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EVALUATION OF DAMPNESS IN RESIDENTIAL BUILDING IN KAURA-NAMODA ZAMFARA STATE, NIGERIA

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ABSTRACT
As one of the most damaging failures that occur in buildings, dampness in all its forms affects both old and modern types of buildings. As an important function, buildings should seek to prevent water penetrations and give envelop to their occupants. This study sought to examine dampness which is non-structural defect in the walls and floors of Residential Buildings in Kaura Namoda. A case study approach which involves a three-stage protocol of damp investigation, thus visual inspection, non-destructive tests using a moisture meter and destructive testing was employed. The results from the visual investigation showed that dampness was seen on the external and internal walls of the building and was accompanied by symptoms such as damp patches in horizontal bands, flaking of mortar, blistering of paint, surface efflorescence and stains. The findings revealed that various forms of dampness existed within the building, including rising damp, penetration damp and, rain water splash back and lateral penetration. A further investigation with the moisture meter showed that dampness was more pronounced in the external walls. Also, destructive tests revealed that the dampness in the bathroom walls were due to plumbing leakages. This study has shown that it is possible to apply the principles of damp for appraisal of dampness or otherwise in buildings.

Keywords: *Dampness, water penetration, residential buildings, rising damp, salt analysis*

1. INTRODUCTION

Dampness in walls of buildings is inextricably linked to most building deterioration [1]. It also creates unsightly appearances, emanates bad odour in houses and causes permanent damage to plaster, paint and finishes [2], [3] and [4]. Dampness is a very serious structural defect which spoils paints and interior decorations, encourages mould and rots growth, hampers aesthetics, poses a threat to the health of occupants [5]. Also, dampness can lead to cosmetic problems, damage to building fabrics, structural problems and at certain instances create adverse health effects on residents of the affected building [6].

Dampness penetration is one of the most damaging faults that can occur, whether a building is old or of modern type of construction [3] and [4]. It can damage brick/block work by saturating it, cause decay and break up of mortar joints, fungal attack in timber and corrosion in iron and steel as well as stained wall surfaces [6]. 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 [7].

In addition, 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 [8]. 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 [7]. Nigeria also has its share of the problem of dampness. Field surveys carried out have shown that the problem has presented an alarming dimension in some residential and institutional buildings in several parts of the country [9], [10], [11] and [12]. The main objective of this study was to identify the symptoms associated with dampness in walls of residential buildings of Kaura Namoda, Nigeria.

2. DAMPNESS IN BUILDINGS

Most of the materials used in the construction of buildings are porous in nature. Thus, an appreciable quantity of water, also known as moisture, will be present in a relatively ‘dry building’. A building element or component that retains this amount of water is said to be damp. Different qualitative terms used to denote the presence of excess water or moisture in buildings include dampness, condensation, damp patches, damp spots, water collection and moisture problem. According to [13] dampness is defined as the wetting of structural elements through moisture rise by capillary action. Dampness is the most frequent and main problem in buildings and contributes more than 50% of all known building failures [14]. According to [1], 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 [14].

Sources of dampness can be classified as rising dampness, penetrating dampness and condensation and pipe leakages [1]. Dampness can also be classified as air moisture, condensation, penetrating dampness and internal plumbing leaks, below ground moisture or building specific sources [4].

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 [2]. 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 [15]. [4] 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'. The visible symptoms of rising damp include dampness on the lower parts of walls, sometimes up to 1.5m in horizontal bands [15]. Rising damp may also present itself as salty yellowy browny patches of plaster/décor just above the height of skirting boards [16].

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 [17]. Penetration damp is the term applied to the penetration of moisture through the fabric of buildings over a period of time. 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. 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.

2.3 **Condensation**

Dampness resulting from condensation occurs where water in the air inside a building condenses on a cooler surface [18]. This is usually indicative of cold spots in the building, sometimes called cold bridges [18]. 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 [19]. 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. [19] which is as a result of running water on windows and walls is the immediate indication of a condensation problem.

2.4 **Principles of Dampness Investigation**

The most important objective of any dampness study is to identify the lead source of moisture in order to recommend actions to remedy the problem [12]. During the course of a damp investigation, the sense of sight, touch, taste, smell and hearing as well as communication and analytical skills should be utilized [4]. The four stages approaches to damp investigation include: Visual Investigation, Non-destructive Testing and Destructive Testing.

3. **STUDY AREAS**

The study was conducted in Kaura Namoda town, Zamfara State which is located in the Northwestern geopolitical zone of Nigeria. It was founded in 1807 and has an area of 868 km^2 and a population of 281,367 at the 2006 census. The building used as a case study is a flat house of three bedroom, located in the Sabuwar Kaura area with coordinates of $12^0$35'11"N; 6^0 35'21"E. It was remodeled in year 2017

4. METHODOLOGY

The survey sought to identify and document areas in the walls of the building severely affected by the problem of dampness. This should assist in a detailed investigation later to aid in the recommendation of appropriate methods to address the problem. The investigation consisted of a single case study of the building reported to be experiencing severe dampness problems. Literature reports that in an invasive inspection, more can be learned about damp damage in one inspection than in a hundred more cursory surveys [4]. The building was chosen because it had been severely affected by dampness and therefore offered a suitable case for study. The study adopted a holistic approach to dampness investigation involving visual inspection, non-destructive test and destructive test.

4.1 Visual Investigation

The visual inspection was conducted through the observation of the surrounding area, checking of the damp zones and physically identifying the causes of the dampness based on the symptoms identified from the building. Furthermore, examinations of the exteriors of the building from street level and from higher access (roofing, rain water gutters, etc.) were carried out for any obvious defects. Also, the interior parts of the building were examined to determine areas affected by dampness. Figure 1 shows some of the damp affected areas identified from the visual inspection.

a) Stain in the horizontal band; b) Water run marks on windows; c) flaking of paint
Figure 1: Affected areas of building identified during visual inspection

4.2 Investigation Using Moisture Meter (Non-destructive Testing)

The non-destructive testing on the building was carried out to identify the problematic areas. Moisture content measurements were taken on the walls of the building which showed symptoms such as blistering of paints, peeling of paints and staining. Grids of 300 mm x 300 mm were drawn on the surfaces of affected walls and moisture contents were recorded.

The universal moisture meter was used to measure moisture contents in the sandcrete block walls of the building. This is

multifunctional equipment that can read moisture content, temperature and the relative humidity of the affected walls. Checklists were prepared to record readings. The readings were important in identifying areas within the wall zones where the problem was very severe for further investigation to be conducted.

For the building under study, since the walls in all orientations had been affected by dampness, grids of 300mm x 300mm were drawn on all the walls using a tape measure and light wooden batten. On the faces of the suspected damp walls, a tape measure was laid along the walls and at right angles to this; alight wooden batten was used to mark some values. These markings created grids against which moisture meter readings could be plotted. Damp walls in the various orientations extended from about 600mm to 900mm depending on how high the water had risen.

Figure 2 shows the procedures that were followed to measure the moisture contents for the gridlines to be drawn.

5. RESULTS AND DISCUSSION

Key findings from the principles used in the study are presented under the various stages to include the following:

5.1 Visual Investigation

The investigation revealed that there were combinations of several sources of dampness. These included plumbing leakages, rising dampness, condensation, among others. This stage further revealed that dampness in the walls of the building was associated with symptoms such as blistering of paint, flaking of plaster, surface efflorescence and stains on the walls. Symptoms such as surface efflorescence, damp base of walls up to1.5m in horizontal band, among others, closely related to rising dampness were identified.

5.2 Non-destructive Investigation

The non-destructive tests conducted with the Universal moisture meter identified the dampness to be pronounced in both the external and internal walls and bathrooms are presented in Table 1 below:

Table 1: Results of the Universal Moisture Meter

source	**Bedroom1**		**Bedroom2**		**Bedroom3**		**Sitroom4**	
	Moisture (%)	Relative Humidity (%)	Moisture (%)	Relative Humidity (%)	Moisture (%)	Relative Humidity (%)	Moisture (%)	Relative Humidity (%)
External walls	2.4	18.8	2.5	19.8	2.3	18.2	2.4	18.8
Internal walls	0.8	6.5	1.0	8.0	0.8	6.5	0.9	6.8
Bathroom walls	10.5	82.3	9.5	74.4	9.6	76.0	10.3	80.2

The results from the universal moisture meter revealed that the readings of the moisture content and relative humidity of the external wall range from 2.3% to 2.5% and 18.2% to 19.8% respectively. This implied that the external walls are under moist condition as recorded by [2] that for moist condition of dampness, moisture content ranges between 1.5% to 2.8% and relative humidity lies between 18% rH to 21% rH.

The result from Table 1 also revealed that that the readings of the moisture content and relative humidity of the internal walls range from 0.8% to 1.0% and 6.5% to 8.0% respectively. This implied that the internal walls are under dry condition of dampness

as recorded by [13] that for dry condition of dampness, moisture content is less than 1.5% and relative humidity lies between 6% rH to less than18% rH.

The results also revealed that that the readings of the moisture content and relative humidity of the bathroom walls range from 9.5% to 10.5% and 74.4% to 82.3% respectively. This implied that the bathroom walls are considered to be a wet zones having recorded higher moisture content greater than 2.8% and relative humidity ranges between 22% rH and 100% rH [2] and [13].

5.3 **Destructive Investigation**

The destructive investigation revealed that the Plumbing leakages were identified in the bathroom walls and could have contributed to the severity of the dampness. Furthermore, dampness was pronounced in the external walls of bedroom than the external walls of bedrooms. All the destructive tests conducted revealed that dampness in most of the bathroom walls were due to plumbing leakages. However, on the exterior walls of the buildings, rising dampness was very predominant up to 1.5m recorded.

6. **CONCLUSION**

Dampness is most frequently reported as the main cause of building defects around the world. If residential properties are to be carefully surveyed regularly, many problems will be identified before they become very severe. Unfortunately, most houses are often inspected by construction professionals when the problem has become sufficiently advanced to be noticed by the occupier. This paper adopted the principles involved in the diagnosis of damp as outlined and accepted internationally, and applied those principles to a real-life scenario. A typical case was selected (a three-bedroom residential building), and the principles were applied to diagnose the presence of dampness or otherwise in the building.

The study revealed that various forms of dampness existed within the building. The forms included rising damp, penetration damp and plumbing leakages, rain water splash back and lateral penetration. The study further revealed that although all the various forms were present, rising damp was the most predominant. A further investigation with the moisture meter showed that dampness was more pronounced in the bathroom walls.

The destructive tests revealed that the dampness in the bathrooms were due to plumbing leakages and water penetration respectively. This study has shown that it is possible to apply the principles of damp for appraisal of dampness or otherwise in building

7. **RECOMMENDATION**

Laboratory test of the samples of the mortar from the building is recommended to investigate form of dampness which is associated with dangerous salts such as Na_2SO_4, $MgSO_4$ and $MgCl_2$.

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