwide as a remediation measure of dampness,



‘construction of aprons at wall base’, ‘tiling of wall bases’ and ‘patching of wall bases’ are also damp remediation measures which are frequently practiced by building occupants in Ghana, and which have shown some level of effectiveness in their applications.These findings will assist in creating the needed environment for all stakeholders to come together and find a common solution to address the problem of dampness in residential buildings in Ghana.

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