

Effect of Moisture on Durability of Concrete Components in Residential Buildings

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Abstract:

Moisture is any visible, measurable, or perceived water indication due to natural and artificial occurrences within and around the building. This research tends to establish causes, effects, and method of controlling the menace usually caused by moisture in residential buildings. This research used descriptive and deductive approach and made use of Nondestructive methods of investigation. Data for this research were retrieved from a structured questionnaire administered to occupants and professionals (in building construction/maintenance) in the Lekki-Ajah axis of Lagos State, Nigeria. The research finds out that the areas of the building where moisture occur most are the bathroom, toilet and laundry room. Poor quality of construction materials, bad workmanship, and rising dampness are major causes of moisture in residential building. Moisture greatly affects the corrosion of metals used in building and also aid microbial/vegetation growth and discolouration of wall paint in the building. The research recommends the use of quality damp proofing materials, proper installation of service pipes, the establishment of a good maintenance program, timely inspection by regulatory agencies (before, during and after the construction work) as ways through which moisture can be controlled in buildings to checkmate the effect of moisture on Building components and to enhance healthy living for occupants of Buildings.

Keywords: Durability, healthy living, moisture, occupants and residential building

1 Introduction

According to WHO (2009), moisture is a visible, measurable or perceived indication of water infiltration into Building components orchestrated by indoor occurrences, climate problems, and errors during assembling and installing building components, which causes various leakages and water movement (vapour and liquid) in building components. Moisture has caused great defect and threatens many buildings, and it is recognized as one of the most dangerous building enemies. Moisture problems occur when an excess of moisture accumulate or get entrapped in parts of the building that ought to be dried, and this could occur due to design oversight, construction error or improper maintenance. (Ahzahar et al 2011, Almas et al 2011, Chew, 2005 and Kubba, 2008). This paper examined the effects of moisture on the concrete component of residential buildings, the wellbeing of occupants of buildings and suggest ways through which the effect can be mitigated to improve the health of the building and its occupants.

2 Literature Review

Othman et al. (2014) express that defects in building components have a shortcoming that makes them unable to fulfil their intended function. Building defect is a failure in the functionality, performance and comfort index of the structure, its fabric, services and associated facilities. (Pheng and Wee, 2001). Defects in the building can be categorized into the patent and latent defects. Patent defects can be physically observed during construction's inspection, usually within the defect Liability Period. Latent defect, on the other hand, occurs after the building is occupied. In addition, building defects sometimes occur due to wear and tear (Olanrewaju et al., 2010). Moisture causes a different type of defect in buildings which include but not limited to stain, discolouration of paint, peeling of paint and plaster, blistering, corrosion, and efflorescence (Flores-Colen et al., 2008). One of the major causes of staining in the building is rainwater (Hassanaian et al., 2013). Discoloration, peeling and blistering occur due to water leakages and seepage (Kian, 2001; Hassan et al., 2011). Corrosion of metal and aluminium occurs due to incompatibility of materials, Pollution, exposure, presence of moisture and microorganism, while the growth of vegetation is favoured by pores, moisture and rise in temperature (Kubba, 2008). WHO (2009) expressed that the growth of microbes such as mould, fungi, and bacteria occurs because of excess moisture in the building elements, which can pollute the indoor air and consequently constitute a health risk to human health.

The moisture condition of a building has a decisive effect on its deterioration processes and its service life (EPA, 2013). Leakages mainly cause moisture problems in a building in roofs, walls and ceilings. Chew (2005) concludes that water leakage through cracks, faulty pipes, and joints is the main source of moisture infiltration in the building. Waterproofing failure is also a major contributor to moisture infiltration into the building, as opined by Kian (2001). Building experiences water problem due to its location, inappropriate materials during construction, improper design and poor workmanship (Ahzahar et al. (2011).

WHO (2009) stated that the movement of moisture in the building from wet areas to dry areas, external walls to the internal walls could cause condensation in walls and ceiling especially when a vapour barrier is not in use and can also encourage deterioration of internal finishes. EPA (2013) and Almas et al. (2011) stated that moisture is responsible for 76% of building defects, while WHO (2009) views that moisture causes 75% - 80% of defects in the building. Kubba (2008) and Wessen et al. (2002) also corroborated that moisture is significantly responsible for the growth of microbes in the building.

According to (EPA 2013), control of moisture infiltration in the building is germane to buildings' functional ability and performance to render comfort and satisfaction to occupants and protect occupants from hazards and health challenges.

ASHRAE (2004) noted that moisture problems are sometimes caused by negligence and quackery during construction and installation. If moisture is adequately controlled in the building, it will prevent unhealthy conditions for both the building and its occupants, and this will help to have a durable, safe and energy-efficient (EPA, 2013). However, moisture problem in the building may also cause sick building syndrome, a situation that may affect the economic and social values of the building (EPA, 2013). Furthermore, Guimeraes et al. (2013) and (EPA 2013) expressed that moisture amidst poor ventilation will encourage the growth of moulds. Moulds could cause health challenges like irritations, stuffiness of the nose, cough, amongst others.

The durability of concrete is the tendency of concrete to tolerate the harmful effects of the environment it will be subjected to, during its life cycle, without experiencing deterioration above acceptable limits. Moisture is one of the many causes of concrete durability problem. (Balamurali, 2015). Infiltration of water, oxygen, carbon dioxide, chloride, sulphate, and related substances negatively affects the durability of concrete (Brandt et al., 2012). There are three main moisture problems in concrete, including carbonation, moisture cycle, and contaminants (EPA 2013).

3 Research Methodology

3.1 Study Population

The study area for this research work is Lekki/Ajah area in Eti Osa Local Government, Lagos State, Nigeria. The study population is the residential buildings that fall under the study area.

3.2 Sampling

Fifty houses in Lekki/Ajah area in Eti Osa Local Government, Lagos State, were randomly selected for the research.

3.3 Research Instrument

A structured questionnaire was used to collect data from respondents while moisture meter, rebound hammer and surface temperature pro were used to investigate the concrete components of the buildings.

4 Findings and Discussion

Table 1 above shows that moisture occurs most in the bathroom (mean 1.29), followed by toilet (mean 1.39), and followed by the laundry room (mean 1.44). This indicates that most areas where moisture occurs in the residential building are bathrooms, toilets, and laundry rooms.

Table 1. Area of the Building that Moisture Occurs Most

Area of the Building	N	Minimum	Maximum	Mean	Std. Deviation	Ranking
Bathrooms	41	1.00	3.00	1.2927	.55874	1 st
Toilet	41	1.00	4.00	1.3902	.66626	2 nd
Laundry room	41	1.00	4.00	1.4390	.74326	3 rd
Floor	41	1.00	3.00	1.6829	.60988	4 th
Wall	41	1.00	3.00	1.7561	.66259	5 th
Roof	41	1.00	5.00	3.0488	.97343	6 th
Furniture	41	2.00	5.00	3.1951	.64107	7 th
Sitting room	41	1.00	5.00	3.2683	.92262	8 th
Bedrooms	41	1.00	5.00	3.2683	1.00061	9 th
Wardrobe	41	2.00	5.00	3.5366	.80925	10 th
Wallpaper	41	1.00	5.00	3.6098	1.02172	11 th

Table 2. Causes of Moisture in Concrete Component in Residential Building

Causes of Moisture	N	Minimum	Maximum	Mean	Std. Deviation	Ranking
Poor quality of construction materials	41	1.00	2.00	1.3415	.48009	1 st
Bad workmanship	41	1.00	3.00	1.3659	.62274	2 nd
Rising dampness	41	1.00	3.00	1.3659	.62274	3 rd
Leaking pipes	41	1.00	4.00	1.3902	.73750	4 th
Roof leakages	41	1.00	3.00	1.4146	.54661	5 th
Defective damp proof course/damp proof membrane	41	1.00	4.00	1.5366	.74490	6 th
Inadequate or lack of building maintenance program	41	1.00	4.00	1.7561	.73418	7 th
Loose or missing roof tiles/slates	41	1.00	5.00	1.7805	.96209	8 th
Porosity in concrete components	41	1.00	3.00	1.7805	.68964	9 th
Improper design	41	1.00	3.00	2.0244	.52382	10 th
Overflow pipe continuous running	41	1.00	4.00	2.0732	.78709	11 th
Poor drainage system	41	1.00	4.00	2.0732	.68521	12 th
Blocked or broken roof gutter	41	1.00	4.00	2.1951	.87234	13 th
Porous or cracked bricks	41	1.00	5.00	2.2195	.98773	14 th
Blocked or broken downpipes	41	1.00	5.00	2.2927	.92854	15 th
Damped basement	41	1.00	5.00	2.3415	.96462	16 th
Cracked or blocked drains	41	1.00	5.00	2.4146	.94804	17 th
Lack of adequate roof space ventilation	41	1.00	4.00	2.7561	.79939	18 th
Condensation	41	1.00	4.00	2.7805	.82195	19 th
Poor ventilation system	41	1.00	5.00	2.8049	.98029	20 th
Use of ineffective humidity control	41	2.00	5.00	3.3171	.90662	21 st

Table 2 shows that Poor quality of construction materials, Bad workmanship, rising dampness, leaking pipes, Roof leakages, Defective damp proof course/damp proof membrane, Inadequate or lack of building maintenance program, Loose or missing roof tiles/slates, Porosity in Concrete components and Improper design ranked 1st to 10th among causes of moisture in Concrete components.

Table 3 above shows that corrosion of metal is the main effect of moisture on concrete component (mean 1.39), followed by microbial growth/vegetation growth (mean 1.51), and followed by discolouration of wall paint (mean 1.59).

Table 3. Effect of Moisture on Concrete Component in Residential Building

Effect of Moisture	N	Minimum	Maximum	Mean	Std. Deviation	Ranking
Corrosion of metals	41	1.00	4.00	1.3902	.66626	1 st
Microbial growth/ vegetation growth	41	1.00	2.00	1.5122	.50606	2 nd
Discolouration of wall paints	41	1.00	5.00	1.5854	.74080	3 rd
Reducing the life span of the building	41	1.00	4.00	1.6341	.69843	4 th
Health risk to the occupants	41	1.00	2.00	1.6829	.47112	5 th
Cracking of the building walls	41	1.00	2.00	1.6829	.47112	6 th
Deterioration of floor coverings	41	1.00	3.00	1.8049	.55765	7 th
Chalking of paints	41	1.00	5.00	1.8293	.80319	8 th
Weakening of roofing sheets	41	1.00	5.00	2.0244	.90796	9 th
Flashing	41	1.00	5.00	2.1707	.97217	10 th
Sagging of walls	41	2.00	5.00	3.2439	.94288	11 th

The above data illustrates that the effect of moisture in residential building cause corrosion of metal, microbial growth/vegetation growth around the building and also causes discolouration of wall paint.

Table 4. Method of Controlling Moisture in Residential Building

Method of Controlling Moisture in	N	Minimum	Maximum	Mean	Std.	Ranking
Using quality DPM material for foundation construction	41	1.00	2.00	1.3171	.47112	1 st
Plumbing lines should be where it can be easily located	41	1.00	3.00	1.4146	.59058	2 nd
Good maintenance program	41	1.00	3.00	1.4878	.63726	3 rd
Quality building materials	41	1.00	3.00	1.5122	.55326	4 th
Using water-impermeable material for construction	41	1.00	3.00	1.5366	.55216	5 th
Laying tiles to the wall	41	1.00	3.00	1.5610	.59367	6 th
Installation of wall cladding to prevent the wall from	41	1.00	3.00	1.5854	.54661	7 th
Checking and replacing all leaking pipes	41	1.00	4.00	1.6341	.62274	8 th
Manufacturing, shipping and storing building materials in	41	1.00	4.00	2.1707	.94611	9 th
Good architectural design	41	1.00	5.00	2.7805	1.01272	10 th
Chemical injection method	41	1.00	5.00	2.9512	.97343	11 th

Table 4 above shows that using quality DPM material for foundation construction is the best method to control moisture (mean 1.31), followed by plumbing lines should be where it can be easily located (mean 1.41), followed by a good maintenance program (mean 1.49). This implies that controlling moisture in residential building uses quality DPM materials for foundation construction; plumbing lines should be at places where they can be located easily for repair and strategizing a good maintenance program that will help the building perform its function.

Table 5. Action by Regulatory Agencies to Reduce the Effect of Moisture on Residential Building

Actions	N	Minimum	Maximum	Mean	Std.	Ranking
Inspection and certification of materials before use	41	1.00	2.00	1.2439	.43477	1 st
Educating and mandating contractors to build according to	41	1.00	2.00	1.4878	.50606	2 nd

Table 5 above shows that regulatory agencies should inspect and certified materials before use to reduce the effect of moisture on residential buildings (mean 1.24), followed by educating and mandating contractors to build according to regulations/codes (mean 1.49). This indicates that inspection and certification of materials before use and educating and mandating contractors to build according to regulations/code is the main role that the government agencies can use to reduce moisture on a residential building.

4.1 Summary of Findings

- The areas of the building where moisture occur most are the bathroom, toilet and laundry room.
- Poor quality of construction materials, bad workmanship, and rising dampness are major causes of moisture in residential building.
- Moisture has a great effect on the corrosion of metals used in building, and also aid microbial growth/vegetation growth, discolouration of wall finishes, and constitutes health risk to Occupants.
- Using quality DPM materials for constructing foundation will reduce the rising of moisture into the building,
- Location of service pipes at the area where they can be easily accessed for maintenance in case of leakages can help to reduce the spread of moisture in the building.
- Adoption and execution of a good maintenance program can enhance the quality performance of the building.
- Specification and monitoring of building materials by government agencies can ensure appropriate material during the construction of the building.
- Sequential inspection of buildings during and after construction by regulatory agencies can ensure conformity to building standards and regulations and enhance the good health of the building and its occupant.

5 Conclusion and Recommendations

After reviewing the findings on the effect of moisture on the durability of the concrete component in residential building, the following conclusion and recommendations were reached.

5.1 Conclusion

- The leading cause of moisture in the concrete component of residential building are using poor quality materials, bad construction methodology, and bad workmanship for building construction.
- Moisture penetration and rising moisture have a great effect on building concrete components by corroding the metals/reinforcement used for constructing concrete components; it aids the fast growth of the microbial organism and vegetation in the building and constitutes a health risk to occupants of buildings.
- Moisture in the building can reduce the life span of the building, which can cause the building not to perform the function which it was designed for. Hence the location of service pipes in an area where they can be easily accessed for maintenance in leakages is essential.
- The use of quality damp proofing material (DPM) for the construction of the foundation will reduce rising dampness in the building,
- Adoption and execution of a good maintenance program can enhance the quality performance of the building.
- Specification and monitoring of building materials by government agencies can ensure appropriate material during construction of the building, and sequential inspection of buildings during and after construction by regulatory agencies can ensure conformity to building standards and regulations and enhance good health of the building and its occupant.

5.2 Recommendation

- Government agencies should strictly engage in inspection and certification of materials used for building construction before they are used for construction project, and they should educate the contractors to build according to the building codes/regulations.
- Quality damp proofing materials should be used during the construction of the foundation of the building.
- A good maintenance program will help keep and restore the building to its original position so that it can continue to perform its function as expected.
- Construction of building should always be handled by professionals who will ensure the quality of construction methodology, materials, workmanship, and cost.
- Government and Professionals should continuously educate homeowners and occupants on the need to make concrete components moisture-free
- Government and professionals should invest more in developing sustainable building materials that can prevent the negative effect of moisture.

6 References

- Ahzahar, N., Karim, N.A., Hassan, S.H. & Eman, J. (2011). A Study of Contribution Factors to Building Failures and Defects in Construction Industry. The 2nd International Building Control Conference 2011, Procedia Engineering 20 (2011) 249 – 255.
- Anders-Johan Almås, Kim Robert Lisø, Hans Olav Hygen, Cecilie Flynn Øyen & Jan Vincent Thue (2011) An approach to impact assessments of buildings in a changing climate, Building Research & Information, 39:3, 227-238, DOI: 10.1080/09613218.2011.562025
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 2004. *Handbook of Fundamentals of Ventilation for Acceptable Indoor Air Quality* ASHRAE Atlanta, GA.
- Balamurali A. (2015) Effect of Moisture on Concrete during Monsoon. *International Journal of Scientific Engineering and applied science (IJSEAS)*. Vol. 1, issue 3, June 2015. ISSN: 2395-3470.
- Brandt, E., Moller, E.B. & Verterlikke, M. (2012), “Reduction of moisture problems in old basements”, *In Proceedings of the 5th IBPC, Kyoto, Japan, May 28-31, 2012*.
- Chew, M. Y. L. (2005). Defect Analysis in Wet Areas of Buildings. *Construction & Building Materials*, 19 (2005), 165-173.
- Chong W.K and Low S.P (2005) Assessment of defects at construction and occupancy stage. Arizona State University, USA. *Journal of performance of constructed facilities* 19(4), 283-389.
- EPA (2013). Moisture Control Guidance for Building Design, Construction and Maintenance From U.S. Environmental Protection Agency. Retrieved from www.epa.gov/iaq/moisture
- Flores-Colen, I., Birto, J. d., & Freitas, V. P. d. (2008). Stains in Facades' Rendering Diagnosis and Maintenance Techniques' Classification. University of Lisbon, Portugal. *Construction & Building Materials*, 22(3): 211-221, March 2008.
- Guimeraes, A.S., Delgado, J.M.P.Q. & de Freitas, V.P. (2013), “Degradation control of walls with rising damp problems”, *Defect and diffusion forum*, vol. 334-335, pp. 31-36, 2013. University of Porto, Portugal
- Hassan, F. P., Ismail, Z., Isa, H. M., & Takim, R. (2011). Tracking Architectural Defects in the Malaysian Hospital Projects. *Paper presented at the 2011 IEEE Symposium on Business, Engineering and Industrial Applications (ISBEIA)*, Langkawi, Malaysia.
- Hassanain, M. A., Al-Hammad, A.-M., & Fatayer, F. (2013). Assessment of Architectural Defects Attributed to Lack of Maintenance Feedback to the Design Team. *Architectural Science Review*, 1-7.
- Kian, P. S. (2001). A Review of Factors Affecting Building Defects in Singapore. *Dimensi Teknik Sipil*, 3(2), 64-68.
- Kubba, S. A. A. (2008). *Architectural Forensics*. United States: McGraw-Hill.
- Nur, L. O., Mastura, J., Wan Mariah, W. H. & Fuziah, I. (2014). A Case Study on Moisture Problems and Building Defects. Asian Conference on Environment Behaviour Studies Chung-Ang University, Seoul, S. Korea, 25-27 August 2014. *Procedia Social and Behavioral Sciences* 170 (2015) 27 – 36
- Olanrewaju, A. A., Faris, K. M., & Arazi, I. (2010). Sustainability in the Context of Maintenance: Building Defects in the Malaysian University Campuses. *Journal of Retails and Leisure Property*, 9, 137-149. Malaysia

- Pheng, L. S., & Wee, D. (2001). Impact of ISO 9000 on the Reduction of Building Defects *Journal of Architectural Science Review*, vol. 44(4), 367-377.
- Wessen, B., Honkanen, J., & Malarstig, B. (2002). Microorganisms, MVOCs and the Health Complaints. Paper presented at the Proceedings of Indoor Air 2002, 9th International Conference on Indoor Air Quality and Climate, Monterey, California.
- World Health Organization. (2009). WHO Guidelines for Indoor Air Quality: Dampness and Mould. WHO Regional Office for Europe Scherfigsvej 8 DK-2100 Copenhagen O, Denmark.