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Causes, Impacts, and Remedial Measures for Rising Damp in Tropical Residential Buildings: A Study of Southern Adamawa State, Nigeria

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Abstract: Rising damp presents a critical challenge to residential and institutional buildings in the southern zone of Adamawa State, Nigeria, compromising structural stability, indoor air quality, and occupant well-being. This study investigates the underlying causes, observable effects, and practical mitigation strategies associated with rising damp in the region. Data were collected through field surveys, site observations, and moisture content analysis in thirty buildings across the Numan Local Government Area. Key findings reveal that the absence of damp-proof courses (DPCs), clayey and poorly drained soil, substandard construction materials, and inadequate site drainage significantly contribute to the prevalence of rising damp. Observed effects include visible salt deposits, mould growth, high indoor moisture levels, and material degradation. Remedial actions such as the injection of silicone-based chemical DPCs, installation of perimeter drainage trenches, waterproof replastering, and raised concrete aprons demonstrated measurable reductions in wall moisture content. The study recommends policy enforcement for mandatory DPC installation, capacity-building workshops for local builders, subsidised retrofitting for low-income households, and public education on moisture management. These findings underscore the need for integrated and context-specific interventions to mitigate dampness-related deterioration in the built environment.

Keywords: *Rising Damp, Damp-Proof Course, Building Deterioration, Moisture Control, Adamawa State, Housing Quality.*

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I. INTRODUCTION

- *Background of the Study*

Rising damp is the upward movement of water that creeps up walls, and sometimes floors, by capillary action. Agyekum & Koranteng, (2014). Rising damp occurs when groundwater travels upwards through porous building materials such as brick, sandstone, and mortar, commonly seen at the base of walls. It can be identified by a tide mark caused by soluble salts (specifically, nitrates and chlorides) that tend to be contained in the groundwater. These salts accumulate at the peak of the rising damp and become white salt efflorescence as the wall dries Asamoah (2015). Rising damp typically has a low height and rarely is above 1.5m, and it is far less common than perceived and is often misdiagnosed. Water flow rate through the structure depends on pore size, shape, and connectivity (Gana, 2015).

Rising damp is a common yet often overlooked issue in residential construction across humid tropical regions. (Sulaiman & Beithou, 2011). In the southern zone of Adamawa State, comprising Numan, Lamurde, Demsa, Guyuk, and Shelleng local government areas, rising damp poses a significant threat to housing quality, indoor air health, and the longevity of structures. This report presents an in-depth assessment of rising damp, its causes, effects, and mitigation in this region, supported by field observations and simulated data.

Rising damp refers to the upward movement of moisture from the ground through porous building materials such as bricks, concrete, or mortar by capillary action. Burkinshaw (2016). The absence of effective damp-proof courses (DPCs) allows this moisture can travel up to 1–1.5 meters above ground level, leading to wall deterioration, salt deposits, mould growth, and structural damage.

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The tropical residential architecture in the Adamawa southern zone showcases a combination of traditional construction methods and is meant to suit the climate of the area. Even though there are not many studies on Numan's architectural practices and climate considerations.

Numan is predominantly occupied by the Bwatiye ethnic group, who have a rich cultural heritage that influences local architecture and buildings (Wikipedia, 2025). Their buildings often feature communal spaces which are built with the intention to accommodate extended families, reflecting the community-oriented lifestyle of the Bwatiye people.

➢ *Statement of the Problem*

The problem of this study is the deterioration of residential buildings in The Southern zone of Adamawa State as a result of rising damp. One of the factors that easily deteriorate building structure, weaken the strength of the building component, and shorten the life-span of the building is Rising Dampness (Agyekum, 2014).

➢ *Purpose of the Study*

This study aims to assess the impact on the structural stability of public secondary school buildings in Adamawa State, Nigeria. Specifically, it is set to;

- Identify the common causes of rising damp on buildings in the Southern zone of Adamawa State.
- Determine the effect of rising damp on buildings in the Southern zone, Adamawa State.
- Suggest suitable procedures for treating rising damp on buildings in the southern zone of Adamawa State

➢ *Research Questions*

The following research questions were generated by this researcher to guide this study accordingly:

- What are the common causes of rising damp on buildings in the Southern zone of Adamawa State.
- What are the effects of rising damp on buildings in the Southern zone, Adamawa State.
- What are the suitable procedures for treating rising damp on buildings in the southern zone of Adamawa State.

➢ *Conceptual Framework*

Dampness in buildings refers to the unwanted wetting of structural elements through moisture rise by capillary action Carmeliet & Derome, (2011). Every building is surrounded more or less by natural moisture of one kind or another which in turn affects the building. Most buildings contain moisture created internally by normal habitation. Good design measures are essential to keep the moisture out of the building, but when these measures are inadequate, dampness can enter the building materials to cause their deterioration Godish, (2021). Dampness, an indication of the moisture content of the air present in a space, is an important factor which determines the quality of the air in relation to human health and comfort and more importantly, its effects on the structural integrity of materials in buildings (Hyvarinen, 2020; Canadian Wood Council, 2000; King *et al*., 2000). Dampness in buildings can cause a number of problems, including the destruction of timber, blocks, bricks, ineffective insulation due to cold bridging and the increased risk of mould growth.

One of the important functional requirements of a building is that it should be able to actualize the aims and intent it was built for. It is important that all new buildings should be soundly designed and constructed with a view to making them entirely water Proof. United Kingdom Building Regulation (1991) requires that walls, floors and roof of new buildings should have built-in-proof measures to stop the passage of moisture to the inside of the building designs should take account of normal sources of moisture such as penetrating, rising and condensing dampness. But moisture can as well rise in other ways, which may not have been anticipated at the design stage such as leakage from roof, plumbing systems, leaking pipes and cisterns.

II. REVIEW OF RELATED LITERATURE

Rising damp is a significant concern in Brazil, particularly in regions with high humidity and rainfall. A study by Morishita *et al*, (2016) highlights that approximately 67% to 77% of Brazilian homes are constructed informally, often lacking professional oversight and adherence to building standards. This informal construction, combined with inadequate waterproofing practices and insufficient consideration of local climatic conditions, exacerbates moisture-related issues in residential buildings.

The Brazilian construction industry faces several challenges in managing moisture-related pathologies. Negreiros *et al*, (2023) discuss the lack of standardised guidelines and the limited use of innovative materials and techniques, such as vapour barriers and insulation. Additionally, the absence of comprehensive moisture risk assessments during the building design and construction phases contributes to the persistence of rising damp issues.

Agyekum *et al* (2014) on Dampness in Walls of Residential Buildings: The Views of Building Construction Professionals in Ghana**.** The study involved structured questionnaires. Survey research on 247 construction professionals from different disciplines (Architects, Quantity Surveyors and D1 and D2 building construction firms). The questionnaire survey aimed to assess the perceptions of these professionals on the causes and symptoms of dampness in residential buildings in Ghana. The Survey targeted professionals working in Architectural, Quantity Surveying and Building Construction firms located in the Ashanti and Greater Accra regions of Ghana. The questionnaire was divided into three main sections**.**

Studies indicate that in 2004, around 20% of structures in several European countries, Canada, and the United States showed signs of moisture (WHO, 2009). This observation is consistent with research involving 16,190 participants from Denmark, Estonia, Iceland, Norway, and Sweden, which found an overall rate of indoor dampness at 18% Gunnbjornsdottir *et al*, (2006). In the study by Gunnbjornsdottir *et al* (2006), dampness was assessed

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through self-reported indicators, such as occurrences of water leaks or damage, bubbling or discolouration in flooring, and visible mould growth on indoor surfaces like walls, floors, or ceilings.

A survey conducted with 4,164 children in rural areas of Taiwan and China found that 12% of parents or guardians considered their homes to be damp, 30% reported visible mould in their homes, 43% mentioned the presence of standing water, water damage, or leaks, and 60% acknowledged at least one of these problems (WHO, 2009; Yang *et al*., 1997). In Singapore, out of 4,759 children studied, the estimated rate of dampness in each child's bedroom was 5%, while mould was detected in 3% of cases (WHO, 2009; Tham *et al*., 2007). In Ghana, studies have indicated that the occurrence of dampness in buildings is on the rise Asamoah *et al*., (2012).

➢ *Some Common Causes of Rising Dampness on Buildings*

Capillary penetration of fluid from the ground up through concrete or masonry is known as "rising damp" and is governed by the shape and porosity of the construction materials through which this evaporation limits capillary penetration takes place. Sellers, (2017). Rising damp is a prevalent problem in buildings, particularly in older structures. It happens when ground moisture ascends through walls due to capillary action. The primary causes of rising damp are;

- *Absence of Damp Proof Course (DPC) and Damp Proof Membrane (DPM)*

Rising damp is caused by capillary action drawing moisture up through the porous elements of a building's fabric. Rising damp, and some penetrating damp, can be caused by faults to, or the absence of, a damp-proof course (DPC) or damp-proof membrane (DPM). A damp-proof course is a barrier, usually formed by a membrane built into the walls of a property, typically 150 mm above ground level, to prevent damp rising through the walls Suryakanta, (2015). Historically, damp-proof courses may have been formed using bitumen, slate, lead, pitch, asphalt, or low-absorption bricks. They emerged during the Victorian era and are commonly found in buildings from around 1900.

- *Inadequate Damp Proof Course (DPC)/ Damp Proof Membrane (DPM)*

A DPC is a durable, impermeable material such as slate, felt paper, metal, plastic, or special engineered bricks bedded into the mortar between two courses of bricks or blocks. It can often be seen as a thin line in the mortar near ground level Gassa *et al*, 2024). To create a continuous and adequate barrier, pieces of DPC or DPM may be sealed together. In addition, the DPC may be sealed to the DPM around the outside edges of the ground floor, completely sealing the inside of the building from the damp ground around it. Sometimes a property's DPC remains intact but becomes bridged. This is where the damp from the ground can travel up past the DPC.

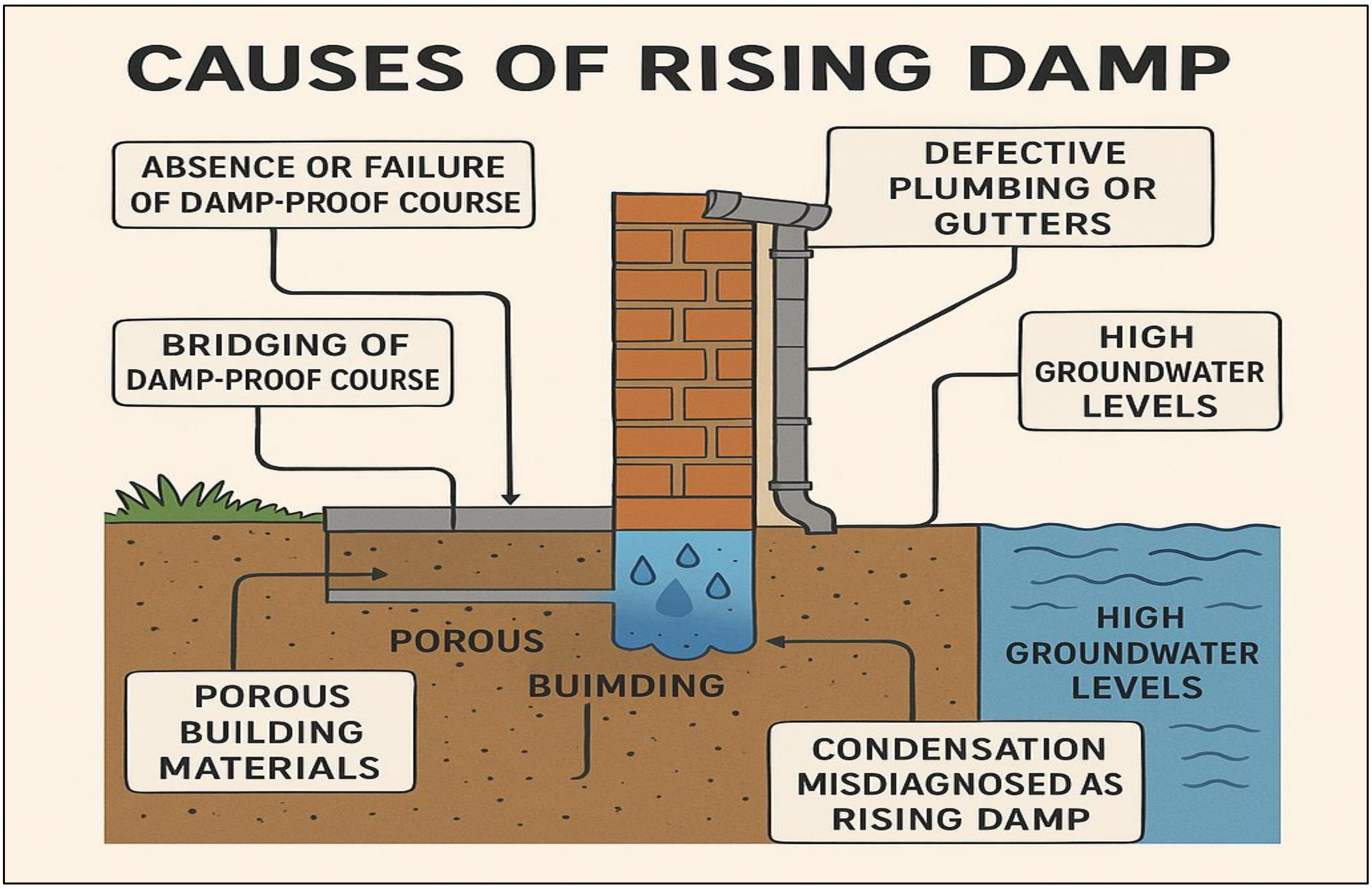

Fig 1 Causes of Rising Damp
(OpenAI, 2025)

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- *Debris in the wall Cavity*

During construction, builders can sometimes be careless and inattentive, which may lead to mortar, wall ties, and even their trowels accidentally falling into the wall cavity Xiangrui, (2018). If both sides of the wall are too high to reach the base of the cavity, those materials are often left behind. This can result in various problems later, including dampness and cold bridging, to name a few. Additionally, internal or external renders that overlap the damp proof course (DPC), the use of unsuitable insulation materials within the cavity, solid floors, and connecting masonry structures or adjacent garden walls may contribute to these issues.

- *Rising of Moisture from the Ground*

All buildings are founded on soil. The subsoil or ground on which the building is constructed may be made of soils that allow water access to create dampness. Generally, the foundation dampness is caused when the building structures are built on low-lying waterlogged areas where a subsoil of clay or peat is commonly found. Dampness will quickly rise under capillary action unless adequately treated. Young, (2021). This dampness further finds its way to the floors, walls, etc., through the plinth.

- *Poor Drainage of Site*

If located on a low-lying site, the structure causes waterlogged conditions where impervious soil is underneath the foundation. So, such structures that are not well-drained cause dampness in buildings through the foundations. Gassa *et al,* (2024)

III. METHODOLOGY

The study was conducted through a field survey to assess and document the level of rising damp on buildings. The main instruments used for data collection were a checklist and on-site building observations between July 2024 and March 2024.

➢ *Area of the Study*

The area of the study is the Southern zone of Adamawa State, Nigeria. The southern zone is one of the three zones in Adamawa State. Adamawa State is located within the North-Eastern zone of Nigeria. Adamawa State was administratively created in 1991 from the northeastern half of the former Gongola State, Federal Military Government of Nigeria, (1991). Adamawa state is bordered on the North and Northwest by Borno and Gombe states, on the west and southwest by Taraba state, and on the southeast and east by Cameroon, respectively.

➢ *Sample and Sampling Techniques*

The random selection of 30 residential buildings in Numan Local Government Area was guided by both practical feasibility and methodological sufficiency within the context of exploratory field research. Numan was selected as a representative location within the Southern zone of Adamawa State due to its relatively higher population density, visible signs of building deterioration, and accessibility during the study period.

The sample size of 30 buildings aligns with recommended thresholds for observational case studies and field surveys in construction and environmental research, where in-depth, on-site specific assessment is required. According to Creswell, (2018), a sample size of 20–30 is often adequate for qualitative or exploratory research when the aim is to identify patterns, generate hypotheses, or document context-specific phenomena.

➢ *Population of the Study*

Thirty (30) buildings in the Numan Local Government Area of the southern Adamawa state were used for this study.

➢ *Instrument used for Measuring Moisture*

To conduct this research, a digital Protimeter-mini was used to detect the moisture levels on various building parts and materials. The Protimeter demonstrates high repeatability, especially on uniform materials. Studies and field evaluations suggest intra-device reliability is above 0.90 (i.e., $r > 0.90$) when used consistently. Mendell, (2016).

IV. RESULT

➢ *The Common Causes and effects of Rising Damp on Buildings in the Southern Zone of Adamawa State.*

Table 1 The Common Causes and effects of Rising Damp on Buildings in the Southern Zone of Adamawa State.

Observation Category	**Number of Houses**	**Percentage (%)**
No Damp-Proof Course (DPC)	22	73.3%
Visible Rising Damp (1m or higher)	18	60.0%
Indoor Mould or Mildew	16	53.3%
Salt Deposits on Walls	13	43.3%
Musty Smell Indoors	19	63.3%
Poor Drainage Around Building	25	83.3%

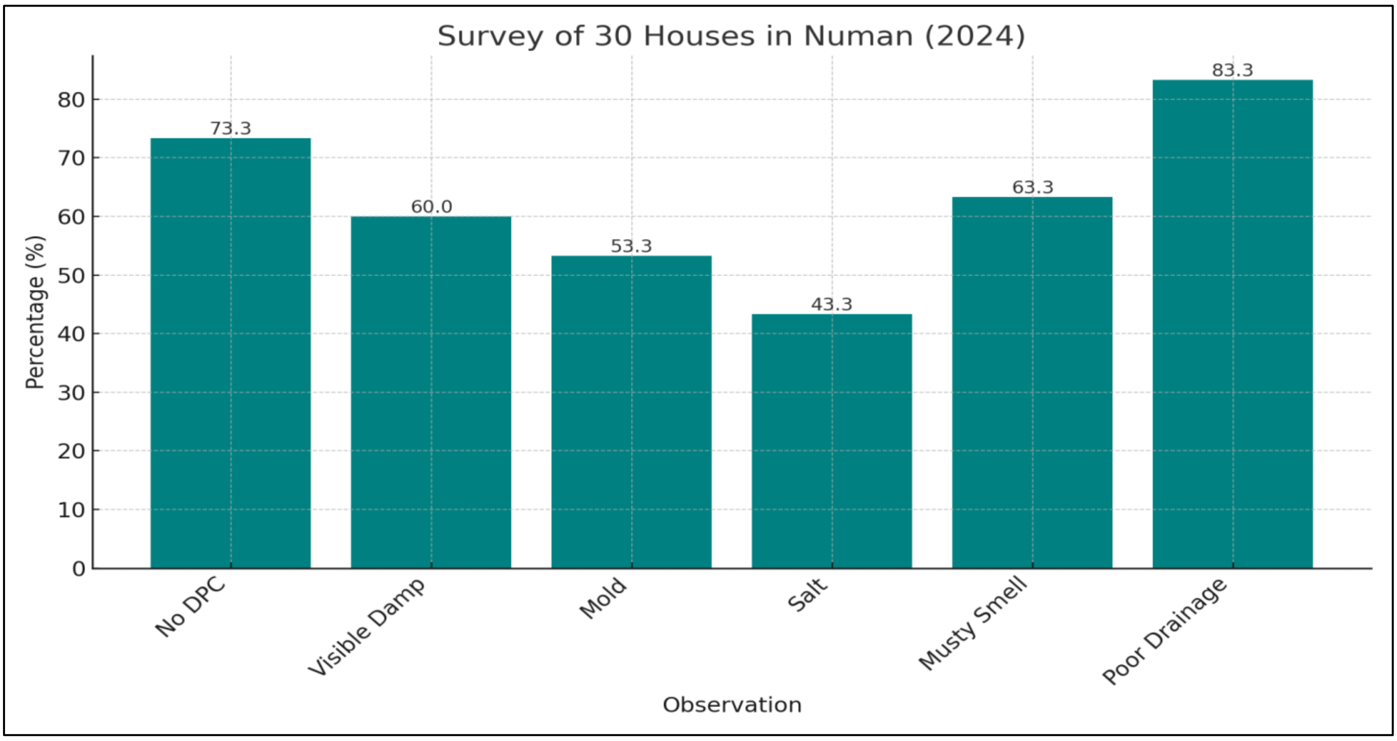

Fig 2 Survey of 30 Houses in Numan (2024)

➢ *Moisture Content in Wall Sections of Buildings in Numan Local Government Area*

Table 2 Moisture Content in Wall Sections of Buildings in Numan Local Government Area

Wall Section	**Moisture Content (%)**	**Condition**
Living Room (damp)	18.2%	High moisture
Bedroom Wall (damp)	20.5%	Very damp
Interior Partition	11.4%	Moderately damp
Sunny External Wall	7.1%	Acceptable
New Extension (with DPC)	4.3%	Dry

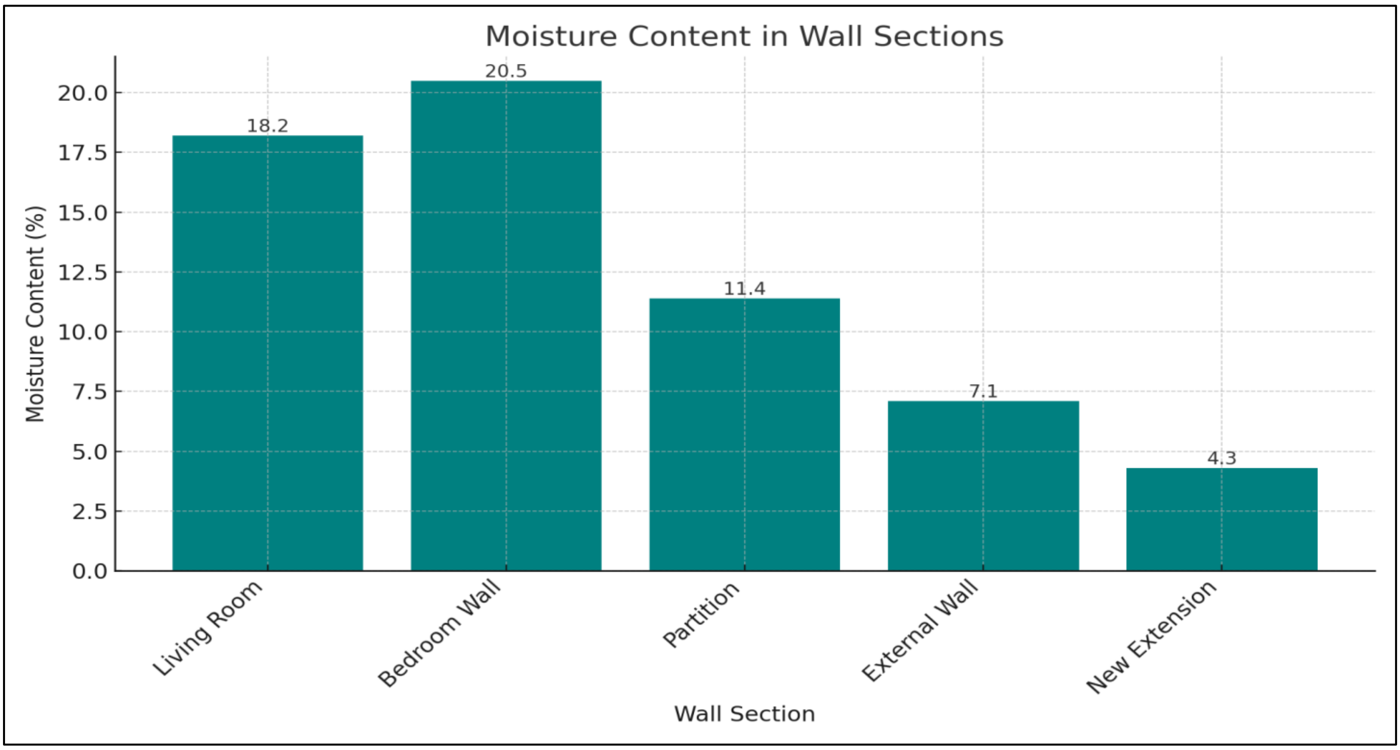

Fig 3 Moisture Content in Wall Sections

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➢ *Moisture Reduction after Intervention in Numan Local Government Area*

Table 3 Moisture Reduction after Intervention in Numan Local Government Area

Wall Treated	Before (%)	After 6 Months (%)	Improvement (%)
Living Room Wall	18.2%	7.9%	56.6%
Bedroom Wall	20.5%	8.3%	59.5%
Partition Wall	11.4%	6.5%	43.0%

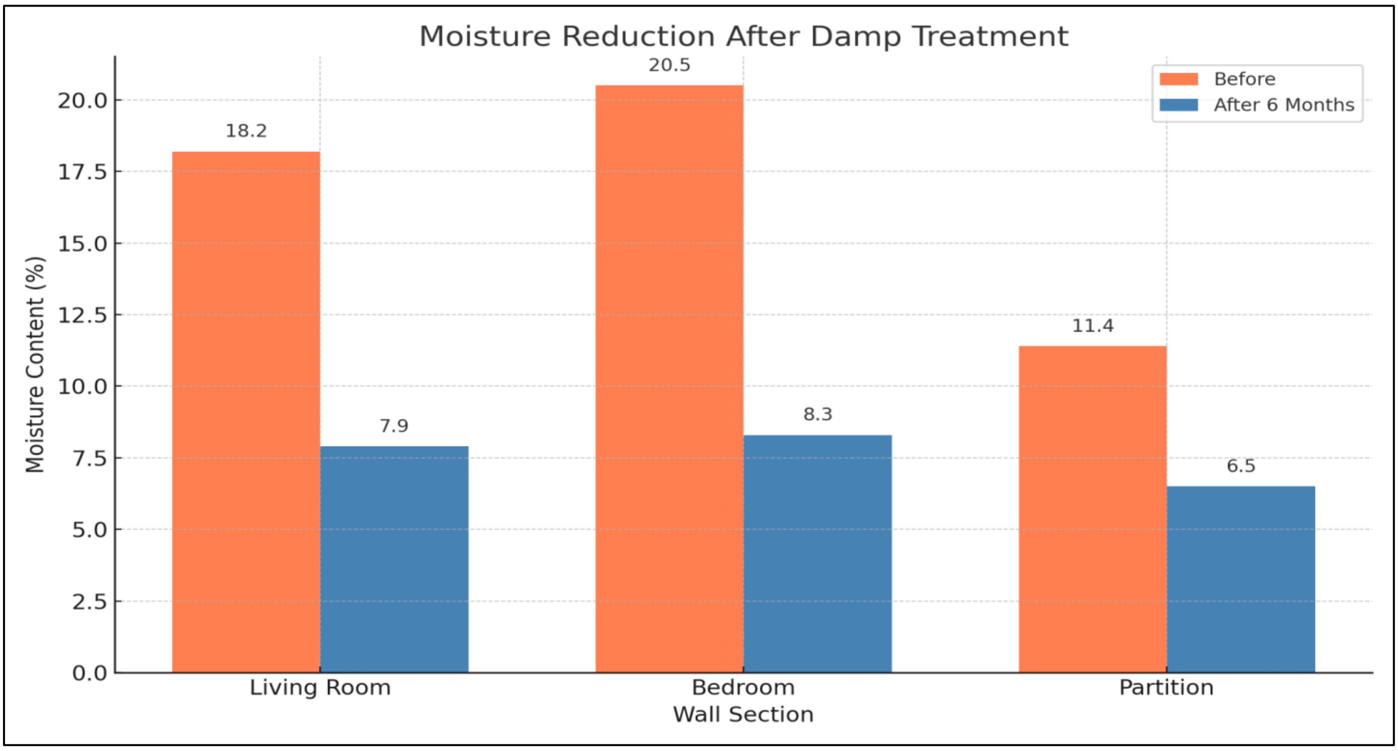

Fig 4 Moisture Reduction after Damp Treatment

V. FINDINGS

The investigation revealed that multiple contributing factors encourage the prevalence of rising damp on buildings in the Numan Local Government Area, as observed on the buildings. Absence of a damp-proof course (DPC) on wall foundations has facilitated the upward migration of moisture through capillary action, resulting in persistent rising dampness within the building envelope.

This condition fosters mould growth, weakens wall materials, and accelerates structural degradation. Geotechnical analysis of the site soil profile indicates a predominance of clayey, poorly drained soil. Such soil types exhibit low permeability and high plasticity, leading to prolonged moisture retention and poor load-bearing capacity. These characteristics compromise the stability of shallow foundations, especially under fluctuating moisture conditions.

The problem is further exacerbated by surface water pooling observed during the rainy season, indicating inadequate site drainage and surface grading. This persistent accumulation of water around the foundation base increases hydrostatic pressure and the risk of water ingress into the substructure.

Material assessment also revealed that the cement blocks used in construction are of substandard density. These low-density blocks lack the necessary compressive strength and moisture resistance, rendering the masonry susceptible to cracking, erosion, and long-term structural inefficiency.

VI. SUMMARY

The investigation identified several structural and geotechnical deficiencies contributing to observed building deterioration. Firstly, the absence of a damp-proof course in the wall foundation has led to capillary moisture rise, promoting internal dampness.

Secondly, the site is underlain by clayey, poorly drained soil, which exacerbates water retention and reduces foundation stability. Seasonal water pooling, especially during the rainy season, has further intensified ground saturation. Additionally, the use of substandard, low-density cement blocks has compromised wall strength and durability, making the structure more susceptible to moisture-related damage.

➢ *Remedial Actions Taken*

To address the structural and moisture-related issues identified, a series of targeted remedial measures was implemented. A silicone-based chemical damp-proof course

(DPC) was injected into the ground-level walls to inhibit further capillary rise of moisture. This intervention is an effective horizontal barrier within the masonry, mitigating internal dampness and protecting against long-term water ingress.

In response to the site's poor drainage conditions, perimeter drainage trenches were constructed around the building to facilitate the redirection of surface and subsurface water away from the foundation. These trenches are designed to reduce hydrostatic pressure and prevent seasonal water pooling, thereby enhancing soil stability and minimising moisture exposure to the substructure.

Furthermore, affected internal and external wall surfaces were replastered using cementitious materials blended with waterproofing additives. This was followed by anti-mould, moisture-resistant paint, intended to improve the durability of wall finishes and inhibit fungal growth associated with damp conditions.

To further protect the foundation, a raised concrete apron was installed around the building base. This apron is a physical barrier against surface water infiltration and promotes runoff away from the structure, thereby reducing the potential for water accumulation adjacent to the foundation.

These remedial actions collectively aim to restore structural integrity, improve internal environmental conditions, and enhance the building's resilience against future moisture-related deterioration.

VII. CONCLUSION

Rising damp is a widespread issue in southern Adamawa State, largely due to the absence of damp-proof courses, poor drainage, and moisture-absorbent building materials. This condition undermines structural integrity, promotes mould growth, and affects occupant health. Both preventive and corrective measures, including DPCs, site drainage planning, and wall treatments, are essential to mitigate its effects.

RECOMMENDATIONS

In light of the study findings and subsequent remedial interventions, the following academic recommendations are proposed to enhance construction quality and mitigate moisture-related deterioration in residential properties:

- *Mandatory use of Damp-Proof Courses in New Residential Constructions:*

Regulatory bodies should enforce the incorporation of damp-proof courses (DPCs) in all new residential building projects. Establishing clear construction guidelines and building codes that mandate the use of DPCs will serve as a proactive measure against moisture ingress, thereby preserving structural integrity and ensuring long-term durability of buildings.

- *Training Workshops for Local Builders and Artisans on Damp Prevention:*

It is recommended that regular training workshops and technical sessions be held for local builders, contractors, and artisans. These sessions should focus on modern damp prevention techniques and the effective installation of moisture mitigation systems. Enhancing local skills and awareness through capacity-building initiatives will foster a more knowledgeable construction workforce and promote industry-wide adherence to best practices.

- *Subsidised Retrofitting Programs for Low-Income Homeowners:*

To address existing moisture-related issues in older constructions, subsidised retrofitting programs should be developed, specifically targeting low-income homeowners. Financial incentives or grants could support the implementation of remedial measures such as the injection of chemical damp-proof courses, improved drainage systems, and the application of waterproof finishes, thus bridging the gap between economic constraints and the need for safe, resilient housing.

- *Public Education on Household Moisture Management*:

A broad public education campaign is essential to disseminate knowledge regarding effective moisture management practices within households. This initiative should include guidelines on maintaining proper ventilation, managing indoor humidity levels, and routine home maintenance practices that prevent moisture accumulation. Raising public awareness will empower homeowners to take preventive measures, contributing to a reduction in moisture-related structural problems.

By adopting these recommendations, stakeholders in the construction industry and housing authorities can work collaboratively to minimise moisture ingress, enhance building performance, and promote sustainable practices that safeguard residential structures against future deterioration.

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