AN INVESTIGATION INTO BUILDING FUNCTIONAL FAILURES IN AKURE SOUTH LOCAL GOVERNMENT, ONDO STATE, NIGERIA

ABSTRACT

Functional failures and faults are regular occurrences in buildings and construction industries. The rate of building collapse in Nigeria has increased dramatically over the last decade and shows no signs of abating which has led to massive losses causing loss of physical properties, destruction of movable properties, injury, and loss of life. Beyond this, building collapse always has far-reaching economic, financial, psychological, and sociological implications. This study reported the causes of functional failures of buildings in Akure South Local Government Area, Nigeria. As a result, this study aimed to investigate the causes of functional failures in buildings and their impact on the quality and functionality of a building to build a theoretical framework that can help address the functional failures in buildings. The study utilized a questionnaire-based survey in the Akure South Local Government area. Data was collected from residents occupying the buildings. Information obtained includes the type of building and the current physical condition of the houses they live in, and 90 responses were collected and analyzed. The analysis identified six factors of functional failures in buildings investigated; damp 30%, cracks 50%, poor plumbing 45%, poor electrical wiring 35%, roofing defects 25% and Inadequate maintenance 70% and four causes of building failures; poor construction materials 32.7%, human errors 20.7%, natural disasters 12.4%, and a combination of the three factors 34.2%. Based on the findings, the results showed that the combination of the three factors was the most significant cause of building functional failures in the Akure South LGA, while natural disasters were the least significant cause. To mitigate the functional failures in buildings, it is important to enforce stringent regulations and standards by involving Governmental bodies (architectural Engineers and structural Engineers) to check building drawings and structural analysis report properly and correctly before design approvals, conduct regular inspections and internal audits, to help detect and rectify errors and maintaining standards throughout the construction process in order to enhance the quality, safety, and resilience of buildings, ensuring their functionality and longevity.

Keywords: Functional failures, buildings, construction material, human error, natural disaster.

1.0 INTRODUCTION

Structure failure is common in the construction and building industry worldwide, particularly in underdeveloped nations, yet it is never intended to happen. In the construction and building industry, the construction of buildings that undergo failure or collapse is now a physical reality and a common occurrence in the developing world. Nigeria, like other countries, is not immune to the ugly trend of increased structural failures in which the citizens have no reasonable access to quality infrastructure, which is critical for a decent standard of living and good sustainability (Onomivbori & Agbafor, 2022; Obebe et al., 2020). Many engineers, builders, and building contractors do not want to recognize or address the trend of building functional failures. The industry's complexity, fragmentation, and relatively casual labour force render it vulnerable to building functional failures.

Structure failures and faults are regular occurrences in the building and construction industry. Negative consequences may develop regarding project cost, length, and resources. In addition, because the building and construction business is unique in its qualities, this problem has long crept under the radar. Furthermore, it has produced an economic hiccup in continual serviceable maintenance that the industry and building owners need help to handle while industry stakeholders are still determining how to chronicle the problem of building functional failure for future reference. Massive losses are frequently sustained as a result of collapsed structures. This necessitates investigating failure issues whenever they occur (Makoond et al., 2023 ; He & Atangana, 2023).

Buildings are structures that provide shelter for people, their belongings, and their activities. They must be appropriately planned, developed, and built to provide the necessary level of enjoyment from the environment. Durability, appropriate stability to prevent failure or pain to users, resistance to weather, fire breakout, and other mishaps are all issues to consider in building design (Okeke et al., 2023; Olurotimi et al., 2023).

The examination of building failures and predictions of load is especially important immediately following the implementation of new design procedures and changes in construction detail. Such changes can have a significant impact on how structures are often subjected to extreme loading conditions that lead to their premature deterioration, and replacement of those structures before the end of their design lives is very expensive and may fail under extreme loads (Siddika et al., 2020; Zhang et al., 2021). Buildings are constructed as structural systems, so when one significant component fails, it may create a chain reaction of problems.
Building failures may give rise to legal action under either criminal or civil law, including but not limited to health and safety regulations, contract or product responsibility statutes, and tort law.

1.1Understanding Functional Failures in Building

Functional failure refers to a structure failing to accomplish its designed function, which can lead to building collapse. Awasho and Alemu (2023) linked building failures to flaws or shortcomings in the design and construction stages. According to Nicholas (2022), building collapse incidents may be managed or limited if the client is willing to pay for high-quality materials and experienced professional services. The rate of building collapse in Nigeria has increased dramatically over the last decade and shows no signs of abating. Each collapse has enormous consequences that any of its victims cannot readily forget. These include loss of human lives, loss of properties, jobs, and incomes, loss of trust and dignity, the exasperation of crises among stakeholders, and environmental disaster (Ede et al., 2021; Ohenhen & Shirzaei, 2022; Atamewan, 2020) and these losses, which would only truly be felt by future generations, have negatively impacted the socio-economic status of its citizenry. Buildings have a projected lifespan of 60 to more than 100 years, during which time they protect the elements from humans, animals, and property; therefore, it is critical to consider the location, natural shading, shelter (from storms, etc.) and structural materials when designing a sustainable building (Ghassan et al., 2021; Iyengar, 2015).

1.2 Causes of Functional Failures in Building

1.2.1 Location of Building

Buildings located near the sea or rivers tend to have common defects. This is because water coming from the ground causes dampness penetration and structural instability (Bakri et al., 2014). In addition, soluble salt from the sea and the presence of a polluted atmosphere can damage the exterior surface of the buildings.

1.2.2 Construction Materials

Most buildings use locally available materials, such as timber, stone, brick, and plaster. Understanding the nature of the building materials and accurately diagnosing defects are the most important aspects of building materials management (Tadesse, 2017).

1.2.3 Building type and change in use

Buildings that change their use and spaces should consider the effect of the new use on the existing structure. This is because some buildings were built only to hold certain loads and sometimes may not withstand additional loads. (Rajus et al., 2022).

1.2.4 Non-maintenance of Building

Buildings that neglect maintenance may have several defects, which may lead to structural failures. (Obot & Archibong, 2017). Any inspections carried out by architects or surveyors should include

- checking for any signs of abnormal deterioration,
- cleaning out gutters of leaves or harmful growth,
- checking roofs, walls, and lighting conductors,
- cleaning out all voids and spaces, and
- changing tap washers.

1.2.5 Faulty Design

A common design error is often made, usually in an effort to save initial construction costs (Ibrahim, 2018).

1.2.6 Faulty Construction

According to the experts, faulty construction mainly caused the buildings' collapse, but legal action against the offenders through proper investigation was abandoned due to various factors, such as the reluctant mood of a section of officials concerned and strong lobbying by vested groups (Awoyera et al., 2021).

1.2.7 Corruption

Corruption within the construction industry is a complex and sensitive issue. (Monteiro et al., 2022; Yap et al., 2020). It can occur during any phase of a construction project, such as project identification, financing, designing, tendering, and execution. Corruption may involve the project owners, funding agencies, consultants, contractors, subcontractors, joint venture partners, and agents in each phase.

1.2.8 Lack of Supervision

Inadequate supervision is believed to be one of the major causes of rework (Shahraki et al., 2018). Therefore, experienced and well-trained supervisors are important in minimizing the amount of rework due to construction defects.

2.0 Remedies for Functional Failures in Buildings

Buildings can fail functionally in several ways, making them unfit or downright dangerous to occupy and work in. Fortunately, most of these failures can be avoided with forethought and careful consideration during design and construction.

2.1 Structural Integrity

To maintain structural integrity, dehumidification, Inspection for signs of deterioration, Pest Control Services, using brace walls when needed, tie-down foundations, and fireproof floor coverings should be considered.

2.1.1 Climate Control

Poor climate control can lead to uncomfortable living and working conditions and costly energy bills. (Mosoarca et al., 2017). Climate control includes installing an air conditioner with a programmable thermostat or air-cooled heat pump if neither is installed, replacing or cleaning the filter heating system regularly, ensuring the building has natural and mechanical ventilation, and closing all doors and windows properly.

2.1.2 Air and Water Quality

Poor air and water quality can lead to a number of health problems, such as respiratory illnesses, allergies, and other illnesses. (Mannan & Al-Ghamdi, 2021).

To improve air quality, regularly clean and maintain your HVAC system and replace the HVAC filter every three months. Improving water quality requires regular testing for bacteria and other pollutants.

2.1.3 Fire Safety

Fire safety is a major factor when it comes to the safety and security of any building and its occupants (Rahardjo & Prihanton, 2020).

The first step in addressing fire safety issues is to ensure that the building (rooms, corridors, stairwells, and other areas of high risk) is properly equipped with smoke detectors and fire alarms. Additionally, each smoke detector should be connected to a central alarm system that can alert the fire department in the event of an emergency.

2.1.4 Accessibility

When it comes to building accessibility, a number of functional failures can arise (de Velasco Machado & de Olivera, 2021). Provide an alternative access route, such as a ramp or a lift clearly marked with signage and well-lit for easy access to physically challenged individuals. Install signs on the floor to make them more visible for wheelchair users if the ceilings are low and narrow.

2.2 Role of Geotechnical engineers and structural engineers

Geotechnical and Structural Engineers play crucial roles in ensuring the safety of structures during construction. By working together and communicating, geotechnical and structural engineers ensure the safety and integrity of structures (Okem et al., 2024 ; Joel & Oguanobi, 2024). An important cause for concern has been the underappreciation and misuse of geotechnical engineering, which has been held accountable for numerous structural and engineering disasters. Soil stability during foundation construction or as building materials affects the stability and longevity of civil engineering projects, such as roads, bridges, buildings and dams. A geotechnical investigation's ability to adequately investigate both surface and subsurface soil conditions is critical to the success of most civil engineering projects. The strength of the soil, the amount of groundwater, and the suggested geometry of the supporting structures are all determined using the geotechnical investigation's findings (Yusuf & Diugwu, 2021).

2.2.1 Geotechnical Engineers

1. Soil investigation: Conduct site investigations to determine soil properties, foundation conditions, and potential hazards.

2. Foundation design: Design foundations, such as shallow or deep foundations, to transfer loads to the soil safely.

3. Soil-structure interaction: Analyze how soil and structures interact, ensuring stability and safety.

4. Site monitoring: Monitor site conditions, settlement, and soil behavior during construction.

5. Risk assessment: Identify potential geotechnical hazards and develop mitigation strategies.

2.2.2 Structural Engineers

1. Design and analysis: Design and analyze structures, such as buildings, bridges, and towers, to withstand various loads and stresses.

2. Materials selection: Select suitable materials for construction, considering factors like strength, durability, and sustainability.

3. Load calculations: Calculate loads, including gravity, wind, seismic, and other external forces.

4. Structural modeling: Create models to simulate structural behavior and optimize designs.

5. Construction supervision: Oversee construction, ensuring compliance with design specifications and safety standards.

Buildings and the provision of safe and affordable homes are major contributors to sustainable development, and through the centuries, these have been important aspects of the socio-economic development of humans. It is common to hear of incidents of building collapse in major Nigerian cities like Lagos, Port Harcourt, Abuja, Enugu, and Ibadan. There were 221 incidents of building collapse across its major towns and cities, leading to the loss of many lives, with several degrees of injuries recorded between 1974 and 2019 (Okeke et al., 2019). According to Omenihu et al., (2016), from 1971 to 2016, a total of 1455 lives were lost in reported 175 occurrences of building collapse in Nigeria.

Building functional failure in Akure South has been a source of concern for real estate, engineering, and construction professionals. As a result, this research work is geared to understand and properly scrutinize the causes of building functional failure in Ondo State's Akure South Local Government Area.

3.0 METHODOLOGY

3.1The primary sources of data collection

The study was limited to the Akure South Local Government area of Ondo State, where student hostels and family residential buildings are privately owned. Primary data was collected through the administration of questionnaires and personal observation. A total of 100 questionnaires were sent out, 70 were delivered by hand, and 30 were delivered as soft copies to residential buildings, students occupying private hostels, estate agents, and civil engineers. 90 responses were collected and analyzed. Information that was obtained from the primary data sources includes the type of building and the current physical condition of the houses they live in.

3.2 Study Population

For this research, the populations for the study are the residents of Apatapiti Layout and Redemption Road. The residents in this context refer to the students living in the hostels off campus and the families living in the houses all within the study area.

3.3 Sampling procedure

This study employed a multi-stage sampling procedure. The first stage involved selecting buildings to be sampled using a random sampling procedure.

Buildings were randomly selected in the areas under review to ensure an adequate representation of each area. The second stage was to investigate functional failures in the selected buildings and administer questionnaires to residents in the houses/ those who have information about the buildings they reside in.

A list of possible variables was developed, investigated, and analyzed. The significant causes were rated based on a Likert scale of 1 – 5, where 1 is "highly insignificant," and 5 is "highly significant." 100 questionnaires mailed/ delivered by hand and soft copies to students and building owners and were analyzed using a standard statistical package, Microsoft Excel. Mail questionnaires were selected as a means of data collection due to financial constraints and problems of distribution and follow-up questionnaires.

4.0 RESULTS AND DISCUSSIONS

4.1 Results

The major factors responsible for building functional failures are shown in table.1

Table.1: Factors of functional failures

No of samples; 100 houses in Akure south local government, Ondo state, Nigeria

Damp 30%	Cracks 50%	Plumbing 45%
Electrical wiring 35%	Roofing defect 25%	Inadequate maintenance 70%

Data in table 1 shows that 100 houses were investigated personally and it was deduced from the investigation that 30% of the houses investigated in Akure south have damping issues, 50% have serious cracks, 45% have plumbing issues,35% have electrical issues, 25% have roof defects and 70% were maintained poorly. From this data it can be concluded that the majority of the houses in Akure south lack adequate maintenance.

4.2 Causes of Failures in Building

The causes of main factors of building functional failures in Akure south are shown in results of questionnaires answered by residents and professionals in the construction industry.

Table 2: Frequency showing respondent's experience on building failure or collapse

Have you ever experienced a building failure or collapse?	Frequency	Percentage
Yes	20	20%
No	50	50%
Not sure	30	30%
Total	100	100%

Table 3: Table showing the respondents main cause of building failure or collapse generally

What do you think are the main cause of building failures or collapses?	Frequency	Percentage
Poor construction quality	42	42%
Human errors	18	18%
Natural disasters	17	17%
Combination of three factors	23	23%
Total	100	100%

Table 4: Table showing respondents factor that causes building wall cracks and damages

what is the main factor that causes building wall cracks and damages?	Frequency	Percentage
Poor construction quality	38	38%
Human errors	17	17%
Natural disaster	9	9%
Combination of the three factors	36	36%
Total	100	100%

Table 5: Table showing respondents main factor in building material deterioration

what is the main factor in building material deterioration?	Table 2: Frequency showing respondent's experience on building failure or collapse	Percentage
Poor construction material quality	41	41%
Human error	15	15%
Natural disaster	10	10%
Combination of three factors	34	34%
Total	100	100%

Table 6: Table showing respondents causes of building systems malfunctions

what contributes most to building system malfunctions?	Frequency	Percentage
Poor construction quality	39	39%
Human error	18	18%
Natural disaster	11	11%
Combination of three factors	32	32%
Total	100	100%

Table 7: Table showing respondents leading cause of building foundation problems

What do you think is the leading cause of building foundation problems?	Frequency	Percentage
Poor construction quality	29	29%
Human errors	21	21%
Natural disasters	14	14%
Combination of three factors	36	36%
Total	100	100%

Table 8: Table showing respondents causes of building electrical systems failure

What do you think is the main cause of electrical system failure?	Frequency	Percentage
Poor construction quality	24	24%
Human errors	24	24%
Natural disasters	14	14%
Combination of three factors	38	38%
Total	100	100%

Table 9: Table showing respondents causes of building settlements and shifting issues

What do you think contributes to building settlements and shifting	Frequency	Percentage

issues?		
Poor construction quality	27	27%
Human errors	26	26%
Natural disasters	12	12%
Combination of three factors	35	35%
Total	100	100%

Table 10: Table showing respondents cause of building HVAC malfunctions

What do you think are the main cause of building HVAC malfunctions?	Frequency	Percentage
Poor construction quality	24	24%
Human errors	25	25%
Natural disasters	12	12%
Combination of three factors	39	39%
Total	100	100%

Table 11: Table showing respondents primary source of plumbing system issues

What do you think are the main cause of plumbing issues in buildings?	Frequency	Percentage
Poor construction quality	30	30%
Human errors	22	22%
Natural disasters	13	13%
Combination of three factors	35	35%
Total	100	100%

Table 12 - Total percentage of causes of functional failures in buildings

Causes of Building Failures	Affected Buildings (%)
Poor construction quality	32.7
Human errors	20.7

Natural disasters	12.4
Combination of the three factors	34.2
Total	100

Table 12 showed Total percentage of the main causes of functional failure in buildings. From the questionnaires, from table 3 to table 11, it was discovered that 32.7% of the failed buildings failed due to poor construction quality, according to (Ohenhen & Shirzaei, 2022). Also, 20.7% of the failed buildings came from human errors, 12.4% of the building failures came from natural disasters. Furthermore, according to Raker (2020), natural phenomena such as earthquakes, tornadoes, and floods are reasons for structure collapse. A combination of the three factors came at 34.2% as highlighted by Ebehikhalu and Dawam (2014).

From the questionnaires issued in the Akure South Local Government area, Civil Engineers comprised about 20% of the respondents, students residing in private hostels comprised about 45%, and estate agents comprised about 35%. Quantity surveyors were about 23% (the average number of years of experience in the building was eight years).

The results showed that the combination of the three factors was the most significant cause of dampness in the Akure South LGA, while natural disasters were the least significant cause. Figure 1 showed the result of the analysis.

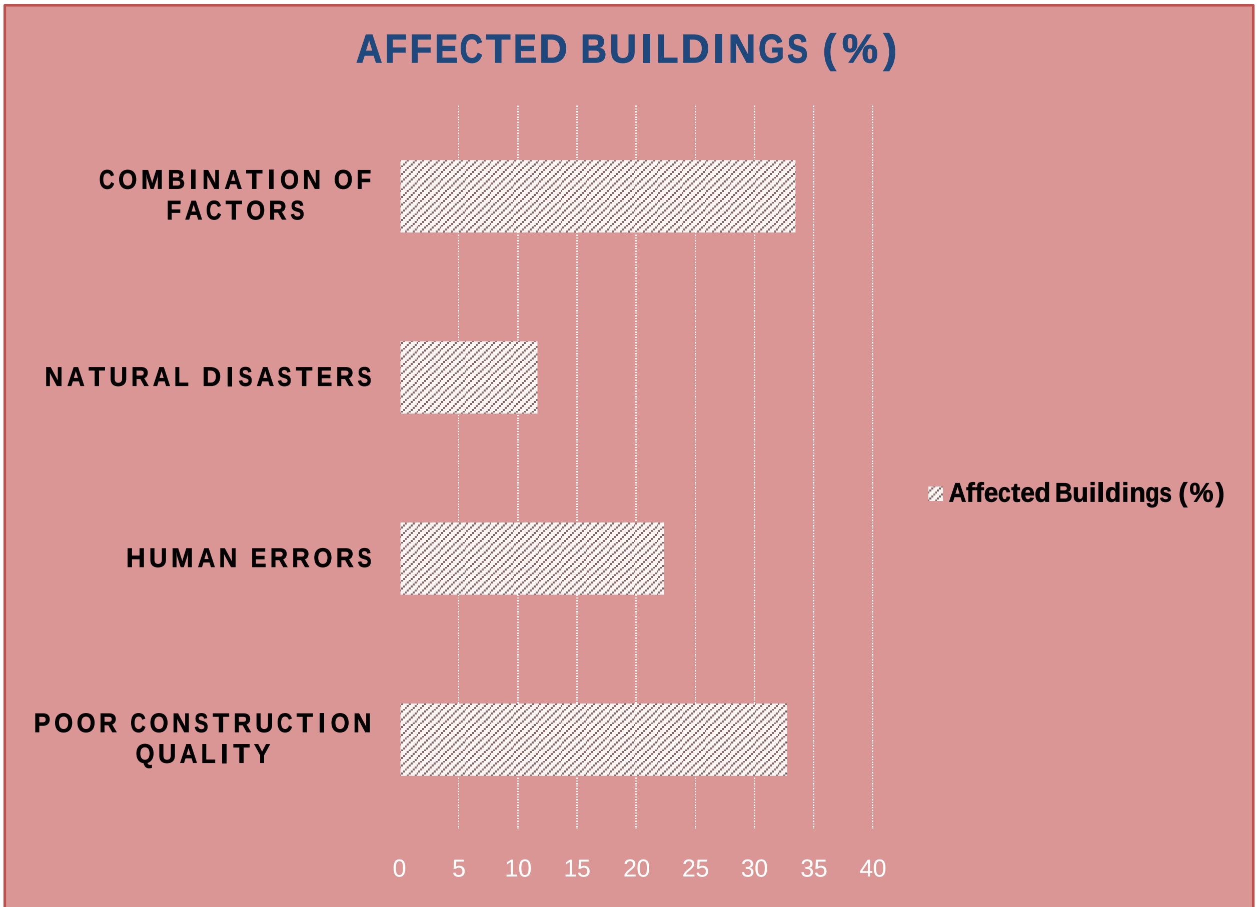

Figure 1: Causes of building failures in the Akure South LGA

Plate 1: Buildings with functional failure as a result of damp

Plate 1 illustrated a building in Akure South Local Government, Ondo State, Nigeria, where dampness has seriously impaired the structure's usability. Signs of dampness on the walls indicated poor waterproofing or improper drainage, which may be predisposing the structure to mold growth, weakening of the building materials, and deterioration of interior finishes—thus reducing the building's usability and useful life.

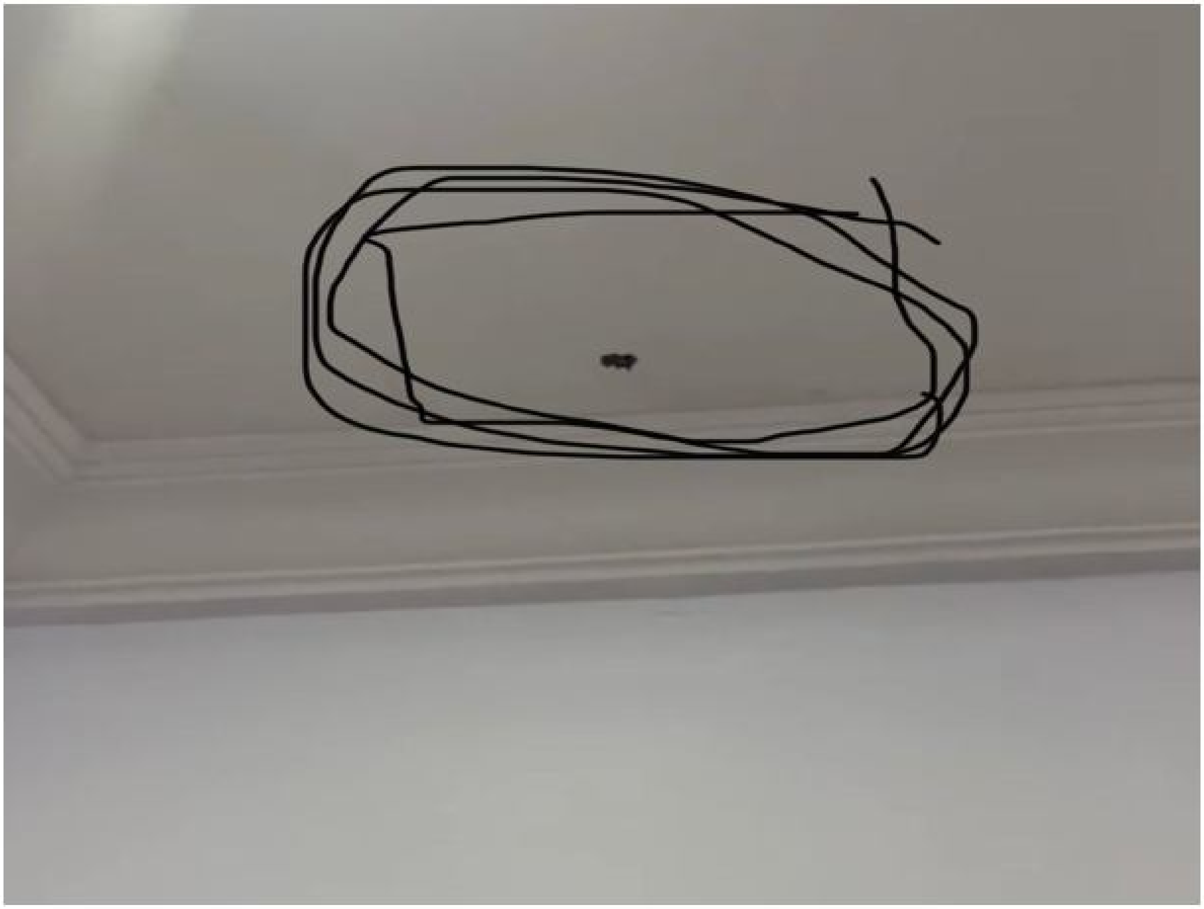

Plate 2: Roof defect

The roof defect depicted in this plate demonstrated a common issue in buildings that can lead to functional failures. The visible damage to the roof structure can result in water ingress, leading to dampness and potential structural damage over time. This defect compromises the building's ability to protect its occupants from the elements and poses a risk of further deterioration if not addressed promptly.

Plate 3 Damp in building which results in functional failures

The plate showed a building where heavy dampness has caused several significant functional failures: areas of damp most likely emanating from water infiltration through walls, floors, or ceilings, perhaps as a consequence of poor construction or lack of moisture barriers. These damages may lead to weak structural elements, health risks based on mold growth, and a general loss of inhabitability.

Plate 4 : Cracks

These cracks in the plate showed the structural defects that may lie within the building. Cracks generally appear due to foundation movement, thermal expansion, and shrinkage of the materials. If left unattended, these may grow further, leading to a major structural failure and hazard to safety and functionality. Cracks may serve as an early warning of more serious underlying defects needing urgent remedial work.

Plate 5: A building with electrical wiring defects which leads to functional failure.

This plate illustrated the functional failures of a building stemming from improper electrical wiring. The evident defects, including but not limited to exposed wires and poor insulation, created serious safety hazards: electrical fires, short circuits, and electrocution are all prevalent. Such defects menace operational safety and the building's ability to function as intended, and urgently, necessary measures must be called for by the operator.

Plate 6: A building with damp, which leads to functional failures

This plate represented another case where, due to dampness, a building has suffered a functional failure, much like Plate 1. The recurrence of this issue across multiple structures suggests systemic problems related to moisture management in the area. This dampness compromises the structural integrity, fosters mold growth degrades indoor air quality, and, for this reason, diminishes the overall utility and safety of the building.

Plate 7: Plumbing defect

This plate illustrated a building with plumbing defects contributing to functional failures. Unless leaks in pipes, blockages of drains, or defects in fixtures are repaired immediately, they can allow water destruction, dampness, or flooding that dents the functionality of the building.

Plate 8: Buildings with cracks

This plate gave further examples of buildings suffering from severe cracking. Where such cracking is found in several buildings in the same area, the problem is a general one, more likely related to soil factors, a general deficiency in foundation design, or construction quality. The resultant loss of structural integrity invites accidents and shortens the service life of the buildings.

Plate 9: Buildings with plumbing defect

Defects in plumbing are evident on this plate, showing apparent water damages and functional failures. These include issues like leakage of pipes, inadequate drainage system, and missing waterproofing. The plumbing defects here lead to the building becoming operationally inefficient and contribute to structural long-term damages and increasing maintenance costs.

5.0 Conclusion

In conclusion, investigating the causes of functional failures in buildings in the Akure South Local Government area has shed light on the factors that regularly contribute to such incidents. Through an analysis of the questionnaire responses, it has become evident that resolving the problem of poor construction quality in building functional failures requires a comprehensive approach that addresses root causes and promotes a culture of excellence, which includes enforcing stringent regulations and standards throughout the construction process and promoting skilled labor and professional development is crucial. Investing in training programs, certifications, and apprenticeships can improve construction practices and ensure competent workforce deployment. Human errors that emerged as a significant factor contributing to functional failures revealed that mistakes during the design phase, incorrect installation of building components, and insufficient maintenance practices are common occurrences. These human errors, due to negligence, lack of knowledge, or inadequate training, can have severe consequences on the functionality and integrity of buildings, which can be cropped through thorough planning and design reviews to minimize potential errors before construction begins. Robust quality control measures, including regular inspections and independent audits, help detect and rectify errors.

Natural disasters pose another significant risk to building functionality in Akure South LGA. The region is prone to events such as flooding, storms, and earthquakes, which can cause structural damage, water intrusion, and electrical failures. While it may be challenging to prevent natural disasters entirely, implementing robust building design and construction practices that account for such risks can mitigate their impact on functional failures.

Moreover, the investigation highlighted that functional failures often result from a combination of factors rather than a single cause. The interactions between poor construction quality, human errors, and natural disasters can exacerbate the risk and amplify the consequences.

5.1 Recommendation

To prevent functional failures in buildings, several key recommendations can be provided to architects, engineers, and stakeholders involved in the construction processto enhance the quality, safety, and resilience of buildings, ensuring their functionality and longevity.

- Governmental bodies (architectural Engineers and structural Engineers) should check building drawings and structural analysis report properly and correctly before design approval.
- Governmental bodies should provide construction permit in two steps. First, temporary permit certificate up to DPC level and then permanent permit certificate for super structure construction.
- Earthquake resistance building design must be made compulsory.
- One registered civil engineer must be appointed in each construction site for supervision during construction.
- Soil test report should be made compulsory .

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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