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Impacts of Dampness on Structural Stability of Public Secondary School Buildings in Adamawa State, Nigeria

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Abstract:- This research assessed the impact of dampness on the structural stability of public secondary school buildings in Adamawa state. Dampness as it were is the infiltration of water through the structural elements (interior and exterior) of an edifice, wetness of structural elements through moisture rise by capillary, or extreme quantity of moisture contained in building materials or the building components (Agyekum, Ayakwa, Koranteng & Adinyira, 2013a; Wilkowska, 2017). A percentage of building structures that deteriorate during wetness, dampness, or excessive moisture movements are perceived, visible, or measurable (Soldatova, Sansone, Stephens & Shah, 2011). A building is described as being affected by dampness when there is moisture that is not wanted to a certain degree in the building than its water-retaining capability such that finishes and structural members are stained or discoloured and certain secondary elements are either upturned or lifted (Ishak, Che Ani, Akashah &Kayan, 2013). The primary sources of moisture in buildings according to Sulaiman and Beithou (2011) are liquid water from precipitation or plumbing leaks; water vapour from the building exterior or activities/processes within the building; liquid and vapour from the soil adjoining a building; and moisture built-in with the materials of construction or brought in with goods and people. Young (2007) and Agyekum et al. (2013), categorise the primary sources of moisture into three types: penetration dampness, condensation, and rising dampness. Specifically, it; determined the common types of dampness and common causes of dampness, it also determined the extent of the impacts of dampness and suggested suitable procedures for treating the impact of dampness. A descriptive research design was adopted for the study. Four purposes and four research questions were raised to guide the study, the population for this study is Grade A public secondary schools in Adamawa State. Three sampling techniques were employed in this study, these are stratified sampling, purposive sampling, and simple random sampling. A checklist and a structured questionnaire were developed.

Keywords:- *Dampness, Impacts of Dampness, Structural Stability, Buildings.*

I. INTRODUCTION

Dampness is the presence of unwanted moisture that may be present in a building. These moistures are unacceptable, but somewhat gain access and penetration into a building through its structural components such as columns, windows, walls, floors, roofs, etc. This study shall provide in-depth information about the various causes of dampness in buildings, the effects of dampness in buildings, methods of preventing dampness in buildings, remedies, and diagnosis of dampness.

A building is a structure or edifice with a roof and walls standing more or less permanently in one place, such as a school, house, hospital, religious center, or factory (Arora and Bindra, 2016). Ever since the first cave paintings, buildings have also become objects or canvasses of much artistic expression (Young, 2021). In recent years, interest in sustainable planning and building practices has also become an intentional part of the design process of many new buildings and other structures, which have an expected lifetime of 60 to over 100 years, during which they offer shelter from the weather to human beings, animals, and properties. Weather and its variations cause the degradation of building materials and structures.

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A school building is a structure designed for various educational activities in the basic, secondary, or tertiary educational system and often includes living areas for students, such as dormitories (Statutory Instrument: No.1943, 2015).

A public secondary school in Nigeria is a school that is built, funded, and operated by the government. They are open to all students, regardless of their background or financial status. Public secondary schools in Nigeria typically offer a six-year academic program, divided into three junior secondary school (JSS) years and three senior secondary school (SSS) years.

➢ *Purpose of the Study*

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

- Determine the common types of dampness on public secondary school buildings in Adamawa State.
- Identify the common causes of dampness on public secondary school buildings in Adamawa State
- Determine the extent of the impacts of dampness on the structural stability of public secondary school buildings in Adamawa state
- Suggest suitable procedures for preventing the impact of dampness on public secondary school buildings in Adamawa State

II. REVIEWED OF RELATED EMPIRICAL STUDIES

(Agyekum, *et al* 2014) Conducted a study on Dampness that affects the walls of residential buildings: The Views of Building Construction Professionals in Ghana**.** Structured questionnaires were deployed to gather data and responses from stakeholders. The questionnaire survey aimed to assess the perceptions of these stakeholder in the construction profession. The questionnaire was divided into three main sections.

The first section of the questionnaire was to obtain information on the designations of the respondents. The second section sought information on the experience of the respondents on the issue of moisture in buildings. Among the issues raised was how frequent dampness was experienced in buildings in recent years. The third part of the questionnaire required respondents to score on the Likert scale of 1-5 the significant causes of dampness identified in the literature and modified to suit conditions in Ghana.

Xiangrui, (2018) also carried out a comprehensive study, "Dampness problems in Tianjin dwellings: A cross-sectional study of associations with building characteristics and lifestyles" The study investigated the association of building characteristics and occupant behaviours as it relates to building dampness indicators. Data were from a cross-sectional study in urban Tianjin and rural Cangzhou, China, from 2013 to 2014. They studied two fundamental types of Chinese dwellings: bungalows typical of rural locales and apartments in low- and high-rise buildings typical of urban settings. Occupants of bungalows reported more dampness indicators than apartment dwellers.

III. METHODOLOGY

This study adopted a descriptive research design which is a qualitative social research technique that involves the direct observation of phenomena in their natural or grounded settings. This differentiates it from experimental research in which a quasi-artificial environment is created to control for spurious factors, and where at least one of the variables is manipulated as part of the experiment.

IV. AREA OF THE STUDY

The area of this study is Adamawa state, Nigeria. Adamawa state is one of the 36 states of Nigeria, located within the North-Eastern zone of Nigeria. Adamawa State is divided into five educational zones, namely; Ganye Zone, Yola Zone, Mubi Zone, Numan Zone, and Gombi Zone respectively. This study covered the five educational zones in Adamawa state.

V. SAMPLE AND SAMPLING TECHNIQUES

Three sampling techniques were employed in this study, stratified sampling, purposive sampling, and simple random sampling. The Grade-A public secondary schools were stratified into urban and suburban areas in the five educational zones of Adamawa state. Urban areas are communities in the city or towns, while suburban are communities outside the city area (Oliver, 2017). This study sampled two Grade-A public secondary schools, from each of the five educational zones of Adamawa state, a school was selected from urban and suburban areas of the educational zones.

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VI. PRESENTATION OF RESULT

The result of the study is presented in tables, based on the research questions.

Table 1: Summary of Checklist Result of the Common Types of Dampness On Public Secondary School Buildings in Adamawa State

S/N	Zone	Name of School	Types of Prevalent Dampness Conditions						Summary of Dampness	
			Rising Dampness		Condensation Dampness		Penetrating Dampness			
			Freq.	%Age	Freq.	%Age	Freq.	%Age	Freq.	% Age
1	Yola Zone	GMMC Yola (urban)	7	6.4	1	2.9	14	10.5	22	7.91
		GGSS Girie (Semi Urban)	11	10.0	2	5.7	18	13.5	31	11.15
2	Mubi Zone	GSTC Mubi (Urban)	13	12.7	3	8.6	15	11.3	31	11.15
		GSS Uba (Semi Urban)	14	11.8	2	5.7	16	12.0	32	11.51
3	Gombi Zone	GSS Hong (Urban)	11	10.0	3	8.6	11	8.3	25	9.00
		GSS Gombi (Semi urban	13	11.8	4	11.4	13	9.8	30	10.80
4	Numan Zone	GSTC Numan (Urban)	11	10.0	5	14.2	12	9.0	28	10.07
		GSS Villanova (Semi Urban)	14	12.7	1	2.9	13	9.8	28	10.07
5	Ganye Zone	GSS Sugu (Urban)	9	8.2	3	8.6	13	9.8	25	8.99
		GSS Mayo (Semi Urban	7	6.4	11	31.4	8	6.0	26	9.35
		TOTAL	110	100	35	100	133	100	278	100

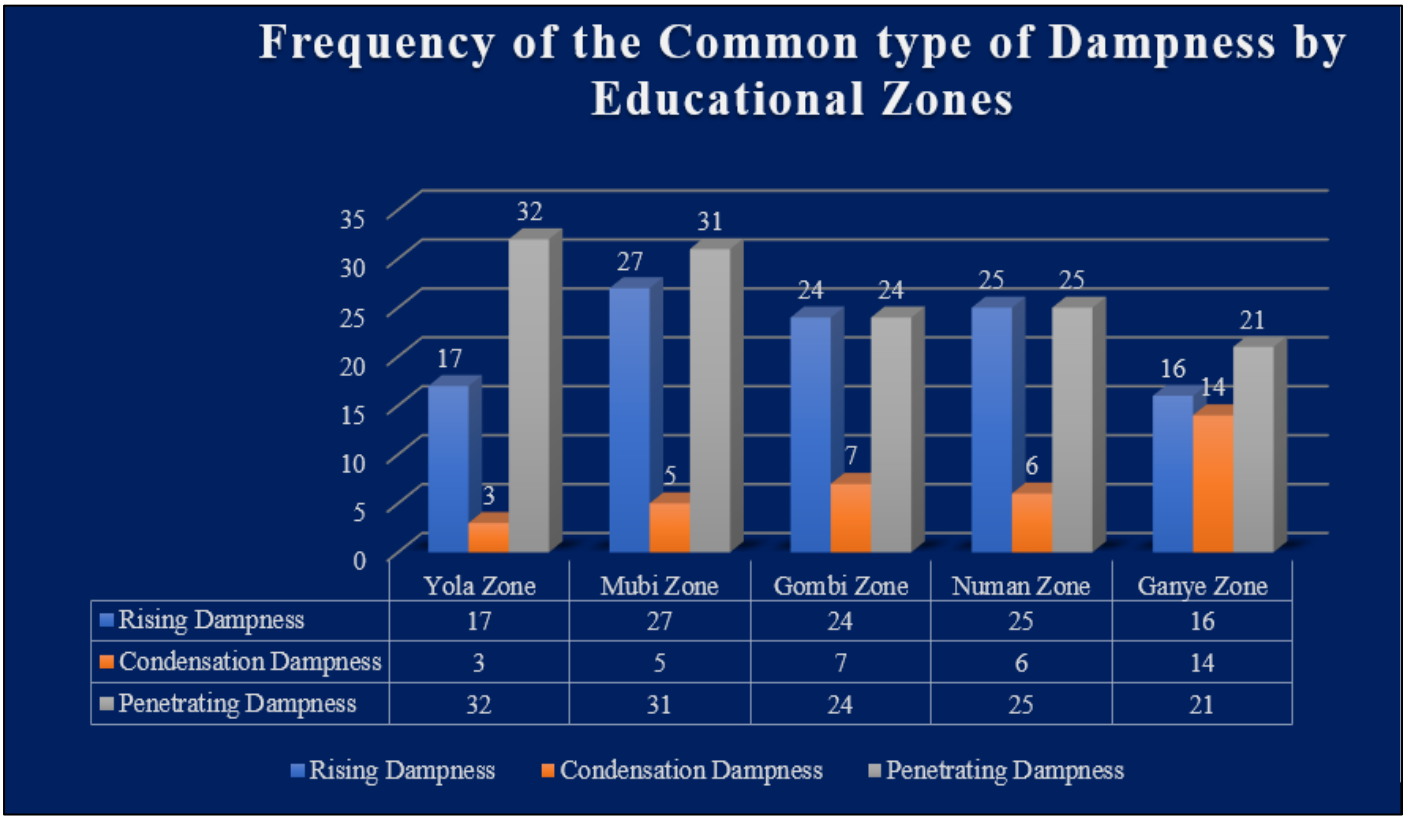

Chart 1: Frequency of the Common Type of Dampness by Educational Zones of Adamawa State

The summary of the common types of dampness found in public secondary school buildings in Adamawa State is presented in Table 1. The data clearly shows that penetrating dampness which is risky for the life-span of a building according to (Oliver, 2017), is the most common type of dampness found in Adamawa state secondary school buildings at 47.84 percent. (See columns 7 and 8 Table 1) as summarized in row 12 of the same Table 1. Penetrating dampness is closely followed by rising dampness at 39.57 percent (see column 3, row 12). Condensation was indicated as the least type of dampness found on secondary school buildings in Adamawa state with 12.53 percent.

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The data in Table 1 further shows that the total occurrence of dampness within the urban center schools stands at 47.12 percent while that of the rural/semi-urban schools stands at 52.88 percent. This shows that secondary school buildings in Adamawa state have a higher incidence of dampness in rural/semi-urban centers than in urban centers. Chart 1 also shows that the Mubi zone has the highest prevalence of dampness in all the five educational zones of Adamawa state at 22.96 percent, closely followed by the Numan zone at 21.40 percent, the Gombi zone has 19.80, the Yola zone at 19.06 percent and the least is Ganye zone with 18.34 percent. This could simply be because the Mubi zone typically receives about 115.45 millimetres (4.55 inches) of precipitation and has 138.09 rainy days (37.83 percent of the time) annually (Weather Watch, 2023).

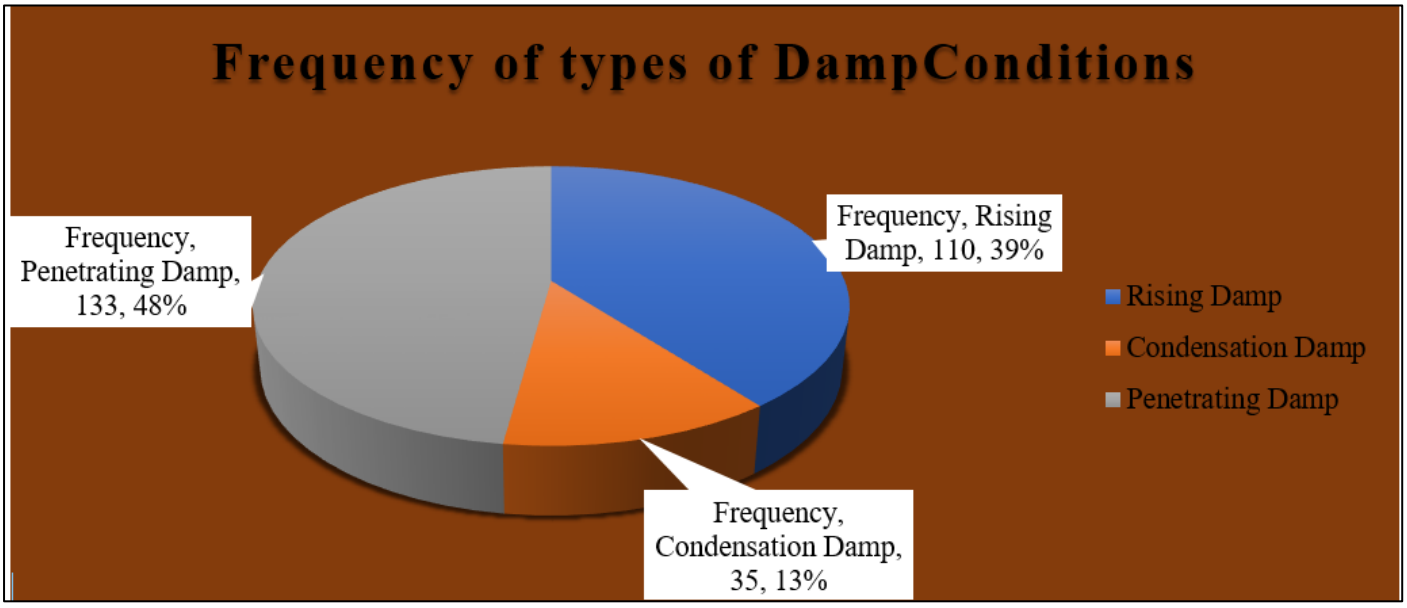

Chart 2: Frequency of type of Damp Conditions in Public Secondary School Buildings in Adamawa State

It is very okay to conclude that the data presented and analyzed so far tells that public secondary school buildings in Adamawa state are mostly affected by penetrating dampness conclude that secondary school buildings in Adamawa state are predominantly affected by penetrating dampness which has a total frequency of 133, closely followed by rising dampness with 110 cases recorded and the least frequency of dampness failure recorded for this research is condensation dampness, only 35 cases were recorded.

Table 2: Summary of the Mean Responses on the State of Dampness on Public Secondary School Buildings in Adamawa state

S/N	State of Dampness	Mean and SD of Responses		
		$\bar{X}$	*SD*	Remark
1	There are Moulds on the Walls and Slabs	3.80	0.75	SS
2	Timber Fittings Such as Doors and windows Deteriorate by Warping, Buckling, and Dry Rutting	4.80	0.75	VSS
3	Metal Frames are Corroded	4.87	0.50	VSS
4	Wall Paint Weaken and Peel Off	4.93	0.25	VSS
5	Fungi Growth is Seen on Ceiling	3.13	0.50	MS
6	The presence of Termite Moulds and Routes are Noticeable on Wooden Members	4.93	0.25	VSS
7	Bricks disintegration is Seen on Some Buildings	3.93	0.25	SS
8	Damaged Floor Covering Exists on the Floors	3.87	0.50	SS
9	Pulling of Tiles Exists on Floors/Walls	3.80	0.75	SS
10	Roof Members Detaching from the Wall are Noticed	3.93	0.25	SS
11	Crack on Walls	4.93	0.25	VSS
12	Spirogyras are Noticed on Building Walls	3.87	0.50	SS
Grand Mean		4.23		SS

$\bar{X}$ = Mean of Responses, SD = Standard Deviation, VSS = Very Severe State, SS = Severe State, MS = Moderate State

The summary of the analysis of the data collected to inquire about the state of dampness in public secondary school buildings is presented in Table 2. With a total of 12 common states of dampness presented to the respondents and the outcome of the data clearly shows that the presence of termite moulds and routes in the buildings (item 6) and cracks on walls (item 11) were the most severe damp conditions on public secondary school buildings in Adamawa State.

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A total of five dampness-related failures were clearly in very severe conditions and shown under items 2, 3, 4, 6, and 11 are major problems to a building according to (Auku, 2013). Of all the 12 dampness-related building failures presented in this study, only one of the items on fungi growth seen on ceilings in moderate, this could be a result of the temperate weather of Adamawa state, this is because fungi as a living organism grows in mostly low temperature and humid environment (Ahmed, 2019), Adamawa state is likely not to experience frequent fungi infestation on its school buildings.

Table 3: Summary of the Mean of Responses on the Common Causes of Dampness on Public Secondary School Buildings

S/N	Common Causes of Dampness	Mean and SD of Responses		Remark
		$\bar{X}$	*SD*	
1	Rain Water Penetrating the Buildings Through the Roofs	4.80	0.75	S. Agreed
2	Topography of the Building Location	3.80	0.75	Agreed
3	The buildings are in Waterlogged Area	4.80	0.75	S.Agreed
4	Poor Water Drainage System	3.93	0.25	Agreed
5	Defective Orientation Buildings and Building Standard	4.73	1.00	S.Agreed
6	Poor Quality Brick/Blocks used for the buildings	4.07	0.25	Agreed
7	There is Absence of Damp Proof Membrane (DPM)	4.80	0.75	S.Agreed
8	Seasonal Flooding	4.13	0.50	Agreed
9	Improper Ventilation	3.93	0.25	Agreed
10	Age of the Building	3.87	0.50	Agreed
11	Poor Cement and Aggregate Mix Ratio	4.73	1.00	S.Agreed
12	Inadequate Concrete Curing	4.73	1.00	S.Agreed
13	Grand Mean	4.36		Agreed

$\bar{X}$ = Mean of Respondents, SD = Standard Deviation

The summary of the analysis in Table 3 of the data collected to find the causes of dampness in public secondary school buildings in Adamawa state, some of the common causes of dampness are presented in Table 3. A total of 12 common causes of dampness in buildings were presented to the respondents and the feedback of the data clearly shows that rainwater penetrates the buildings through the roofs (item 1), buildings are in the waterlogged area (item 3) and the absence of Damp Proof Membrane (DPM) were the most common causes of dampness in public secondary school buildings in Adamawa state with a mean of 4.80. Also, a total of six common causes of dampness were strongly agreed to be the major causes of dampness in public secondary school buildings in Adamawa state this is shown under items 1, 3, 5, 7, 11, and 12.

Of all the twelve common causes of dampness presented in this study, six were also agreed to be the causes of dampness in public secondary school buildings in Adamawa state, these were items 2, 4, 6, 8, 9, and 10. The highest mean of the data analysed was 4.80 while the lowest was 3.87 with their complementary standard deviation which ranges between 0.25 and 1.00.

Table 4: Summary of the Extent of the Impact of Dampness on Structural Stability of Public Secondary School Buildings

S/N	The Extent of the Impact of Dampness	Mean and SD of Responses		Remark
		$\bar{X}$	*SD*	
1	The buildings are Abandoned	3.93	0.25	SE
2	There are Visible Patches and Moulds on the Building Walls	4.93	0.25	VSE
3	The presence of Growing Plants Inside Buildings	4.87	0.50	VSE
4	Decay of Timber and Furniture Members	4.80	0.75	VSE
5	The Building Floors Loses It Bind	3.84	0.63	SE
6	Collapsing Ceilings and Ceiling Fans	3.93	0.44	SE
7	Visible Corrosion of Metals Used in the Construction of the Buildings	3.93	0.25	SE
8	Termite Attack on Movable and Fixed Items	4.07	0.25	SE
9	Peeling off of Paints	3.83	0.64	SE
10	Colony of Pests Within the Rooms	3.87	0.50	SE
11	Presence of Reptiles Due to Humidity	4.07	0.25	SE
12	Grand Mean	4.18		SE

$\bar{X}$ = Mean of respondents, SD = Standard Deviation, VSE = Very Severe Extent, SE = Severe Extent

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The summary of the analysis of the data collected to investigate the impact of dampness on public secondary school buildings in Adamawa state is presented in Table 4. A total of eleven common impacts of dampness on buildings were presented to the respondents and the outcome of the data is clearly shown in Table 4.

The respondents indicated a total of three Very Severe Extent impacts of dampness on structural stability as recorded in Items 2, 3, and 4, with mean values of 4.93, 4.87, and 4.80 with their accompanying standard deviation of 0.25, 0.50, and 0.75. The Analysis in Table 4 entails that there are visible patches, efflorescence, and moulds on the walls of public secondary school buildings in Adamawa state, the presence of growing and unwanted plants inside public secondary school buildings in Adamawa state, and decay of timber and furniture, this indicate a very severe extent impact of dampness menace according to (Amadi & Higham, 2020). However, to a severe extent, the impact of dampness on the structural stability was noticed in items 1, 5, 6, 7, 8, 9, 10, and 11, having Presence of reptiles due to humidity, building floors lose it their bind, collapsing ceilings and ceiling fans, corrosion of metals used in the construction of the buildings, termite attack on movable and fixed items, peeling off of paints and colony of pests within the rooms. With a mean value ranging between 3.83 and 4.07. The standard deviation also ranges between 0.25 and 0.64. The grand mean of 4.19 dampness has to a severe extent sent public secondary school buildings into a state of oblivion and disrepair.

Table 5: Summary of Suitable Procedures for Preventing the Impact of Dampness on Public Secondary School Buildings

S/N	Suitable Procedures for Preventing and the Impact of Dampness	Mean and SD of Responses		Remark
		$\bar{X}$	*SD*	
1	Guniting or Shotcrete	4.73	1.00	VS
2	The Use of Damp Proof Membrane on Foundation	4.82	0.70	VS
3	Epoxy Injection into Cracks	4.88	0.47	VS
4	Building Cavity Walls	4.07	0.25	S
5	The Use of Pressure Grouting or (Cementation)	4.89	0.51	VS
6	Repair or Replace Guttering or a Leaky Roof	4.87	0.50	VS
7	Adequate Ventilation on Building	4.80	0.75	VS
8	Use Damp-Proof Paint on Walls	4.73	1.00	VS
9	Fixing Faulty Plumbing Fittings	4.07	0.25	VS
10	Install Air Bricks or Vents on the Building	3.94	0.23	S
11	Using Dehumidifier	3.87	0.50	S
12	Conducting Soil Analysis	3.82	0.70	S
13	Used Standard and Quality Roofing Sheets	4.93	0.25	S
14	Reinforcing the Foundation	3.92	0.31	S
15	Higher Sand and Cement Mix Ratio	3.87	0.50	S
Grand Mean		4.41		S

$\bar{X}$ = Mean of Respondents, SD = Standard Deviation, VS = Very Suitable, S = Suitable

The summary of the analysis of the data collected to identify the suitable ways for prevention of the impacts of dampness on public secondary school buildings in Adamawa state on Table 5. A total of seven dampness prevention were very suitable and shown under items 1, 2, 3, 5, 6, 7, 8, and 13 this is in conformity (Asamoah & Boakye, 2015), (Ahmed, 2019) and (Franzoni, 2014).

Of all the 15 dampness preventions related to buildings presented in this study, items 4, 9, 10, 11, 12, 14, and 15 were also suitable procedures for preventing and treatment of the impact of dampness on public secondary school buildings with mean values ranging between of 3.82 and 4.07, with a grand mean of 4.41, it is safe to say that dampness failure is preventable. (Item 13) has the highest mean response of 4.93, this strongly agrees with Table 1, which explicitly shows that penetrating damp is at high prevalence in public secondary school buildings in Adamawa state. This also indicates that there are problems with roofing orientations, techniques, or standards of walling materials used. Economically, damp prevention is cheaper and less cumbersome compared to treatment. Also, the easiest remedy and prevention of dampness is appropriate and strategic cross-ventilation.

VII. SUMMARY OF MAJOR FINDINGS

- The findings of this study are in line with the research questions, these were summarized as follows:
- The major findings of this study are summarized as follows:
- Penetrating dampness, rising dampness, and condensation dampness are the most common types of dampness on public secondary school buildings across the five educational zones of Adamawa State,
- As a result of the listed common types of dampness severe cases of decaying timber fittings such as doors, deteriorated/warped windows, buckling and dry rotting of other wooden members, infestation of termites, noticeable detachment of wooden roofing members from the building walls, and decay of timber furniture members are common features on several public secondary school buildings across the five educational zones of Adamawa State.

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- In addition to the identified effects of the damp conditions on the wooden members the study also discovered that metal frames and roofing sheets are corroded, wall paint weakened, and peeling off in many of the public secondary school buildings across the five educational zones of Adamawa State.
- The common causes of dampness on public secondary school buildings across the five educational zones of Adamawa State are rainwater, topography of the building location, waterlogged soil conditions, defective building orientation, non-adherence to building standards, codes of practice and regulation resulting in the use of poor-quality brick/blocks
- The secondary common causes of dampness on public secondary school buildings in Adamawa State include the aging of some of the buildings with poor maintenance programs over the years.
- The common visible impact of dampness conditions on structural stability includes major cracks on the building walls and, the growth of sponges/plants within some of the buildings.
- The major suggested suitable procedures for managing the impact of dampness on public secondary school buildings are guniting or shotcrete, proper application of damp proof courses (DPC) on the foundation, repair or replacement roof gutters or a leaky roof, adequate ventilation of the buildings, constant repairs/maintenance of faulty plumbing fittings, quality soil test analysis, reinforcing foundation where necessary and general adherence to building regulations and standards of practice.

VIII. IMPLICATION OF THE STUDY

The findings of this study have significant implications for both teaching and building professionals. This study is necessary, it provides relevant and adequate information to school proprietors, school administrators, ministries, education departments, and building professionals.

IX. CONCLUSION

Based on the findings, it was concluded that the common types of dampness on public secondary school buildings in Adamawa State are rising dampness, penetrating dampness, and condensation dampness. At a very severe state, the dampness on public secondary school buildings in Adamawa State is detected as timber fittings such as doors, and windows deteriorate by a warp, buckle, and dry rutting, metal frames corroded, wall paint weakens and peels off, and infestation of termite is noticeable on wooden members, roof members detaching from wall are noticed. At a severe state, there are moulds on the walls and slabs, brick disintegration is seen on some buildings, damaged floor covering exists on the floors, pulling of tiles exists on floors/walls, roof members detaching from the wall are noticed, and spirogyras are noticed on building walls. Furthermore, the common causes of dampness on public secondary school buildings in Adamawa State are rainwater, topography of the building location, soil within the building being waterlogged, defective orientation buildings and building standards, poor-quality brick/blocks used for the buildings, age of the building, poor cement and aggregate mix ratio, and inadequate concrete curing.

Finally, The suitable procedures for preventing and treating the impact of dampness on public secondary school buildings, guniting or shotcrete, the use of damp proof membrane on foundation, building cavity walls, the use pressure grouting or (cementation), repair or replace guttering or a leaky roof, adequate ventilation on building, use damp-proof paint on walls, fixing faulty plumbing fittings, using dehumidifier, conducting soil analysis, reinforcing the foundation, and higher sand and cement mix ratio.

RECOMMENDATIONS

- According to the findings and conclusion of the study, the following recommendations were proffered:
- The government should always ensure that contractors conduct proper site surveys with a well-detailed soil analysis before a public secondary building project is approved. This will determine how the structure will behave with a certain topography and the type of work to be done at the foundation level; it will significantly reduce the chances of rising dampness.
- The structural stability of school buildings is a critical investment and also an aspect of ensuring the safety and well-being of students, teachers, and staff. By prioritizing structural stability, educational institutions can protect lives, property, and the continuity of education. Compliance with building codes, engaging professional expertise, and promoting education and awareness are key measures to achieve structural stability. By implementing these measures, schools can create a secure environment that withstands various hazards, contributing to the overall resilience of the community.
- Proper cross-ventilation should be in place to check the impacts of condensation on wooden classroom furniture, metal frames, paints, moulds, and spirogyras. Also, dehumidifiers should be installed in public secondary school buildings of Adamawa state.
- Building professionals and building regulatory agencies should make sure that all building codes, ethics, and standards are well and judiciously followed while building public secondary school facilities in Adamawa. Sub-standard materials and quackery hands should be turndown
- It is more economical to address dampness at the conception period than to treat dampness on an already existing structure, meanwhile, a frame structure with glass walls should be considered. Also, non-attached wooden or brick walls should be considered too.
- A Damp Proof Membrane (DPM) should be used as a seal for preventing underground rising moisture, proper Damp Proof Course (DPC) should be prioritized.

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LIMITATION OF THE STUDY

The use of a structured questionnaire to obtain data at the cost of this research has limited the level and speed of obtaining relevant and unbiased observations from individuals. Also, some school administrators are adamant about the researcher's request for information about the state of dampness in their school buildings.

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