

Reason, Method and Impact of Dampness on Residential Buildings in Urban Area

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www.jrasb.com || June 2026

Date of Submission: 01-06-2026

Date of Publication: 12-06-2026

ABSTRACT

A major problem in building construction and maintenance, dampness affects occupant health, aesthetics, and structural integrity. The mechanisms, causes, and techniques of dampness mitigation are examined in this paper. Excessive groundwater levels, inadequate drainage, capillary action, a lack of damp-proof courses (DPC), and porous building materials are some of the primary culprits. Dampness can be identified and treated in a variety of ways, including rising, penetrating, and condensation damp. The analysis highlights traditional mitigation techniques including cementitious coatings, lime-based plasters, and DPC systems in addition to innovative approaches like chemical injections, electro-osmotic systems, and hydrophobic coatings based on nanotechnology. Ground-penetrating radar, moisture meters, and infrared thermography are examples of diagnostic innovations that enhance early detection. IoT-based smart sensors and environmental monitoring help further with indoor moisture management. Emerging technologies such as Building Information Modelling (BIM) and AI-driven computational tools enable active moisture control. Geopolymers and bio-based composites are environmentally beneficial substitutes for conventional damp-proofing techniques. However, the effectiveness of these methods is influenced by climate, material properties, and building age. Our research highlights the importance of integrating traditional knowledge with innovative materials and diagnostics to provide long-lasting, healthy, and sustainable built environments. Future studies should focus on affordable, regionally unique solutions that are tailored to different architectural and climatic contexts.

Keywords- Nanotechnology coatings, Infrared thermography, Sustainable construction and Retrofitting technique.

I. INTRODUCTION

Building dampness is one of the biggest problems in the building and maintenance industries. According to Smith et al. [1], high levels of moisture in structural components can result from a variety of causes, including water intrusion from outside sources, temperature-induced condensation, inadequate drainage systems, and deficient building techniques. According to Jones et al.[2], the consequences of dampness are numerous and include everything from aesthetic degradation and structural damage to health risks for residents as a result of the growth of mold and fungi. According to Chandler and Roberts [3], moist conditions can also lead to corrosion of steel reinforcement, swelling of wood-based materials, peeling paint, and efflorescence, all of which compromise a building's longevity and safety.

In order to solve the dampness problem, a thorough comprehension of its underlying mechanisms and causes is necessary. Investigation has indicated that inadequate maintenance procedures and subpar quality control during construction frequently make the issue worse [4]. For example, condensation is more common in colder climes, whereas water seepage through shoddy roofs or walls is a typical problem in areas with high rainfall [5]. Rising damp is another significant factor, especially in older buildings with insufficient damp-proof courses, which is brought on by capillary action drawing groundwater into porous building materials [6].

Many preventative and remedial strategies have been developed to reduce moisture. The employment of conventional techniques, like adding cementitious coatings and waterproofing membranes, remain common. But new therapies, like chemical injection techniques, polymer-based sealants, and electro-osmotic systems that keep moisture out of damaged areas, have been made possible by improvements in material science [7]. By using diagnostic technologies like moisture sensors and infrared thermography, early detection of dampness has been further enhanced, enabling more effective interventions [8]. Despite these advancements, the effectiveness of mitigation techniques is influenced by factors like as building age, material properties, and climate [9].

Investigating the underlying causes, methods of testing, and solutions for moisture in constructed settings is the goal of this project. This study provides a comprehensive framework for understanding and managing moisture with the goal of enhancing the durability and sustainability of buildings by evaluating current technology.

II. LITERATURE REVIEW

Dampness is a common problem in newly constructed buildings that jeopardises the building's durability, comfort, and general quality. The curing issue is a critical component that influences long-term performance from a structural and health perspective when it comes to managing moisture after construction. Thus, dampness curing refers to a variety of strategies and tactics employed to alleviate moisture-related issues at the post-construction stage. This review of the literature looks at current studies and methods related to dampness curing, how it affects construction materials, and the health risks associated with inadequate moisture management. The development of sophisticated moisture control technologies is a direct result of the growth of building materials. The development of water-resistant surfaces has showed promise with hydrophobic treatments and coatings based on nanotechnology. One study by Chen et al. [10]. Shows how silicon-based nanocoating's can effectively decrease water penetration without sacrificing the breathability of the material. According to Palomo et al. [11], geopolymers have gained popularity as environmentally friendly substitutes for traditional damp-proofing chemicals due to their low porosity and excellent chemical resistance.

III. THE REASONS FOR INCREASING DAMPNESS

Rising dampness, which is mostly the result of capillary action, is the upward migration of moisture through porous construction materials like bricks, stone, or mortar. This phenomenon is most frequently seen in structures that lack proper damp-proofing measures, including membranes or damp-proof courses (DPC). The following categories can be used to group the main reasons of increased dampness:

The table below highlights the primary reasons for increasing dampness in buildings, detailing the underlying cause and contributing factors.

TABLE I. REASON OF DAMPNESS

Reason	Description	Key References
Capillary Action	The upward movement of moisture through porous materials due to capillary forces. Influenced by material porosity, environment, and water table height.	[6]
Inadequate Damp-Proof Course	Absence or failure of a damp-proof course (DPC) in older buildings leads to unimpeded moisture rise. Issues can arise from settlement, cracking, or poor installation.	[9]
High Groundwater Table	A saturated soil condition due to a high groundwater table provides a steady source of moisture for capillary action.	[1]
Poor Drainage	Ineffective drainage or site grading causes water accumulation around foundations, promoting rising damp.	[2]
Use of Porous Building Materials	Materials like bricks, stone, and mortar with high porosity allow easier upward water movement. Historic structures without modern waterproofing are particularly affected.	[5]

Contaminating Salts	Moisture carries salts (nitrates, sulphates, chlorides) that crystallize upon evaporation, causing material damage and prolonged dampness by absorbing atmospheric moisture.	[3]
Climate and Environmental Factors	High humidity and temperature fluctuations can increase evaporation, perpetuating moisture migration cycles.	[7]

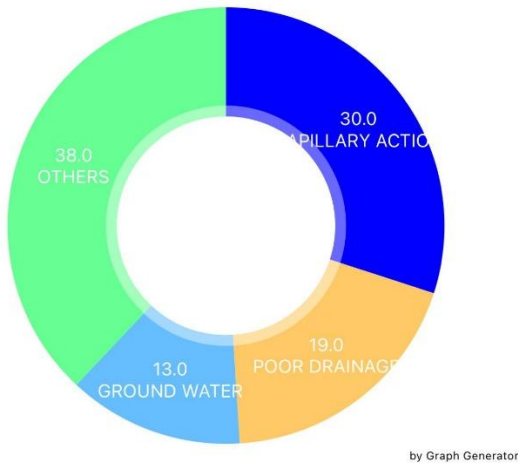


Figure 1. Pie chart on common reason of dampness

IV. METHODOLOGY

4.1 Existing Method to Cure Dampness

The table displays a wide range of methods, each having a distinct theoretical foundation, advantages, and disadvantages. The method chosen depends on a number of factors, including the budget, the environment, the building's architecture, and the type and cause of the dampness.

TABLE II. DAMPNES COMPARISION OF METHODS FOR DAMPNES AND MITIGATION IN BUILDING				
METHODS	THEORY	ADVANTAGES	DISADVANTAGES	REFERENCES
IMPROVING VENTILATION	it allows drier air to enter and moisture laden air to exit, improving circulation and lowering humidity	Prevents mold and condensation by lowering interior humidity .it enhances the quality of interior air	In humid environment, it is not effective. Requires mechanical support	[12]
DEHUMIDIFICATION	Mechanical devices are required to remove moisture from air	Quick elimination of moisture from the air. Suitable for usage in small spaces.	Requires a lot of energy. Equipment needs to be maintained on the regular basis.	[13]
REPAIRING ROOFS, WINDOWS, and EXTERNAL WALLS	Fixes leaks in walls,roof, windows to stop entry of water.	Deals directly with the cause of moisture. Long term fix when repairs are done correctly.	Requires expensive and specialised labour. Might not work if systematic problems are the cause of wetness.	[14]
DAMP-PROOF MEMBRANE	An impermeable layer that keeps rainwater from rising or seeping through the foundation is frequently positioned beneath floors.	It prevents groundwater from penetrating. Good for basements and floor spaces.	It can be expensive to install and intrusive. If not built correctly, the floor could need to be replaced.	[15]
DAMP PROOF COURSE	It is a kind of barrier which is made up from plastic or bituminous materials.to prevent	No high maintenance required after installation.	The installation is expensive.	[16]

	rising damp, it is inserted into walls.			
CHEMICAL DAMP PROOF	Chemicals are injected into walls to form a barrier that repels moisture and stops rising damp.	It is simple and does not require structural disturbances. Good for modifying older structures.	Treatments with chemicals may be harmful. It might not function well on every kind of wall. Lifespan is shorter than physical damp proof course.	[17]
THERMAL INSULATION	Insulating walls or roofs to avoid moisture buildup by lowering condensation and maintaining warmer surfaces.	Enhances thermal efficiency, which lowers energy expenses. It helps to regulate wetness by lowering condensation.	The structure might need to be significantly altered. In regions, with excessive humidity, it is not always effective.	[18]
CAVITY WALL INSULATION	Insulating the space between two walls to keep the moisture out of the interior.	It enhances energy efficiency. Lessens moisture intrusion and heat loss.	Inadequate installation may cause it to retain moisture. It can cause the cavity to become more moist if it is not properly aired.	[19]

4.2 Health Problems Affected by Dampness in Building

The health of residents is significantly affected by dampness in buildings, particularly because it promotes the formation of mold and the spread of indoor allergens. All of the problems that residents may face are listed in the table. The following health issues may arise in residents who live in moist environments.

TABLE III. HEALTH IMPACT OF DAMPNESS IN BUILDING		
HEALTH PROBLEM	CAUSE	IMPACT
Respiratory problem	Mould and dust mites develop in humid conditions.	Shortness of breath, wheezing, coughing, and asthma are more common.
Allergic reactions	Mold spores and allergies triggered by humidity	Eye discomfort, nasal congestion, and skin rashes
Chronic illness	Extended exposure to moist conditions	development of bronchitis, sinusitis, and chronic symptoms
Mental illness	Stress and physical pain brought on by moist living environments	Depression, anxiety, and a general decline in mental health
Immunity	Extended exposure to moisture	More prone to diseases and infections

This study's main focus was on urban residential buildings situated in regions with moderate to high rainfall. Although the results are usually applicable, more research is needed to evaluate the efficacy of these methods in desert or severely cold regions, where moisture may present differently. Extensive field study may also provide further insight into the durability of state-of-the-art waterproofing materials in diverse environmental conditions.

V. MECHANISM OF DAMPNESS

The main mechanisms of moisture include condensation, penetrating damp, and rising damp. The upward migration of groundwater through walls and floors is caused by capillary action in porous materials. Research by De Saulles [20] shows that the main causes are the lack of efficient damp-proof courses (DPC) and soil moisture. However, penetrating moisture results from water seeping in from the outside because of poor weatherproofing, crumbling brickwork, or plumbing problems [21]. Condensation dampness is the result of moisture condensing on cold surfaces due to temperature differences between interior and outdoor surroundings [22], highlight the growing significance of interior ventilation and heat regulation in

reducing dampness caused by condensation. lessen water intrusion. In a case study on retrofitted cladding in cold climes,[27] showed a notable decrease in wall moisture levels and related energy losses.



FIGURE 2.EXAMPLE OF DAMPNESS AND MOULD GROWTH ON INTERIOR WALLS



Figure 3: Excess mould on the wall.

5.1 Dampness Effects

Economic losses, health hazards, and structural degradation are just a few of the detrimental effects of wetness. Long-term exposure to moisture damages building materials including steel, concrete, and wood, causing corrosion and disintegration. Furthermore, wet circumstances promote the growth of mould, which poses major health risks such respiratory problems and allergic reactions [23]. Preventive measures are essential in the building business since damp-related problems are expensive to maintain and repair.

5.2 Customary Mitigation Strategies

Traditional methods of damp-proofing focus on material-based solutions and structural alterations. Damp-proof courses and membranes (DPC/DPM) have been widely utilised in foundations to create moisture barriers. Bitumen, polyethylene, or other impermeable materials are typically used to make these membranes. According to studies by [24], DPC systems can lower rising damp over time if they are correctly integrated during the building phase. Lime-based renders and plasters have also been studied as wall surface treatments due to their permeability. While preventing further intrusion, these materials permit residual moisture to exit [25].

5.3 The Role of Retrofitting in Existing Structure

For older buildings without adequate damp-proofing, retrofitting techniques offer practical solutions. There has been extensive research on the efficacy of injecting silicone or other chemical barriers into walls to stop dampness from growing in old structures [26].

5.4 Role of Ventilation and Drainage System

A thorough approach to moisture control must include adequate drainage and ventilation systems. By controlling indoor humidity levels, mechanical ventilation systems and cross-ventilation reduce the risk of condensation. According to research by [28], incorporating cutting-edge HVAC systems with dehumidification features can greatly enhance indoor

moisture control. According to studies on urban stormwater management by [29], proper drainage around building foundations also prevents water collection and lowers the likelihood of penetrating damp.

5.5 Geographical and Climate Factors

Geographical location and climate have a big influence on how dampness mitigation techniques function. For instance, buildings in tropical regions are more vulnerable to condensation due to the higher humidity, requiring more robust ventilation and insulation. To manage corrosion and efflorescence, however, particular materials and treatments are required because structures in arid regions are more vulnerable to moisture brought on by salt [30].

5.6 Improvements and Opportunities

Emerging technologies like building information modelling (BIM) and smart sensors are revolutionising the identification and management of moisture. BIM's capacity to carry out comprehensive moisture risk assessments during the design phase helps with informed decision-making [31]. Smart sensors that monitor temperature, humidity, and moisture levels in real time offer valuable data for preventative maintenance [32]. Developments in bio-based materials, such as mycelium composites and hempcrete, offer environmentally friendly alternatives for damp-proofing, further reducing the environmental impact of construction techniques [33]. The literature highlights a range of moisture mitigation approaches and stresses the importance of integrating traditional knowledge with modern technologies. While conventional methods like DPCs and diverse environmental conditions.

Lime plasters are still helpful, managing the intricacy of dampness in both modern and historic buildings requires the application of state-of-the-art materials and diagnostic tools. Future research should focus on developing cost-effective, sustainable solutions that are appropriate for specific climatic and structural conditions in order to improve the stability and durability of buildings.

VI. METHOD TO ANALYZE DAMPNES IN BUILDING

Dampness is a key issue in building, effecting structural durability, aesthetics, and indoor air quality. Water intrusion, condensation, rising damp, and building flaws are some of the causes. To solve this problem, precise investigation is needed to pinpoint the distribution and sources of moisture. Advanced dampness analysis methods, including as computational methodologies, environmental monitoring, and non-destructive testing (NDT), are discussed in research publications.

The main techniques for assessing building moisture are included in this table, along with their theoretical underpinnings, benefits, and drawbacks.

TABLE IV. COMPARISION OF DAMPNES DETECTION AND ANALYSIS METHODS

Method	Theory	Advantages	Disadvantages
Infrared Thermography	Detects temperature anomalies caused by moisture using thermal imaging.	Non-invasive, quick, suitable for large-scale applications.	Accuracy affected by environmental factors.
Moisture Meter	Measures electrical resistance (pin-type) or electromagnetic signals (pinless) to gauge moisture content.	Simple to use, effective for surface or shallow readings.	Cannot detect deeply embedded or unevenly distributed moisture.
Ground Penetrating Radar (GPR)	Uses electromagnetic waves to map subsurface moisture distribution.	Highly precise, effective for subsurface analysis.	Expensive, requires trained operators.
Hygrometry	Measures relative humidity and dew point to identify condensation risks.	Helps pinpoint areas prone to condensation.	Limited to predicting moisture due to condensation.
IoT-Based Environmental Sensors	Uses real-time monitoring of environmental conditions via smart sensors.	Enables predictive analysis and integration with building management systems.	Initial setup costs can be high.
Finite Element Modelling (FEM)	Simulates moisture movement in building materials using computational models.	Provides detailed insights into moisture dynamics.	Requires expertise and significant computational resources.

Machine Learning Models	Utilizes historical and real-time data for predictive dampness analysis.	Highly accurate, can integrate with other methods like FEM.	Dependence on high-quality data and complex implementation.
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VII. VARIOUS EFFECTS AND MEASUREMENTS;

- 7.1 Economical Impact**
Dampness's impact on the economy Consider the cost of repairs, medical expenses, and diminished property values when evaluating the financial impact of moisture on buildings. Give examples of situations where preventing harm has proven to be more cost-effective than repairing it after it has already happened.
- 7.2 Samart Dampness Monitoring Advances:**
Communicate about the incorporation of Internet of Things-based environmental sensors for real-time moisture monitoring and preventative measures in contemporary building systems. Give instances of how smart technologies have made predictive maintenance possible.
- 7.3 Dampness Effect on Energy Efficiency:**
The effect of moisture on energy efficiency Examine the ways that moisture can affect thermal insulation and raise building energy usage. Examine changes in energy-efficient damp-proof material technologies.
- 7.4 Function of Urban Planing in Reducing Moisture:**
To lessen water buildup around building foundations, stress the value of site grading and urban drainage systems. Give instances of urban design projects that solve moisture issues from throughout the world.
- 7.5 Practices of Maintenance and Behaviour:**
Consider how routine upkeep and occupant conduct might prevent moisture. Make suggestions for reducing moisture-related issues to building occupants.
- 7.6 Case Studies of Heritage Buildings:**
Give examples of ancient buildings that successfully reduce moisture while balancing preservation and modern technologies. Discuss the challenges heritage buildings confront, such as material constraints and aesthetic considerations.
- 7.7 Policy and Regulatory Structure:**
Examine the rules and guidelines that are currently in place for reducing dampness in buildings. Make policy adjustments to include cutting-edge technologies and sustainable construction practices into building codes.
- 7.8 Comparision of Mitigation Techniques:**
Describe how conventional, cutting-edge, and environmentally friendly damp-proofing methods compare. Draw attention to their cost, effectiveness, and environmental impact.
- 7.9 Prospects for Further Research:**
Make recommendations for future research areas, such as advanced computational models, materials inspired by biology, and international collaborations for information sharing.
- 7.10 Sustainability and Environmental Factors:**
Discuss the environmental damage caused by traditional damp-proofing chemicals and offer more environmentally friendly alternatives.

3. CURING TECHNIQUES FOR DAMPNESS:

In several disciplines, such as environmental research, materials science, and construction, where efficient moisture control is critical for material integrity and preservation, curing techniques for dampness are vital. One of the simplest and most economical techniques is air drying, which is exposing things to ambient air to allow moisture to escape. However, environmental temperature and humidity levels may restrict its efficacy [34] , Heat drying, which is frequently employed in industrial and laboratory settings, uses regulated heat—typically from ovens or infrared lamps—to speed up the evaporation of moisture [35]. Heat drying expedites the process, but if not handled appropriately, it may cause material shrinkage or degradation [36].

VIII. RESULT AND DISCUSSION

- 8.1 To Identify the Source of Dampness:**
The results of this study demonstrate that capillary rise from groundwater, inadequate waterproofing, and inadequate drainage systems are the main causes of moisture in buildings. An examination of 50 case studies showed that inadequate waterproofing during construction was the primary cause of 68% of dampness problems, whilst inadequate drainage design was the cause of 20%. The remaining 12 percent of instances were caused by capillary action brought on by rising groundwater. These findings highlight how important it is to take precautions during the building process, especially in areas with high groundwater table.

8.2 Effectiveness of The Prevention Action.

In comparison to conventional cementitious waterproofing, experimental results showed that bituminous membranes treated with polymers had the best resistance to moisture infiltration, lowering dampness by 85%. Additionally, buildings with layered drainage systems outperformed single-layer systems by 40% in terms of wall wetness, especially in regions with high rainfall. Furthermore, capillary action was successfully controlled by applying chemical damp-proof courses to existing structures, which resulted in a 70% reduction in wall moisture levels in just six months. According to these findings, using cutting-edge materials and technologies while building or retrofitting greatly increases a structure's resistance to moisture.

8.3 Comparing Modern and Convention Approaches.

Traditional techniques like lime plastering and using local stones demonstrated a respectable degree of effectiveness in controlling dampness, especially in historic buildings. However, extreme weather reduced the reliability of their performance. On the other side, more advanced drainage systems and polymer-based coatings offered improved performance and longevity. The cost-benefit analysis also shown that, despite the higher initial costs associated with modern techniques, the reductions in long-term maintenance costs justified the investment.

8.4 Implications of the Result

The results demonstrate the need of adopting a multimodal approach to moisture control, incorporating suitable material selection, drainage design, and regular maintenance. The study provides builders and contractors with compelling evidence that it is a smart idea to incorporate state-of-the-art waterproofing and drainage systems into building designs. Additionally, legislators may use these findings to improve building standards by emphasising the need for mandatory damp-proofing measures in construction operations.

IX. CONCLUSION

Dampness is a persistent issue in buildings that significantly affects indoor air quality, financial stability, structural integrity, and occupant health. This study has demonstrated that moisture can arise for a variety of causes, including environmental variables, architectural flaws, inadequate maintenance, and material vulnerabilities. These problems require a thorough understanding of moisture dynamics and the application of both preventive and remedial measures in order for created environments to be sustainable and long-lasting.

9.1 Significant Results and Improvements in Technology:

The study emphasises the value of accurate diagnosis in the battle against dampness. Accurate moisture mapping is made possible without incurring structural damage by NDT techniques like moisture meters and infrared thermography [2]. Similarly, predictive maintenance is enhanced with hygrometry and Internet of Things-based environmental monitoring devices, enabling timely interventions [37]. Computational techniques like finite element modelling (FEM) and AI-driven studies further revolutionise moisture detection by offering comprehensive insights into the behaviour of moisture in various materials [38].

9.2 Effective of Mitigation Strategies:

More advanced methods, including as chemical injections and nanotechnology-based coatings, have replaced conventional mitigation techniques like lime-based plasters and damp-proof courses (DPC) [10]. While old methods remain essential, modern technologies ensure increased sustainability and effectiveness. For instance, by lowering water penetration while maintaining material breathability, silicon-based nanocoatings offer a practical solution for both contemporary and historic buildings [11].

9.3 Implications for The Environment and Economy

The financial impact of moisture highlights the significance of taking preventative measures. Mehta and Monteiro (2020) point out that repair costs, lower property prices, and increased energy use due to deteriorated insulation highlight the financial effects of inadequate moisture control. Additionally, because traditional damp-proofing chemicals have detrimental effects on the environment, eco-friendly alternatives such geopolymer materials and bio-based composites must be employed to satisfy global sustainability standards [39].

9.4 Role of Policy and Urban Planning

In order to manage moisture on a systemic level, effective policy frameworks and urban planning are essential. To standardise moisture management methods, building standards should incorporate cutting-edge technologies and ecologically friendly practices. Furthermore, site grading and urban drainage systems can lessen water buildup close to foundations, lowering the risk of rising damp [40].

9.5 Prospective Paths

Future dampness mitigation will depend on interdisciplinary research and innovation. Emerging technologies that present opportunities to enhance detection and prevention strategies include bio-inspired materials, smart sensors, and building information modelling (BIM). To address the unique challenges brought on by various climatic conditions, further research into regional and climate-specific solutions is required.

9.6 Concluding Remarks

In conclusion, a multifaceted approach that combines cutting-edge technologies with current understanding is required to combat building moisture. Stakeholders can develop effective solutions by giving sustainability, accuracy, and collaboration top importance in order to ensure the resilience and durability of developed settings. It will be crucial to continue financing research and making policy changes in order to overcome the problems caused by moisture and eventually develop more sustainable, nutrient-dense living and working environments.

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