FACTOR CONTRIBUTING TO THE DAMPNESS ON EXISTING BUILDING IN MINNA NIGER STATE

BY

ELEDIKO, Mujidat
2016/1/63793TI

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
FEDERAL UNIVERSITY OF TECHNOLOGY

APRIL, 2023

FACTOR CONTRIBUTING TO THE DAMPNESS ON EXISTING BUILDING IN MINNA NIGER STATE

BY

ELEDIKO, Mujidat
2016/1/63793TI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF B. TECH DEGREE IN INDUSTRIAL AND TECHNOLOGY EDUCATION (BUILDING TECHNOLOGY)

APRIL, 2023

DECLARATION

I hereby declare that this project is my original work. **"Factor Contributing to the Dampness on Existing Building in Minna Niger State"** is a collection of my original research work and it has not been presented in any other institution for other qualification anywhere. All the information from the published and unpublished work of other sources has been duly acknowledge.

ELEDIKO, Mujidat **DATE**
2016/1/63793TI

CERTIFICATION

The project titled **"Factor Contributing to the Dampness on Existing Building in Minna Niger State"** by ELEDIKO, Mujidat (B.TECH/SSTE. 2016/1/63793TI) meets the regulation governing the Award of B.Tech in Education, in the Department of Industrial and Technology Education, Federal University of Technology, Minna, and it is approved for its contribution on scientific knowledge and literacy presentation.

_____ _____

Mrs. F.C Nwankwo DATE
Project Supervisor

_____ _____

Dr. T. M Saba DATE
Head of Department

_____ _____

DATE

External Examiner

DEDICATION

This research work is dedicated to Almighty Allah for his grace, mercy and help upon my life and also to my beloved parents.

ACKNOWLEDGEMENT

My continuous gratitude goes to God Almighty who has made it possible for me to be able to successfully write this research project and who has shown me mercy and made me who I am today and for what He will still do in my life for this is just the beginning, may His name alone be glorified both now and forever (Amen).

My profound gratitude goes to my devoted supervisor Mrs. F.C Nwankwo for her kindness, devotion, moral discipline, meaningful advice and patient contribution and also despite his tight schedules took time to read through the manuscripts for correction so as to ensure that the research project is in order. I pray that God Almighty continue to uplift you in your career and endeavors.

I also want to use this medium to appreciate the outstanding, reliable, efficient Educational Technology lecturers that have taught me throughout my program. Thanks a lot, May God honour and bless you all.

I am highly and in no small measure very grateful to my Uncle; Alh. Akeeb Kareem for his financial support, my mother; Mrs. Azeez Kudirat for her guidance, advice, support and prayers and my beloved siblings for their care and concern

I also want to thank all my wonderful friends and family for their prayers and encouragement, God bless you all.

ABSTRACT

This study assess the factors contributing to the dampness on existing building in Minna Niger state. Four research questions were developed to guide the study. The study employed a survey research design. The study used a four-point scale questionnaire, which contains a total of 31-items, as instrument. The total population of the study was 100 respondents which comprises of 90 residential occupants and 10 residential building contractors, there was no sampling because of the manageable size of the population. Mean, standard deviation was used to analyze the research questions. The findings of the study revealed the Poor quality of workmanship, Excessive condensation on windows, not just during the winter. The study recommended among other things, Building professionals should be educated and made aware of the need to the need to make our buildings and spaces healthy and liveable this can start by engage in the built environment and remodelling of users' behaviour.

TABLE OF CONTENTS

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

A building is a structure that has a roof and walls and stands more or less permanently in one place. Buildings by their very nature are composites of differing materials and forms of construction each having their own specific performance characteristics (Reckien, 2018). The demands placed on a building or an element of its construction by occupants and users relate to its location and siting, climatic and environmental conditions, the manner in which it is used, current and past levels of damage, deterioration and decay (Reckien, 2018).

Buildings are structures that serve as shelters for humans, properties and activities such as houses, factories, offices, schools and hospitals. Bortolini and Forcada (2019) stated that buildings should be properly planned, designed and constructed to obtain desired satisfaction from the environment. The primary function of a building is to provide shelter from the weather, fire outbreak, warmth, and comfort to the users. Chidi, Shamsudeen, Oladipupo and Owolabi (2017) stated that buildings are used for residence and support for other human activities. In essence a building has an important role in the life of man as it is one of man's basic necessities of life after food in the ranking of man's greatest needs and it must be properly constructed in order to avoid any defect.

Despite the lasting qualities of buildings, all buildings, be it old or modern types of construction are susceptible to natural and man-made mechanisms of deterioration (Gualtieri, *et al.,* 2022). If these buildings are not properly maintained they would not survive in an acceptable state beyond the generation that built them. Of all defects associated with buildings, moisture is the most frequent and dangerous, and contributes more than 50% of all known building failures (Halim *et al.,* 2012).

Accumulation of moisture or dampness in buildings or components of a building leads to physical, biological or chemical deterioration of the building or its materials Riahinezhad, *et al.,* 2021). Buildings by composition are bound to retain a certain percentage of moisture. However, when this limit is exceeded, the comfort level is disrupted (Wargocki &Wyon, 2013). (Baarimah, 2019) posit that damp penetration is one of the most serious defects in buildings. (Coskuntuna and Barnoshian 2021) report that moisture is responsible for over 70% of defects in building envelope. According to (Sandak, et al 2019)., aside from the deterioration of building structure, moisture results in damage to the façade and finishing with severe cases adversely affecting occupants. Sundell (2004) infers that a building system is a potent factor in determining indoor air quality.

Damages to buildings caused by dampness pose a serious risk to the performance of the building (Oliver, 1997) in Bastien and Winther-Gaasvig (2018). Dampness in buildings is moisture that should not be present in that building (Wolkoff, 2018). According to (Wolkoff, 2018), a building is described as having a dampness problem when the materials in that building becomes sufficiently damp to cause material damage and visible mould growth. Dampness is the penetration of water through the elements of a building, wetting of structural elements through moisture rise by capillary action or excessive quantity of moisture contained in building materials/components (Wilkowska, 2017). An ample percentage of building structure or fabrics has deteriorated by the time wetness, dampness, or excessive moisture movements are perceived, visible or become measurable (Soldatova, *et al.,* 2011). A building is described as being affected by dampness when there is more moisture in the building than its water-retaining capability such that finishes are stained or discoloured and certain secondary elements are either upturned or lifted (Ishak, *et al.,* 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. Also the sources of dampness are classified to include rising dampness, penetrating dampness, condensation and pipe leakages (Pereira, *et al.*, 2018).

Rising dampness results from the capillary suction of moisture from the ground into porous masonry building materials (Halim and Halim, 2010; Ahmed and Rahman, 2010). Though rising damp is a problem common in older buildings, it is gradually becoming a common issue with modern types of buildings as well (Rirsch, 2010).

Penetration damp is the term applied to the penetration of moisture through the fabric of buildings over a period of time and is usually characterized by localized areas of damp or saturated wall/ceiling finishes (Latta, 2005; Oliver, 1988). The simultaneous occurrence of the presence of water, an opening through which water can enter and a physical force to move the water are the three main issues that underpin water penetration through a building enclosure (Beall, 2000). Water plays a major role in the deterioration of masonry materials and often has a negative and devastating influence on buildings. The penetration of water is one of the most damaging defects that can occur in both old and modern constructions (Hetreed, 2008). Condensation occurs when water in the air inside a building condenses on a cooler surface (Curtis, 2007). Severe mould growth which create health hazards and damp patches on plastered walls in odd places are some of the symptoms associated with severe condensation (Burns, 2010).

Condensation is one of the most common forms of dampness in buildings, mainly caused by warm moist air originating from activities such as cooking, washing, bathing or even by just breathing and condensing onto colder surfaces in the homes. Condensation describes moisture formation on a surface as a result of moist air coming into contact with a surface

that is at a lower temperature. Factors that contribute to condensation include high humidity of indoor air, low temperature of walls/surfaces and inadequate ventilation. Notable areas such as stair-halls/lobbies, stores, wardrobes/cupboards built against external walls and posterior view of furniture or pictures are prone to condensation due to poor-ventilation tendency which does not allow the walls to fully warm up (Agyekum *et al*, 2013; Karagiannis, *et al.*, 2017). Condensation can be detected with damp patches on outside plaster walls often appearing and disappearing regularly (Agyekum, *et al*., 2013). Excessive condensation frequently results in severe mould growth on walls, ceiling and underneath bay windows which can in turn create health hazards. More than three-quarters of dampness problems in the United Kingdom are due to condensation or man-made moisture (Mumovic, Ridley, *et al.*, 2006).

Despite the importance of water to living, water or moisture resulting in dampness poses a great danger because the water is 'no longer in the free state'. Thus issues such as attack on decoration, building fabrics deterioration, loss of paint adhesion/discolouration of paint/blistering of wallpaper, stains on wall surfaces, dark/yellow-brown patches, loss of plaster, wrot/removal of skirting, cracks, attack of reinforcement, mould and algal growth and unpleasant odour inside the home become evident (Sauni *et al.*, 2013). Consequently, thermal insulation property of building materials and structural integrity becomes undermined thereby leading to an adverse effect on the environmental microclimatic conditions of the buildings with discomfort to the occupants (Yang, *et al.*, 2019). This study therefore seek to assess the factors contributing to the dampness on existing building in Minna Niger state.

1.2 Statement of the Problem

Water or moisture resulting in dampness poses a great danger because the water is no longer in the Free State. Thus issues such as attack on decoration, building fabrics deterioration, loss

of paint adhesion/discolouration of paint/blistering of wallpaper, stains on wall surfaces, dark/yellow-brown patches, loss of plaster, wrot/removal of skirting, cracks, attack of reinforcement, mould and algal growth and unpleasant odour inside the home become evident (Sauni *et al*, 2013). Consequently, thermal insulation property of building materials and structural integrity becomes undermined thereby leading to an adverse effect on the environmental microclimatic conditions of the buildings with discomfort to the occupants (Yang, *et al.*, 2019).

In Ghana, the problem of dampness is pronounced and studies conducted on the health of patients have shown that most respiratory diseases are caused by this problem (Asamoah *et al*., 2012). In a survey of 5,800 buildings affected by dampness, Agyekum *et al.* (2013) report that all the buildings showed one or more signs of rising dampness, penetration damp and condensation. The commonest problem, which is rising dampness, was identified in 5,037 of the buildings (Agyekum *et al.*, 2013).

In Nigeria highlight rising dampness in foundation substructure and leaking roofs as the prevalent dampness in the study area. In a related study, Othman, *et al*. (2015) identified fourteen major defects at walls and floor levels originating from water leakages through cracks, through pipe penetration and joints. Theoretically, it has been established that dampness is a widespread problem that is associated with most types of buildings. Based on the composition of buildings, therefore, there is a need to assess the factors contributing to the dampness on existing building in Minna Niger state.

1.3 Purpose of the Study

The major purpose of this study is to assess the factors contributing to the dampness on existing building in Minna Niger state. Specifically, the study will determine:

i. The causes of dampness in existing residential buildings?

ii. The common signs associated with dampness in existing residential buildings?

iii. The most dominant type of dampness associated with existing buildings?

iv. The remedies to dampness in existing residential buildings?

1.4 Significance of the Study

The study would be of immense benefit to the scholars/academicians, building construction industries, the Building Construction Regulatory Bodies and the society.

The findings of this study will be of benefit to the scholar/academicians as it will enlighten them on the areas to make more improvement in their research processes. Also the findings of this study will the scholar/academicians to be able to improve their knowledge and be able to impact knowledge to the students

Building construction industries will benefit from the findings of this study as it will be an eye opener for them on the problem of dampness in building and also profound solution to the problem thereby give rise to better building construction in the state, nation and worldwide.

The findings of this study will be of benefit to the regulatory bodies as it will help them to be able to make laws, benchmarks and standard to guide building constructions in Nation.

The society will benefit from the findings of the study as the will have knowledge of the materials to go for when constructing their various buildings.

1.5 Scope of the study

The study is seek to assess the factors contributing to the dampness on existing building in Minna Niger state. Specifically, the study will cover the causes of dampness, symptoms

associated with dampness, direction of the building exposed to dampness and the remedy to dampness.

1.6 Research Questions

The following research questions will guide the study:

1. What are the causes of dampness in existing residential buildings?
2. What are the common signs associated with dampness in existing residential buildings?
3. What are the most dominant type of dampness associated with existing buildings?
4. What are the remedies to dampness in existing residential buildings?

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

The review of related literature to this study is organized under the following subheadings:

2.1 Conceptual Framework

2.1.1 Dampness in Buildings

2. 1.2 Rising Dampness

2.1.3 Penetration Dampness

2.1.4 Condensation

2. 1.5 Causes of Rising Damp

2. 1.6 Building Construction

2. 1.7 Functional Requirement of Building

2.1.8 The Effects of Rising Damp

2.1.9 Dampness Preventive Techniques in building

2.2 Related Empirical Studies

2.3 Summary of Review of Related Literature

2.1 Conceptual Framework

2.1.1 Dampness in Buildings

Most of the materials used in the construction of buildings are porous in nature. Thus, an appreciable quantity of water, also known as moisture, will be present in a relatively „dry building". A building element or component that retains this amount of water is said to be damp. Different qualitative terms used to denote the presence of excess water or moisture in buildings include dampness, condensation, damp patches, damp spots, water collection and moisture problem. According to (Agyekum, *et al.,* 2014) dampness is defined as the wetting of structural elements through moisture rise by capillary action. Dampness is the most frequent and main problem in buildings and contributes more than 50% of all known building failures (Halim, *et al.,* 2012). According to Sani, *et al* (2022), dampness is inextricably linked to most building deterioration. A source of water close to a building will also be one of the problems associated with dampness. These problems include symptoms such as dirty spots on the building, biological plants like the growth of fungi, mosses and creeping plants, paint flaking, blistering (Halim, *et al.,* 2012).

Dampness can be defined as water penetration through the walls and certain elements of a building (Halim *et al.,* 2012). Dampness can also be defined as an excessive quantity of moisture contained in building materials and components which causes adverse movements or deterioration and results in unacceptable internal environmental conditions (Oryema and Sentongo 2022). Agyekum, *et al* (2017) defined dampness as the amount of moisture content present in a material and can be classified as capillary moisture content, equilibrium moisture content, hygroscopic moisture content, total moisture content and potential moisture content. Dampness is the most frequent and main problem in buildings and contributes more than 50% of all known building failures (Halim *et al.,* 2012). According (Halim *et al.,* 2012), dampness

is inextricably linked to most building deterioration. A source of water close to a building will also be one of the problems associated with dampness. These problems include symptoms such as dirty spots on the building, biological plants like the growth of fungi, mosses and creeping plants, paint flaking, blistering etc. (Halim et al., 2012). In order to successfully diagnose and make appropriate recommendations for remedial actions, one should understand dampness and its impact on buildings.

The ultimate objective of any dampness study is to identify the lead source of moisture in order to recommend actions to remedy the problem (Halim et al., 2012). According to Agyekum and Ayarkwa (2014), sources of dampness can be classified as rising dampness, penetrating dampness, condensation and pipe leakages. According to Burkinshaw and Parrett (2004), dampness can be classified as air moisture condensation, penetrating dampness, internal plumbing leaks, below ground moisture or building specific sources.

Sources of dampness can also be classified as rising dampness, penetrating dampness and condensation and pipe leakages Sani, *et al* (2022). Dampness can also be classified as air moisture, condensation, penetrating dampness and internal plumbing leaks, below ground moisture or building specific sources Ekekezie, *et al* (2022).

2. 1.2 Rising Dampness

Rising damp is common in buildings around the world and it plays a major role in the decay of masonry buildings (Halim *et al.*, 2012). It results from porous masonry sucking up water from the ground. The water rises up the wall, about one metre or more high and often deposits a horizontal tide mark (Halim *et al.*, 2012).

A number of published articles have been dedicated to defining the phenomenon of rising damp in addition to the provision of an in-depth understanding of the mechanisms involved. According to Agyekum and Salgin, (2017), rising dampness results from the capillary flow of

water from the ground. Agyekum, *et al* (2016) described rising dampness as 'ground water reaching the foot of a wall which tends to rise in the walling material and continues to do so due to capillary action to varying degrees of intensity. According to Burkinshaw, (2010), rising damp is said to have occurred when water rises upwards through the pores of masonries, cracks in buildings, or the floors of buildings, with the water being sourced from the ground. Zainal *et al* (2019) defined rising damp as 'the upward transfer of moisture in a porous material due to capillary action. Ubi, *et al* (2020) also defined rising damp as 'the upward vertical flow of water through a permeable wall structure'. In another study by Sellers, (2017) the issue of rising damp was not defined but it was demonstrated as walls that stand in water or saturated soils. This infers that a low level penetration damp could also be rising damp. Rising damp usually presents itself by salty brownish-yellow patches of plaster/decor just above skirting board height (Burkinshaw, 2012).

In the same vein Agyekum, *et al.,* (2014), identified the causes of rising damp as follows: salt attack, porosity of Building Materials, workmanship. However, the visible symptoms of rising damp include dampness on the lower parts of walls, sometimes up to 1.5m in horizontal bands (Rirsch, 2010). Rising damp may also present itself as salty yellowy browny patches of plaster just above the height of skirting boards (Burkinshaw, 2010). It tends to cause many problems to a building with associated health, environmental, social and economic implications. Rising dampness serves as a platform for the growth of fungi in wood which causes rot, deterioration of wall plasters and paints, loosening of wall papers, staining of wall surfaces, crumbling of mortar, rusting of steel and iron fasteners, etc.

2.1.3 Penetration Dampness

Penetrating dampness is the term applied to the penetration of moisture laterally through the fabric of a building from the outside, typically as a result of defective roof coverings or

damaged guttering, cracks in walls and opening (e.g windows). Dampness from rain penetration will vary with the weather conditions, including the direction and strength of the wind. Penetration damp is the term applied to the penetration of moisture through the fabric of buildings over a period of time. It is usually characterized by localized areas of damp or saturated wall/ceiling finishes Brandon, *et al* (2021). Water penetration through a building enclosure depends on the simultaneous occurrence of three things: the presence of water; an opening through which water can enter and a physical force to move the water Waldron, (2021). Penetration damp is caused by plumbing issues in a building or where a problem allows water to enter a building. Symptoms associated with penetration damp usually occur during wet weather. Though penetration dampness may look harmless but can cause damages to buildings even if it does not penetrate all walls of the building. Penetration dampness can lead to moss growth, heat loss, frost damage into masonry, etc.

2.1.4 Condensation

Dampness resulting from condensation occurs where water in the air of a room condenses on a cooler surface Koca, *et al* (2022). This is usually indicative of cold spots in the building, sometimes called cold bridges Koca, *et al* (2022). Condensation frequently results in severe mold growth which can in turn results in health hazards. Damp patches can appear on plastered walls in odd places, especially on outside walls, often appearing and disappearing on a regular basis (Burns, 2010). Condensation is mostly accompanied by mould which is black but can virtually be of any colour and is very common on walls and ceiling, underneath bay windows, etc. (Burns, 2010). Running water on windows and walls is the most immediate indication of a condensation problem. This problem leads to deterioration in the decorative condition of a property, stained curtains and decaying window frames. Condensation is also associated with the appearance of molds on the surface of wall papers and paints in poorly ventilated areas Koca, *et al* (2022).

Pipe and Roof leakage

Rain water may percolate through defective roof covering. In addition, faulty eaves and valley gutters may allow the rain water to descend through the top supporting wall thereby causing dampness. Inadequate roof sloping of the roof may results to water ponds formed on flat roof, improper rainwater pipe connections, and defective junction between roof slab and parapet wall may prove to be the source of dampness. Ekekezie, *et al* (2022), opined that roof-loose or missing tiles including the hip and ridge will allow rain water to run down rafters, causing dampness patches on the ceiling and tops of walls. Also, leakages from faulty plumbing pipes is a serious source of dampness in buildings.

2. 1.5 Causes of Rising Damp

The following are the causes of rising damp in a building:

Salt Attack: Rising damp is caused by capillary suction of water through fine voids that occur in all masonry materials. Capillaries draw water from the soils beneath a building against the force of gravity leading to damp zones at the base of walls Wei, and Mydin (2017). In most cases, dampness contains some amount of salt. It must be noted that the main source of moisture rise is the availability of water in the soil, which in its natural form contains various types of soluble salts. The slow process of absorption of water into block wall with subsequent evaporation leads to gradual deposit of salts in masonry walls. The masonry wall acts as a filter system for impure water as the various soluble salts are drawn into the wall and are left behind.

Porosity of Building Material: The amount of water a material absorbs depend on the volume of the interconnected pore space. Rising damp occurs in materials with high rate of porosity such as sandcrete block and concrete Oduro, *et al* (2017). Materials with a lot of very small pores are generally less durable than materials with fewer but larger pores. All

masonry materials, whether stone, brick, mortar, earth, or concrete block, are porous to some degree. Porosity is a rough guide to durability.

Workmanship: The durability of a building is greatly dependent on the quality of workmanship, specifications, and the design details. Lack of understanding of design details, specification, and poor workmanship on the part of artisans has contributed to many modern buildings with maintenance problems Jigyasu, (2019). The quality of construction methods and the attention to details are of great importance. When artisans fail to comply with standards and specifications in design, the result leads to rising damp. Inadequate knowledge on the part of artisans makes it very difficult for them to understand and implement basic principles.

Bad design: it is important to consider the source of water that can penetrate through the building and the type of damp proof course to be provided mentioned during the design stage of the building.

2. 1.6 Building Construction

Buildings are structures that serve as shelters for man, his properties and activities. They must be properly planned, designed and constructed to obtain desired satisfaction from the environment. Abubakar, (2021) said that building is a structure used especially for a dwelling, factory, store, shop, or warehouse. Buildings existing to meet a primary physical need of shelter for man, his goods, his animals and all the mechanical and electrical equipment he requires for his present-day existence. In addition to meeting this physical need, buildings and well related groups of buildings may also satisfy man's desire for mental and spiritual satisfaction from his environment. To achieve these, buildings must be well designed as well as efficiently constructed.

A building is essentially a space that is project from the natural environment and is constructed for a specific use. Structures are part of a building and cannot be conceived in isolation but must be conceived as part of the whole design architectural, structural services. App, (2019) said that, the structure of the building is that of the building construction, which gives the construction sufficient strength to withstand the loads to which the whole building is subjected. A building structure does this by carrying the load imposed on it and transferring them safely to the foundation and hence the ground thus, every part of a building structure.

2. 1.7 Functional Requirement of Building

A shelter is basically a protection from the elements and the function of a building is to enclose space-so that a satisfactory internal environment may be created relative to the purpose of the building. Adenuga (2009) said that, the space within the building must provide conditions appropriate to the activities to take place within it and satisfactory for the comfort and safety of any occupant. Thus, the space will be designed in terms of size and shape and in terms of environmental factors such as weather and noise exclusion, and the provision of adequate heat, light and air. The fabric of the building must be designed to ensure that any standard in respect to these are attained.

The building fabric can be seen, therefore, as the means by which the natural or external environment may be modified to produce a satisfactory internal environment and for this reason it has been called the environment envelop. In filling this function the building and its parts must satisfy certain requirements related to environmental factors on which the design of the spaces within it is based. According to Richardson, (2009) these functional requirements are the provision of adequate weather resistance, thermal insulation, sound insulation, light and air, in addition, adequate strength and stability must be provided together with adequate fire protection for the occupants, contents and fabric of the building. The

importance of any of these will vary with the part of the building and with its primary function

The Nature of Building Structure

Building is concerned with providing in physical form the envelops to the spaces within buildings and it has been primary activity of man throughout history (Ede 2010). He said, it is now, to a large extent, an erection process in which the products of other industries are assembled, a complex process, more so than for most other products, both organizationally and technically, involving on most of which are carried out on site and subject, therefore, to the hazards of weather.

The basic requirements that a structure must satisfy are: -

1. Each member of a structural system should be able to resist, without failure of collapse, the applied loads under service conditions. In other words, it must possess adequate strength. This demands that the materials of the structure must be adequate to resist the stresses generated by the loads and the shape and size of the structure must be adequate.
2. Every component of the structure should be able to resist deformation under loading conditions.

Deformation implies a change in size or shape when a body is subjected to stress. Excessive deformations that are deformations exceeding specified acceptable limits will impair the functional performance of a structure and any attached services. This demands that the stiffness of a beam of column is a measure of its resistance to bending or bucking. It should be noted the noted that a component may be strong and not stiff, and vice visa.

- Every component of a structure must be stable otherwise the whole structure is assumed to be unstable.

According to Ometar, (2002), structural stability is needed to maintain shape. It is the ability of a structure to retain, under load its original state of equilibrium. It can mean anything from resistance to a minor degree of movement to resistance to sliding overturning partial or complete collapse. Any phenomenon (which will be a potentials source of load) that can alter the load carrying behavior of structure, if not properly taken care of can lead to instability, a condition in which the support reaction is less than applied load. Thus to ensure stability, loads must be balanced by the moments due to reactions.

Functional Requirement of Building

The primary function of the wall is to enclose or divide space but in addition it may have to provide support. In order to fulfil these functions efficiently there are certain requirements which it must satisfy. They are the provision of adequate: -

Strength and stability: The strength of a wall is measured in terms of its resistance to the stresses set up in it by its own weight, by superimpose load and by lateral pressure such as wind: its stability in terms of its resistance to overturning by lateral forces and buckling caused by excessive slenderness. According to Ofori, (2010) the mode of failure of a wall by over loading, overturning or by buckling there the provision of adequate thickness and, possibly, lateral support are necessary in order to attain sufficient strength and stability.

In small-scale buildings of solid masonry construction, the external wall thickness is rarely determined by strength requirements alone. The load on the wall of two storey domestic building pieced with average size window and door opening quite small and well within the bearing capacity of a normal half brick wall. This results in functional requirement other than that of strength being the determining factors as far as thickness is concerned. The latter is

not normally, therefore, calculated in terms of strength for building up to three storeys in height.

Weather resistance: The external walls of a building, whatever their form is required to provide adequate resistance to rain and wind penetration. The actual degree of resistance required in any wall will depend largely upon its height and the locality and exposure. Oyewande (2002) said that wind force and rain fall vary considerably throughout the form of construction adequate for one locality may not be satisfactory in another. Within any locality there can also be variation of exposure for example, a site near the coast is likely to present greater problems of rain execution than one a mile or two in land. Such factors must be borne in mind. Reference to variations in rainfall can be seen from maps of average rainfall over the British Isles.

Fire resistance: A degree of fire resistance adequate for the circumstances is an essential requirement in respect of walls which, like upper floors, are often required to act as highly resistance fire barriers. They are used to compartmentalize a building so that a fire is confined to a given area, to separate specific fire risk with in a building, to form safe escape routes for the occupants and to prevent the spread of fire between buildings.

According to Chinwokwu (2000) the term fire resistance is a relative term applied to elements of structure and not to a material. It is not to be confused with non-combustibility. An element may in-corporate a combustible material and still exhibit a degree of fire resistance which will vary with the way in which the material is incorporated in the element. The degree of resistance necessary in any case depends on a number of factors.

Thermal insulation: The external walls of a building together with the roof must provide a barrier to the passage of heat to the external air in order to maintain satisfactory internal conditions without a wasteful use of the beating system. They should also serve to prevent the

interior heating up excessively during hot weather. According to Ogunwusi (2009), adequate thermal insulation is attained of normal solid structural masonry and concrete necessitates impractical thickness of wall and it is necessary to incorporate in such consulting values in order to keep the thickness within reasonable limits frame walls of timber, which is a good insulating materials by their nature in corporate casualties and with appropriate internal lining they provide good insulation with a relatively small thickness of wall construction.

Sound Insulation: Only in exceptional circumstance are the sound insulation qualities of an external wall a significant factor in its design since the other functional requirements which must be fulfilled usually necessitate a wall which excludes noise sufficiently well in most circumstances. Windows, of course, provide weak points in this respect and in some circumstances these may have to be treated as double window environment and sciences, in order to attain a satisfactory degree of insulation. Sound insulation is, however, often significant factor in the design of internal walls. Weather exclusion and, generally, thermal insulation are not functional requirements of these walls but the prevention of the passage of sound from one enclosed space to another is often an important function they must fulfill.

2.1.8 The Effects of Rising Damp

The World Health Organization publications on Damp and Mould (WHO, 2009) indicated that, in Europe, between 10 and 50% of the indoor environment, where people live, work, and play, are damp as a result of humid conditions Zhang, *et al* (2022). Humid walls create coldness, which require more heating energy leading to increase in energy bills. This buttresses the need to consider thermal conductivity materials of various types in relation to dampness. The rate of evaporation on the external wall is related to the nature of wall surfaces, climate, orientation, and location Bhamare, *et al.,* (2019). As moisture evaporates from both sides of the wall, more water is drawn from the ground and a continuous upward

flow of water occurs. The upward movement of water causes stains on internal walls, crumbling of plastered surface, paint peel off, and leaving a musty smell. On the external walls, signs of rising damp can usually be seen at the base of the masonry walls, where crumbling plaster and peeling paint are evidence. Severely affected masonry exhibits extensive decay, and powdery salt residue can clearly be seen at the base of the wall resulting into effloresence, tide mark, mould, and fungi Parsekian, *et al* (2019). Dampness in walls of buildings lead to physical, biological, or chemical deterioration of building materials. The presents of damp also affect the quality of air in relation to human health and comfort. According to the WHO (2009), some occupants of damp rooms are at risk of experiencing health problems such as respiratory infections, allergic rhinitis, and asthma Lu, *et al* (2020). Damp also affect the structural integrity of timber products, walls, and thermal insulation in buildings.

In line with the opinions of Kportufe, (2015) and Shad Muhammad, (2020) and for easy assessment, this study summarizes the effects of dampness as follows: a) It causes rots to the wooden members provided in the building.

Efflorescence on building surface: The presence of dampness condition causes efflorescence on building surfaces which ultimately results in the disintegration of bricks, stones, tiles etc. and hence reduction of strength of the building component. Efflorescence occurs as a result of the presence of an appreciable quantity of salts in a rising dampness. When rising dampness carry the salts up into the walls of the structure at the level where the moisture evaporates leaving behind the salts, this salt can often be seen as a whitish powder paint on the surfaces of walls. This situation decolorizes buildings (Kubal, 2008).

Bleaching and flaking off of paint and wallpaper: Dampness in building causes bleaching and flaking off of paints which results in the formation of coloured patches on the wall surfaces. This is as a result of the loss of adhesion between the paint and the wall surfaces because of the presence of moisture (Marshall, 2003).

Creates unhealthy living: Marshall, (2003) opined that dampness in building creates unhealthy living and working conditions for the occupants. Healthy indoor air is recognized as a basic right. People spend a large part of their time each day indoors: in homes, offices, schools or other private or public buildings. The quality of the air they breathe in these buildings is an important determinant of their health and well-being. The inadequate control of indoor air quality therefore creates a considerable health burden (World Health Organisation, 2009).

Softening and peeling off plaster from wall: It is the softening and crumbling of plaster into smaller particles or powder. This is as a result of non-quality materials or chemical reaction in the presence moisture (Marshall, 2003).

Corrosion of metals used in the construction of buildings: Corrosion has direct effects on reinforced concrete structures. It weakens the structure; reduces the bonding strength of the materials, limits the ductility, and reduces the shear capacity of the buildings. When corrosion occurs, the entire structure loses its strength and becomes very weak to the loads it was originally built to carry. It starts by reducing the effectiveness of each structural component, which in turn reduces the axial, and flexural strength of each element and makes it structurally weak. Corrosion also affects the iron rods which provide strength to the concrete by eating and smoothing their grooves and cross-section. As a result of this, the bond strength is often compromised. This leads to slippage of the concrete and eventual collapse of the building or structure. Corrosion is also capable of significantly reducing the ductility of the

overall structure, exposing it to crumbling under stress. Corroded sections of a building have lower ductility which have their response to earthquake and other natural disasters. Corrosion reduces shear capacity in beams and columns, concrete slabs and footings. This reduces the shear strength of the slabs close to the columns and increases the possibility of shear failure. Also in footings, corrosion can result to shear failure of the footing, anchorage failure, or flexural yielding of steel reinforcement

2.1.9 Dampness Preventive Techniques in building

Dampness prevention in construction is any type of treatment applied to buildings to prevent moisture from having access to the fabric of the building Oxley, (2011). For a new building construction site, the following procedures should be adhered to in order to avoid letting in water into the building components:

Surface Treatment: The surface treatment consists of filling or blinding the pores of the material exposed to moisture by painting a water-repellent material over the surface. Some of the materials employed are: Sodium or potassium silicate, aluminium or zinc sulphates, barium hydroxide and magnesium sulphate in alternate applications, soft soap and alum also in alternate applications, lime and linseed oil, coal- tar, bitumen, waxes and fats, shellacs, resins and gums etc.

Integral Damp-Proofing Treatment: The integral treatment consists of adding certain components to the concrete or mortar during the process of mixing, to make it denser by filling the pores through chemical action or mechanical effect. Compounds like chalk, talc, and fuller's earth etc. act mechanically and compounds like alkaline silicates, aluminium or zinc sulphates, calcium, aluminium or ammonium chlorides, iron fillings etc. act chemically. If 5% soap is added in the water to be used for preparing the mortar, the pores get clogged

and coating of water repellent substance stick to the wall surface which makes it sufficiently damp proof.

Special Constructional Techniques

The following techniques can help prevent dampness in buildings:

1. By constructing the external walls of sufficient thickness.
2. By using the bricks of good quality for constructing the external walls.
3. By building the walls in rich cement mortar.
4. By providing string courses and cornices.
5. By fixing down water pipes sufficiently so that water may not leak through the junction of walls and roof.
6. By constructing hollow brick walls. (these walls are built, usually with nine inches inside, the air space of about 2inches between and the outer skin of four and half inches outside. The two skins are boned together by means of galvanized iron wall ties). As there is no contact between outer and inner walls of cavity wall, possibility of moisture penetration is reduced to a minimum. It prevents the transmission of heat through wall. The cavity wall tends to reduce the nuisance of efflorescence.

Guniting (shotcrete): This entails forming an imperious layer of rich cement mortar (1:3) or fine aggregate mix for water proofing over the exposed concrete surface or over the pipes, cisterns etc. for resisting the water pressure. By this technique, an impervious layer of high compressive strength (600 to 700 kg/cm2) is obtained and is also very useful for reconditioning or repairing old concrete works.

Pressure Grouting (Cementation): This is mixture of cement, sand and water under pressure into cracks, voids or fissures present in the structural component or the ground. In general, the foundations are given this treatment to avoid the moisture penetration. This technique is also used for repairing structures, consolidating ground to improve bearing capacity, forming water cut-offs to prevent seepage etc.

Use of Damp Proof Courses (DPC): It is the continuous layer of an impervious material, which is provided in between the source of dampness and part of the structure. These layers or membranes of water repellent materials such as bituminous felts, mastic asphalt, plastic sheets, cement, concrete, mortar, metal sheets, stones etc. are interposed in the building structure at all locations wherever water entry is anticipated or suspected. It should be laid at least 15cm above ground level. The damp proof course is provided horizontally and vertically in floors, walls etc.

Horizontal DPC: It is provided in the walls at plinth level in the form of 1 ½ in. thick layer of 1:2:4 cement concrete covered with two coat of hot bitumen or a polythene sheet or metal sheets of lead, copper or aluminum. It is also provided in the roofs in the form of two coats of hot bitumen, bitumen felt, mastic asphalt or sheets of polythene, lead, copper, or aluminum over the R.C.C. slab. Horizontal D.P.C. is also provided in floors if the sub-soil water table is high and moisture is likely to rise in the floors by seepage, added by the capillary action of the soil.

Vertical DPC: Vertical D.P.C. is mostly provided in the external walls in the form of ¾ in. thick 1:3 cement sand plaster, coated with two washings of hot bitumen. It is also provided to prevent the dampness into the walls of the basements from the adjacent soils.

2.2 Related Empirical Studies

Kofi (2013) carried out a study on Preliminary Assessment of Dampness in Walls of Residential Buildings in Four Climatic Zones in Ghana. A questionnaire survey of inhabitants of 5,800 residential buildings was conducted in the Dry Equatorial, South Western Equatorial, Tropical Continental and the Wet Semi Equatorial climatic zones in Ghana to identify the most severe symptoms associated with dampness in the walls of residential buildings. Onsite building investigations were also conducted by trained assessors to identify the lead source of dampness in the walls of these residential buildings in Ghana. Data were analyzed using frequency and severity index. Majority of the houses surveyed were of lateritic materials and sandcrete block walls. The results showed that the most dominant symptoms in the walls of the residential buildings surveyed were hygroscopic salts, decayed skirting, dampness below 1.5m and mold growth on walls up to 1m high. These symptoms point to the presence of rising dampness as the lead source of dampness in the walls of these residential buildings. The results provide a platform for addressing the problem of rising dampness in buildings.

Agyekum (2014) study sought to conduct a diagnosis of the problem of rising damp in the walls of a six-bedroom residential apartment in Ghana. In achieving this aim, the study sought to determine the types of soluble salts and their concentrations in the soils and accumulated percentages in the walls over time and whether there exists any linkage between the salts in the walls and those in the ground. The results showed that the main salts predominant in the walls of the building were magnesium sulphate, magnesium chloride, sodium sulphate, and sodium chlorides. Sodium nitrates, sodium chlorides, sodium sulphates, magnesium chloride, magnesium nitrate, magnesium sulphate, potassium chloride, potassium nitrate and potassium sulphate salts were also present in the soil samples collected from the boreholes. Thus sodium sulphate, magnesium sulphate, sodium chloride and magnesium

chloride salts found in the soil were also found in the walls, establishing a linkage between the salts found in the ground and that found in the walls and therefore confirming the presence of rising dampness. The results is of value and significance since knowing the types of salts present in an affected building will lead to the adoption of appropriate treatment mechanisms to address the problem.

Magaji (2022) carried out a research on evaluation of dampness in residential building in Kaura-Namoda Zamfara state, Nigeria. As one of the most damaging failures that occur in buildings, dampness in all its forms affects both old and modern types of buildings. As an important function, buildings should seek to prevent water penetrations and give envelop to their occupants. This study sought to examine dampness which is non-structural defect in the walls and floors of Residential Buildings in Kaura Namoda. A case study approach which involves a three-stage protocol of damp investigation, thus visual inspection, non-destructive tests using a moisture meter and destructive testing was employed. The results from the visual investigation showed that dampness was seen on the external and internal walls of the building and was accompanied by symptoms such as damp patches in horizontal bands, flaking of mortar, blistering of paint, surface efflorescence and stains. The findings revealed that various forms of dampness existed within the building, including rising damp, penetration damp and, rain water splash back and lateral penetration. A further investigation with the moisture meter showed that dampness was more pronounced in the external walls. Also, destructive tests revealed that the dampness in the bathroom walls were due to plumbing leakages. This study has shown that it is possible to apply the principles of damp for appraisal of dampness or otherwise in buildings.

Ekekezie (2022) conducted a study on investigation of the causes, effects, and preventive measures of dampness in buildings in Enugu metropolis. Water plays a major role in the deterioration of masonry materials and often has a negative and devastating influence on buildings. The penetration of water is one of the most damaging defects that can occur in both old and modern constructions, the faces of our built environment is littered with ugly stains of damp surfaces. The aim of this study is to examine the causes, effects, and preventive measures for dampness in buildings in Enugu metropolis. Survey method was adopted for the collection of primary data through a well-structured questionnaire distributed to seventy-two (72) registered professionals in the building industry. The population of the study is 87. The sample size was got using Taro Yamane (1973) formular. Data obtained were analyzed using simple percentage, relative important index and weighted mean. This study has revealed that the factor with the most significant impact in causing dampness is flooding followed by leakages in roof and plumbing system; while, the factors with the most insignificant impact in causing dampness in building is moisture trapped during construction and defective building orientation. Effects of dampness: It reduces the whole life of the structure; blistering, bleaching of paints & disfiguring of wall; causes rots to the wooden members; destruction of floor carpets; floors of the building remain ugly; deterioration, peeling off of plaster; corrosion of metals used in building; mould growth; unhygienic conditions; unpleasant smell and poor air quality. The study recommends that provision of good roof, integral water proofing, special construction techniques, avoidance of leakage of water; provision of damp proof membrane and provision of damp proof course are good preventive measures for dampness in buildings.

2.3 Summary of Review of Related Literature

The review of related literature is discussed under the following subheadings: Dampness in Buildings, Rising Dampness, Penetration Dampness, Condensation, Causes of Rising Damp ,

Building Construction, Functional Requirement of Building, The Effects of Rising Damp, Dampness Preventive Techniques in building. It deduced from the study that the ultimate objective of any dampness study is to identify the lead source of moisture in order to recommend actions to remedy the problem. Adequate and relevant literatures were reviewed in the study.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Design of the Study

The study will adopt the descriptive survey research design used to assess the factors contributing to the dampness on existing building in Minna Niger state. Survey design according Nworgu (1991) is aimed at collecting data on and describing in a systematic manner, the characteristics features or facts about a given population. Osuala (2005) said that it is a design which studies the characteristics of people, the vital facts about people and their beliefs, opinions, attitude, motivation, and behavior. The design is suitable for the study because it solicits information from Residential occupant and Building contractors.

Commented [f1]: Will adopt

3.2 Area of the study

The study will be carried out in the following areas in Minna metropolis.

Commented [f2]: What areas in Minna metropolis?

5. Tunga
6. Mandela
7. Bosso estate
8. M.I wushishi
9. Maitunbi

3.3 Population for the Study

The population for the study consists of 1200 respondents comprising 1000 residential occupants and 200 residential building contractors.

Commented [f3]: What is the definition of your contractors? Are they residential building contractors or industrial building contractors?

3.4 Sample and Sampling Technique

Random sampling technique will be adopted to sample the population, therefore the total population of the is 100 respondents which comprises of 90 residential occupants and 10 residential building contractors

Commented [f4]: Do you mean we have only 90 residential buildings in Minna metropolis?
There are over 1000 residential buildings in Minna metropolis, therefore, tell us why you are using just 90 residential building owners and 10 contractors.

3.5 Instrument for Data Collection

The researcher designed a structured questionnaire titled: assessment of factors contributing to the dampness on existing building in Minna Niger state. As an instrument that will be used in collecting data for the study. The questionnaire is made up of four sections (A, B, C, D and E). Section 'A' contains items on personal information of the respondents. Section 'B' seeks the causes of dampness in existing residential buildings. Section 'C' find out common signs associated with dampness in existing residential buildings. Section 'D' find out most dominant type of dampness associated with existing buildings. While Section 'E' find out the remedies to dampness in existing residential buildings. The questionnaire items were based on four points scale types. Items for section ' B' , ' C' , ' D' and ' E' contain four responses category each. The response categories for section ' B' , ' C' , ' D' and ' E' are strongly Agree (SA), Agree (A), and Disagree (D) and strongly disagree (SD). These response categories will be assign numerical values of 4, 3, 2 and 1 respectively. Respondents were require checking (√) against the response category that best satisfies their opinion.

3.6 Validation of instrument

The instrument will be validated by three lecturers from the department of Industrial and Technology Education, Federal University of Technology, Minna. Contributions on the appropriateness of the instrument will be considered in the final draft of the research instrument.

3.7 Reliability of instrument

In order to determine the reliability of the research instrument, a pilot test will be conducted using fifteen residential occupants in Barikin sale area. During the test, the questionnaires were distributed by the researcher. The questionnaire was filled by the respondents and then returned to the researcher. The data collected will be analyzed using Crombach Alpha.

Commented [f5]: Fifteen what?

3.8 Administration of instrument

The instrument that will be used for the data collection will be administered to the respondents by the researcher and three research assistants in the study area.

3.9 Method of data analysis

Data collected will be analyzed using mean and standard deviation for the research questions while t-test was used to test the hypothesis at the 0.05 level of significant. A four (4) point rating scale was to analyze the data as shown below.

Strongly Agree	(SA)	=	4points (3.5 - 4.0)
Agree	(A)	=	3points (2.5 - 3.49)
Disagree	(D)	=	2points (1.5 - 2.49)
Strongly Disagree	(SD)	=	1point (1.0 - 1.49)

Therefore, the mean value of the 4 point scale is:

$$\bar{X} = \frac{4+3+2+1}{4} = \frac{10}{4} = 2.5$$

3.10 Decision Rule

The cutoff point of the mean score of 2.50 will be chosen as the agreed or disagreed point. This will be interpreted relatively according to the rating point scale adopt for this study.

Therefore, an item with response below 2.49 and below will be regard or consider as disagreed while an item with response at 2.5 and above was regard or considered as agreed.

CHAPTER FOUR

4.0 PRESENTATION AND ANALYSIS OF DATA

4.1 Research Question 1

What are the causes of dampness in existing residential buildings?

Table 4.1: Mean responses of the residential occupants and residential building contractors on the causes of dampness in existing residential buildings.

N_1= 90 N_2=10

S/N	ITEMS	$\bar{X}$	SD	Remark
1	Capillary action of water through fine voids	3.53	.540	Agreed
2	Porosity of Building Materials	3.50	1.020	Agreed
3	Poor quality of workmanship	3.78	.524	Agreed
4	Lack of understanding of design details	3.68	.530	Agreed
5	Poor quality of construction methods	3.06	1.229	Agreed
6	Moisture rising up the wall from the ground	3.18	.809	Agreed
7	Rainwater traveling from the wall top	3.77	.548	Agreed
8	Rain beating against the external wall	3.14	.985	Agreed
9	Condensation of atmospheric moisture	3.46	.797	Agreed
10	Improper orientation of walls	3.67	.570	Agreed
11	Improper slope of roof	3.58	.768	Agreed
12	Poor drainage at the building	3.48	.674	Agreed
13	Defective damp proof course (DPC)	3.72	.533	Agreed
14	Leakage of pipes	3.66	.572	Agreed
15	Wet areas of buildings (such as kitchens, bath rooms)	3.44	.845	Agreed

N=100

$\bar{X}$= mean of the respondents

N_1 = No. of residential occupants

N_2= no. of residential building contractors

SD = standard deviation of the respondents

Table 4.1 showed that both the residential occupants and residential building contractors agreed on all items from 1 to 15. This is because none of the mean response was below 2.50 which was the beach mark of agreed on the 4-points response options. The standard deviation score ranged between 0.533 and 1.229. This showed that the responses of the residential occupants and residential building contractors on the items were not divergent.

4.2 Research Question 2

What are the common signs associated with dampness in existing residential buildings?

Table 4.2: mean response of the residential occupants and residential building contractors on the common signs associated with dampness in existing residential buildings.

N_1= 90 N_2=10

S/N	ITEMS	$\bar{X}$	SD	Remark
1	The appearance of mould or mildew on walls, floors or ceilings	3.61	.510	Agreed
2	Water droplets on walls	3.31	1.195	Agreed
3	Dark or discoloured patches on walls or plaster	3.82	.500	Agreed
4	Excessive condensation on windows, not just during the winter	3.71	.518	Agreed
5	Rotting woodwork, such as skirting boards.	2.81	1.285	Agreed
6	Surface efflorescence just above skirting/floor	2.99	.835	Agreed
7	Dampness at the base of walls up to 1.5m in horizontal band	3.80	.532	Agreed
8	Discoloration on the wall	3.01	.959	Agreed
9	Rotten of floorboards	3.53	.758	Agreed

N=100

$\bar{X}$**=** mean of the respondents

N_1 = No. of residential occupants

N_2= no. of residential building contractors

SD = standard deviation of the respondents

Table 4.2 showed that both the residential occupants and residential building contractors agreed on all items. This was because none of the mean response was below 2.50 which was

the bench mark of agreed on the 4-point response options. The standard deviation score ranged between 0.500 and 1.285. This showed that the responses of the residential occupants and residential building contractors on the items were not divergent.

4.3 Research Question 3

What are the most dominant type of dampness associated with existing buildings?

Table 4.3: mean response of the residential occupants and residential building contractors on the most dominant type of dampness associated with existing buildings.

N_1= 90 N_2=10

S/N	ITEMS	$\bar{X}$	SD	Remark
1	Rising damp	2.78	.871	Agreed
2	Penetrating damp	3.81	.506	Agreed
3	Condensation-caused damp	2.97	.937	Agreed
4	Defective Plumbing	3.62	.693	Agreed
5	Insulation condensation	3.68	.618	Agreed
6	Leakage through foundations	3.73	.633	Agreed
7	Lateral Damp	2.87	.825	Agreed

N=100

$\bar{X}$= mean of the respondents

N_1 = No. of residential occupants

N_2= no. of residential building contractors

SD = standard deviation of the respondents

Table 4.3 showed that both the residential occupants and residential building contractors agreed on all items. This was because none of the mean response was below 2.50 which was the bench mark of agreed on the 4-point response options. The standard deviation score ranged between 0.506 and 0.937. This showed that the responses of the residential occupants and residential building contractors agreed on all items on the items were not divergent.

4.4 Research Question 4

What are the remedies to dampness in existing residential buildings?

Table 4.4: mean response of the residential occupants and residential building contractors on the remedies to dampness in existing residential buildings.

N_1= 90 N_2=10

S/N	ITEMS	$\bar{X}$	SD	Remark
1	Installation of Damp Proof Material	3.78	.524	Agreed
2	Application of Cement grouting	3.68	.530	Agreed
3	Injection of Liquid Damp Proof Products	3.06	1.229	Agreed
4	Integral damp proofing	3.18	.809	Agreed
5	Use of surface treatment	3.77	.548	Agreed
6	Adoption of cavity wall construction	3.14	.985	Agreed
7	Adequate guniting	3.46	.797	Agreed
8	Use of extractor fans in bathrooms and kitchens	3.67	.570	Agreed

N=100

$\bar{X}$= mean of the respondents

N_1 = No. of residential occupants

N_2= no. of residential building contractors

SD = standard deviation of the respondents

Table 4.4 showed that both the residential occupants and residential building contractors agreed on all items. This was because none of the mean response was below 2.50 which was the bench mark of agreed on the 4-point response options. The standard deviation score ranged between 0.524 and 1.229. This showed that the responses of the residential occupants and residential building contractors agreed on all items on the items were not divergent.

4.5 Findings of the study

The following are the main findings of the study; they are prepared based on the research questions.

What are the causes of dampness in existing residential buildings?

1. Capillary suction of water through fine voids
2. Porosity of Building Materials
3. Poor quality of workmanship
4. Lack of understanding of design details
5. Poor quality of construction methods
6. Moisture rising up the wall from the ground
7. Rainwater traveling from the wall top
8. Rain beating against the external wall
9. Condensation of atmospheric moisture
10. Improper orientation of walls
11. Improper slope of roof
12. Poor drainage at the building
13. Defective damp proof course (DPC)
14. Leakage of pipes
15. Wet areas of buildings (such as kitchens, bath rooms)

What are the common signs associated with dampness in existing residential buildings?

1. The appearance of mould or mildew on walls, floors or ceilings
2. Water droplets on walls
3. Dark or discoloured patches on walls or plaster
4. Excessive condensation on windows, not just during the winter
5. Rotting woodwork, such as skirting boards.
6. Surface efflorescence just above skirting/floor
7. Dampness at the base of walls up to 1.5m in horizontal band
8. Discoloration on the wall

9. Rotten of floorboards

What are the most dominant type of dampness associated with existing buildings?

1. Rising damp
2. Penetrating damp
3. Condensation-caused damp
4. Defective Plumbing
5. Insulation condensation
6. Leakage through foundations
7. Lateral Damp

What are the remedies to dampness in existing residential buildings?

1. Installation of Damp Proof Material
2. Application of Cement grouting
3. Injection of Liquid Damp Proof Products
4. Integral damp proofing
5. Use of surface treatment
6. Adoption of cavity wall construction
7. Adequate guniting
8. Use of extractor fans in bathrooms and kitchens

4.6 Discussion of findings

The result from table 4.1 shows the findings on the causes of dampness in existing residential buildings. The findings of the study revealed that Capillary action of water through fine voids, Porosity of Building Materials, Poor quality of workmanship, Lack of understanding of design details, Poor quality of construction methods, Moisture rising up the wall from the ground, Rainwater traveling from the wall top, Rain beating against the external wall, Condensation of atmospheric moisture, Improper orientation of walls, Improper slope of roof,

Poor drainage at the building, Defective damp proof course (DPC), Leakage of pipes, Wet areas of buildings (such as kitchens, bath rooms). The findings of the study is inline with Boje *et al.,* (2020) stated that the durability of a building is greatly dependent on the quality of workmanship, specifications and the design details. Lack of understanding of design details, specification, and poor workmanship on the part of artisans has contributed to many modern buildings with maintenance problems.

Table 4.2 shows the result of the findings on the common signs associated with dampness in existing residential buildings. The findings of the study reveal that the appearance of mould or mildew on walls, floors or ceilings, Water droplets on walls, Dark or discoloured patches on walls or plaster, Excessive condensation on windows, not just during the winter, Rotting woodwork, such as skirting boards, Surface efflorescence just above skirting/floor, Dampness at the base of walls up to 1.5m in horizontal band, Discoloration on the wall, Rotten of floorboards are the common signs associated with dampness in existing residential buildings. The finding of the study is inline with Maagi *et al.* (2022) stated that dampness is inextricably linked to most building deterioration. A source of water close to a building will also be one of the problems associated with dampness. These problems include symptoms such as dirty spots on the building, biological plants like the growth of fungi, mosses and creeping plants, paint flaking, blistering.

The results from table 4.3 reveal the findings on most dominant type of dampness associated with existing buildings. Rising damp, Penetrating damp, Condensation-caused damp, Defective Plumbing, Insulation condensation, Leakage through foundations, Lateral Damp. The findings of the study reveal that most residential buildings in minna metropolis face high rising damp in buildings. The findings of the study is in line with Congedo *et al.* (2022) who stated that Rising damp occurs when the water rises upwards through the pores of masonries, cracks in buildings, or the floors of buildings, with the water being sourced from the ground,

through the pores of masonries or cracks through a process known as capillary suction or capillarity. Capillary suction becomes stronger as the pore size gets smaller; if the pore size is fine enough; damp may rise many inches in a wall until the upward suction is balanced by the downward pull of gravity.

The results from table 4.4 reveal the findings remedies to dampness in existing residential buildings. The findings the study revealed that Installation of Damp Proof Material, Application of Cement grouting, Injection of Liquid Damp Proof Products, Integral damp proofing, Use of surface treatment, Adoption of cavity wall construction, Adequate guniting, Use of extractor fans in bathrooms and kitchens remedies to dampness in existing residential buildings. The findings of the study is inline with Suryakanta, (2017) who recommended the following techniques for damp prevention Use of damp proof courses (DPC) as layers or membranes of water repellent materials such as bituminous felts, mastic asphalt, plastic sheets, cement concrete, mortar, metal sheets, stones etc. which are interposed in the building structure at all locations wherever water entry is anticipated or suspected. It should be laid at least 15cm above ground level. The damp proof course is provided horizontally and vertically in floors, walls etc. Water proof surface treatment which entails filing up the pores of the material exposed to moisture by providing a thin film of water repellent material over the surface (internal / external). External treatment is effective in preventing dampness.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Study

The main focus of this research study was to assess the factors contributing to the dampness on existing building in Minna Niger state.

Chapter one of the study discussed the background of the study, the statement of problem, purpose, significance, scope and the research questions were all stated and discussed for the conduct of this research.

The review of related literature looked into Dampness in Buildings, Rising Dampness, Penetration Dampness, Condensation, Causes of Rising Damp, Building Construction, Functional Requirement of Building, The Effects of Rising Damp, Dampness Preventive Techniques in building. Various views of different authors concerning the topic were harmonized in a comprehensive literature review and empirical studies.

A survey approach was used to developed instrument for the study; the respondents identified as the population of the study were the residential occupants and residential building contractors. The entire respondents were used. A number of 100 questionnaires were administered. The instrument used was analysed using frequency count, and mean scores. The research questions were discussed base on the findings from the responses and results of the instrument used.

Implication of the study and conclusions were also drawn from the findings discussed. Recommendations and suggestions for further study were formulated and stated according to the findings of the study.

5.2 Implication of the Study

The findings of the study had implications for government, Residential building contractors and residential building occupant. From the outcome of the study, it implies that If the

identified areas where put in place it will bring about standard building in the minna Niger state.

5.3 Contribution to Knowledge

The study enhanced the knowledge of the building professionals on the causes of dampness in existing building. Also the study improved the approaches of building professionals to building construction, therefore give rise to the use of quality materials in building construction. The study highlighted the common signs associated with dampness in existing residential building.

5.4 Conclusion

Based on the findings of the study, the following conclusions were drawn: Dampness is most frequently reported as the main cause of building defects around the world. If residential properties are to be carefully surveyed regularly, many problems will be identified before they become very severe. Unfortunately, most houses are often inspected by construction professionals when the problem has become sufficiently advanced to be noticed by the occupier. The study adopted the remedy to dampness. The study revealed that various forms of dampness existed within the building. The forms included rising damp, penetration damp and plumbing leakages, rain water splash back and lateral penetration.

5.5 Recommendations

Based on the findings of the study, the following recommendations were made:

1. Building professionals should be educated and made aware of the need to the need to make our buildings and spaces healthy and liveable this can start by engage in the built environment and remodelling of users' behaviour.
2. A more detailed laboratory diagnosis be conducted of the problem of rising dampness in the masonry walls of residential buildings to aid in the recommendation of appropriate treatment mechanisms to address the problem.

3. All plumbing fittings and fixtures should be tested to detect leakages, making them good before finish works commence.

5.6 Suggestion for Further Study

The following are suggested for further studies:

1. Factors contributing to the dampness on existing building in other state.
2. Factors contributing to poor maintenance on existing building in Niger state

REFERENCES

Abubakar, M. I. (2021). *Implementation of e-procurement in public building construction projects of the federal capital territory administration, Abuja* (doctoral dissertation).

Agyekum, K. & Ayarkwa, J. (2014). A case study of dampness in a three bedroom residential building in Kumasi, Ghana. *Journal of Building Performance*, *5*(1).

Agyekum, K. & Salgin, B. (2017). Diagnosing rising damp in residential buildings: lessons from three cases. *Annals of the Faculty of Engineering Hunedoara-International Journal of Engineering*, *15*(3).

Agyekum, K., Ayarkwa, J. & Koranteng, C. (2016, July). Controlling rising damp in new buildings: field trials of proposed treatment methods. In *Proceedings of the International Conference on Infrastructure Development in Africa (ICIDA), Johannesburg, South Africa* (pp. 10-12).

Agyekum, K., Ayarkwa, J. & Salgin, B. (2017). Diagnosing damp in a tropical building: applying theory to practice. *International Journal of Architecture, Engineering and Construction*, *6*(4), 44-50.

Agyekum, K., Ayarkwa, J. & Koranteng, C. (2014). "Holistic diagnosis of rising damp and salt attack in two residential buildings in Kumasi, Ghana." Journal of Construction Engineering, 1, 1-13.

App, O. M. (2019). Building collapse in schools Nigeria: causes, effects and solutions–Complete Project Material. *Education*.

Bhamare, D. K., Rathod, M. K. & Banerjee, J. (2019). Passive cooling techniques for building and their applicability in different climatic zones—The state of art. *Energy and Buildings*, *198*, 467-490.

Brandon, D., Hopkin, D., Emberley, R. & Wade, C. (2021). Timber Structures. In *International Handbook of Structural Fire Engineering* (pp. 235-322). Springer, Cham.

Burkinshaw, R. (2010). The rising damp tests of Camberwell Pier: Potential height of moisture rise in brickwork and the effectiveness of a modern chemical injection cream damp coursing application. *Journal of Building Appraisal*, *6*(1), 5-19.

Burns, G. (2010). What is rising damp? Burns Property Care Services. Retrieved December 2, 2013 from Burnspropertycare.com

Ekekezie, C. U., Nnadi, E. O. & Okeke, F. N. (2022). Investigation of the causes, effects and preventive measures of dampness in buildings in Enugu metropolis. *Only one earth*, 208.

Halim, A.A., Harun, S.N. & Hamid, Y. (2012). "Diagnosis of dampness in conservation of historic buildings." *Journal Design + Built*, 5 (1), 1-14.

Jigyasu, R. (2019). Reducing disaster vulnerability through local knowledge and capacity. In *The Cultural Turn in International Aid* (pp. 192-206). Routledge.

Koca, A., Atayılmaz, Ş. Ö. & Ağra, Ö. (2022). Numerical and experimental examinations of free convection condensation of steam in the presence of air over the cooled panel. *Energy and Buildings*, *269*, 112250.

Lu, C., Norbäck, D., Zhang, Y., Li, B., Zhao, Z., Huang, C. & Deng, Q. (2020). Common cold among young adults in China without a history of asthma or allergic rhinitis-associations with warmer climate zone, dampness and mould at home, and outdoor PM10 and PM2. 5. *Science of the Total Environment*, *749*, 141580.

Oduro Asamoah, R., Solomon Ankrah, J., Bannor, P. & Ofei-Nyako, K. (2017). Construction practices contributing to rising damp in Kumasi Metropolitan and Ejisu Municipal Assemblies in Ghana. *Journal of Construction Engineering*, *2017*.

Oryema, P. & Sentongo, W. K. (2022). *The Assessment and Diagnosis of Rising Damp in Masonry Walls in Kampala Region Buildings with Recommended Treatment Methods* (Doctoral dissertation, Makerere University).

Parsekian, G., Roman, H. R., Silva, C. O. & Faria, M. S. (2019). Concrete block. In *LONG-TERM performance and durability of masonry structures* (pp. 21-57). Woodhead Publishing.

Sani, M. A. G. A. J. I., Nuhu, A., & Sholadoye, I. O. (2022). Evaluation Of Dampness In Residential Building In Kaura-Namoda Zamfara State, Nigeria. *Evaluation*, *2*(4).

Sellers, L. (2017). *Rising damp evaluation and treatment a quasi-experimental case study*. University of Salford (United Kingdom).

Ubi, S. E., Obun, P. N., Agbor Reagan, B., Tom, T. & Agbor, M. (2020). Effect of damp and treatment methods on residential buildings in Calabar metropolis of Cross River State.

Waldron, I. R. (2021). *There's something in the water: Environmental racism in Indigenous & Black communities*. Fernwood Publishing.

Wei, A. N. & Mydin, A. O. (2017). Appraisal of salt crystallisation and rising damp problems in building. *Analele Universitatii'Eftimie Murgu*, *24*(1), 418-228.

Zainal Abidin, Z., Ahmad, N. A. & Abdullah Salleh, A. (2019). Rising damp study in UiTM Perak's accommodation: a pilot study.

Zhang, P., Wei, S., Wu, J., Zhang, Y. & Zheng, Y. (2022). Investigation of mechanical properties of PVA fiber-reinforced cementitious composites under the coupling effect of wet-thermal and chloride salt environment. *Case Studies in Construction Materials*, *17*, e01325.

APPENDIX

QUESTIONNAIRE

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

A QUESTIONNAIRE FOR RESIDENTIAL OCCUPANT AND BUILDING CONTRACTOR ON FACTORS CONTRIBUTING TO THE DAMPNESS ON EXISTING BUILDING IN MINNA NIGER STATE.

INTRODUCTION: Please kindly complete this questionnaire by ticking the column that best present your perception about the topic. The questionnaire is for research purpose and your view will be confidentially and strictly treated in response to the purpose of the research work.

SECTION A

PERSONAL DATA

Residential Occupant: ☐

Building Contractor: ☐

Note: A four (4) point scale is used to indicate your opinion, tick the options which best describe your agreement as shown below:

Strongly Agree	(SA)	=	4points
Agree	(A)	=	3points
Disagree	(D)	=	2points
Strongly Disagree	(SD)	=	1points

Section B

Research question 1: What are the causes of dampness in existing residential buildings?

S/N	**Items**	**Scales**			
		SA	**A**	**D**	**SD**
1	Capillary action of water through fine voids				
2	Porosity of Building Materials				

3	Poor quality of workmanship				
4	Lack of understanding of design details				
5	Poor quality of construction methods				
6	Moisture rising up the wall from the ground				
7	Rainwater traveling from the wall top				
8	Rain beating against the external wall				
9	Condensation of atmospheric moisture				
10	Improper orientation of walls				
11	Improper slope of roof				
12	Poor drainage at the building				
13	Defective damp proof course (DPC)				
14	Leakage of pipes				
15	Wet areas of buildings (such as kitchens, bath rooms)				

Research question 2: What are the common signs associated with dampness in existing residential buildings?

S/N	**Items**	**Scales**			
		SA	**A**	**D**	**SD**
1	The appearance of mould or mildew on walls, floors or ceilings				
2	Water droplets on walls				
3	Dark or discoloured patches on walls or plaster				
4	Excessive condensation on windows, not just during the winter				
5	Rotting woodwork, such as skirting boards.				
6	Surface efflorescence just above skirting/floor				
7	Dampness at the base of walls up to 1.5m in horizontal band				
8	Discoloration on the wall				
9	Rotten of floorboards				

Research question 3: What are the most dominant type of dampness associated with existing buildings?

S/N	Skill Items	Scale			
		SA	A	D	SD
1	Rising damp				
2	Penetrating damp				
3	Condensation-caused damp				
4	Defective Plumbing				
5	Insulation condensation				
6	Leakage through foundations				
7	Lateral Damp				

Research question 4: What are the remedies to dampness in existing residential buildings?

S/N	Skill Items	Scale			
		SA	A	D	SD
1	Installation of Damp Proof Material				
2	Application of Cement grouting				
3	Injection of Liquid Damp Proof Products				
4	Integral damp proofing				
5	Use of surface treatment				
6	Adoption of cavity wall construction				
7.	Adequate guniting (Shotcrete)				
8.	Use of extractor fans in bathrooms and kitchens				