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SYSTEMATIC REVIEW OF BUILDING FAILURE AND COLLAPSE IN NIGERIA

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ABSTRACT

Building failure often results to collapse if not discovered and addressed. Many authors have in times past discussed on various factors that contribute to incessant building failure and collapse in Nigeria. Most of the findings are based on individual findings and as such, general consensus on the causes of building failures and collapses in Nigeria have not been reached. This systematic review harmonizes the various causes from papers indexed in Scopus database and recommendations were given. The causes of building collapse in Nigeria are: poor materials used in the construction of buildings, geophysical or natural causes, structural defects, failure of efficient management of construction processes, construction defects, corruption or sharp practices and noncompliance to legal requirements in the building industry. The review concluded with some likely research areas on building failure and collapse as it relates to the study area.

Keywords: Building collapse, building failure, Nigeria, concrete, structural defects, poor materials.

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1. INTRODUCTION

Building failure precedes collapse. The failure can be defined as defect, flaw, imperfection, deficiency, weakness, shortcoming, mistake, error, kink, bug and fault in building elements and component that make up a building structure. Building collapse in Nigeria is widely reported and occurs mainly in the urban centers in Nigeria. Building collapse results in loss of lives and properties. Nigeria in recent times has experienced building a collapse in worrying scale. Building collapse in particular and structural defects in general have been witnessed and recorded. The types are but to limited to, the following: rooftop parking structure, chimney, escalator, lattice tower, pier, tower, wedding hall, church, highway bridge, bridge, walkway, motorway bridge, suspended bridge and walkway, pavilion, highway overpass, shopping mall, roof collapse and cooling tower. Others are: residential building, wind turbine, crane, guyed mast, gymnasium, theater, commercial building, stage, office building, stadium and stadium roof, flyover bridge, scaffold, guyed tower, overpass, water park, balcony, embankment dam, free standing tower, hangar and footbridge.

Many authors have in times past discussed on various factors that contribute to incessant building failure and collapse in Nigeria. Most of the findings are based on individual findings. This systematic review is aimed at harmonizing the various causes from papers on building collapse indexed in Scopus database and bringing out a pattern that can serve as a referenced document. The outcome of this review is an evidence from published articles on the causes and major findings on building failure in Nigeria. Recommendations and possible research areas are included to stimulate research interest in this area.

The paper is organized as follows: section one is the introduction, section two is the methodology used in the review, section three is the aim of the surveyed articles, section four is the major findings from those articles, section five is the summarized causes of building collapse, section six is the summary of the recommendations from the surveyed articles, section seven is the summary of findings, section eight is the possible research area and section nine is the conclusion.

2. METHODOLOGY

The methodology followed in this review is summarized in the subsections.

2.1 Data and Inclusion Criteria

Building collapse was typed in the document section in Scopus website and 35 documents were displayed. Out of the 35 documents, 28 representing 80 percent was used in the review while 7 documents representing 20 percent were excluded because their abstracts do not reflect the subject topic being queried.

2.2 Scope

The 28 documents (articles) considered only buildings which may be residential, office and commercial buildings, churches, mosques, public and privately owned. Other structural defects such as dam collapse, dam, tower, road and bridge collapse and guyed masts were not considered as they did not feature in the surveyed papers.

2.3 Data Organization and Presentation

The data are organized based into four types; the aim, major findings of the surveyed articles, observed causes of building collapse as reported by the various investigators and the summary of the recommendations from the surveyed articles. Attempts were made to find perceived patterns and are presented in the subsequent sections.

3. AIM OF THE SURVEYED ARTICLES

The aim of a research determines the direction and the end result of research activities. It is important to know if there are areas of convergence and divergence of views. The various aim as published by the 28 articles are summarized in Table 1.

Table 1 Research Aim of the 28 Surveyed Papers

Authors	Aim
[1]	Prediction of seismic induced building failure and collapse in Lagos, Nigeria.
[2]	Prediction of design strength of some commonly used standard concrete.
[3]	Quality assessment of cements used in some selected building sites.
[4]	Assessment of the hazardous effect of excess near surface water of the foundation of building in a reclaimed land.
[5]	Evaluation of the effect of building information management (BIM) as a tool for effective construction management in Nigeria.
[6]	Comparative analysis of the quality of steel reinforcement produced locally in Nigeria and imported ones.
[7]	Preliminary investigation of building foundation using geotechnical techniques.
[8]	Quality improvement methods for concrete used in building structures.
[9]	Geotechnical and geophysical investigation of building collapse.
[10]	Geotechnical investigation of building collapse.
[11]	Determination of the appropriate concrete mix ratio required to produce standard concrete.
[12]	Mechanical analysis of reinforcing steel bars obtained from collapse buildings.
[13]	Chemical analysis of reinforcing steel bars obtained from collapse buildings.
[14]	Importance of pre-construction investigation.
[15]	Importance of structural sub-surface settings.
[16]	Importance of geological input in building construction.
[17]	Expert opinion on the causes of building collapse.
[18]	Sequence of subsurface strata on low resistivity zones.
[19]	Investigation of the insurance regime in Nigeria as it relates to building.
[20]	Poor quality concrete and concrete materials as predictors of building collapse.
[21]	Solution to building collapse using geotechnical and surface geology.
[22]	Examination of the incidence of building collapse.
[23]	Environmental and socioeconomic effects of illegal mining on rural dwellers.
[24]	Appraisal of building survey practices in Nigeria
[25]	Investigation of the effects of poor-quality building materials and workmanship on building collapse.
[26]	Assessment of the nature and causes of building collapse in Nigeria.
[27]	Soil characterization of the study area.
[28]	Investigation of hazardous earth processes.

It can be seen that some of the article did not addressed the issue of building collapse directly. Hence, building collapse was one of the objectives of the studies.

4. MAJOR FINDINGS OF THE SURVEYED ARTICLES

The major findings are the key results obtained from research activities. They are used to evaluate if the aim of the research has been met. The major findings from the 28 articles contains to an extent, evidences on the causes of building collapse in Nigeria. This is presented in Table 2.

Table 2: Major Research Findings of the 28 Surveyed Papers.

Authors	Major Findings of the surveyed papers
[1]	The quality of steel reinforcement and chances of seismic occurrence are positively correlated.
[2]	Choices of aggregate sizes, concrete mix ratio and cement types are predictor hardened properties of normal concrete.
[3]	Some cements used in building are not standard.
[4]	Foundation of buildings may not be properly founded directly on the oils of reclaimed lands.
[5]	Building information management is a vital tool in building construction.
[6]	Locally made steel bars deviated significantly from standard specifications than the imported one.
[7]	The soil characterization of the study area revealed that deep seated foundation must be adopted if higher loads are expected.
[8]	Poor quality concrete is prevalent in Nigeria. Cement brands and aggregate sizes are determinants of compressive strength of acceptable concrete.
[9]	Soils from areas that have experienced building collapse have lower permeability, lower angle of shearing resistance and high plasticity index.
[10]	Soils from areas that have experienced building collapse have low bearing capacity peat, lower permeability, lower angle of shearing resistance and high plasticity index.
[11]	The compressive strength of the concrete produced is less than the standard specification.
[12]	The reinforced steel bars investigated, have low ductility.
[13]	Chemical analysis of reinforcing steel bars reveled significant deviation from standard specification.
[14]	Complex subsurface geology can affect buildings.
[15]	Structural subsurface settings are often ignored in preconstruction planning.
[16]	Soils from areas that have experienced building collapse have low bearing capacity.
[17]	The expert's opinions are unanimous on the perceived causes of building failure and collapse.
[18]	Soils from areas that have experienced building collapse have high quantity of clay/peat of low resistivity.
[19]	Most buildings lack insurance policies.
[20]	Poor concrete and concrete materials affect the load carrying capacity of building structures.
[21]	Subsurface geology can trigger building failure and collapse.
[22]	High incidence of building collapse occurs in previously reclaimed swampy lands.
[23]	Building collapse was listed among the adverse effects of illegal mining.
[24]	Building survey is not practiced the ay it is supposed to be.
[25]	Poor concrete and concrete materials affect the load carrying capacity of building structures. This is worsened by inadequate supervision of construction works.

[26]	Building collapses can be as a result of deterioration of building components at different rates and degrees.
[27]	Efficient soil characterization is needed to address foundation issues.
[28]	Sinkholes and cracks can be triggered by seasonal changes of the soil.

5. CAUSES OF BUILDING FAILURE AND COLLAPSE

The major findings from the 28 articles contains to an extent, evidences on the causes of building collapse in Nigeria. That is, the causes of building failures are subset of the major findings. This is presented in **Table 3**.

Table 3 Causes of Building Collapse as discussed in the 28 Surveyed Papers.

Authors	Causes of building Collapse in Nigeria	Classification
[1]	Poor quality materials (concrete), earth tremors.	Poor materials, Geophysical
[2]	Poor quality materials (concrete)	Poor materials
[3]	Poor construction process, use of substandard materials.	Structural defects, poor materials
[4]	Structural defects on the foundation of buildings done on reclaimed lands.	Structural defects, Geophysical
[5]	Inefficient construction management.	Management, construction defects
[6]	Substandard steel bars, corrupt practices by local steel manufacturers leading to significant deviations from standard specifications.	Poor materials, corruption
[7]	Foundation flaws due to near- subsurface geomaterials characterization.	Structural defects, Geophysical
[8]	Poor concrete practices and technology.	Corruption, management, construction defects
[9]	Structural problem due to the presence of smectite in the soils.	Structural defects, Geophysical
[10]	Geotechnical and geological reasons.	Geophysical
[11]	Use of low-quality building materials and concrete, incompetent craftsmen.	Poor materials, management, construction defects
[12]	Low quality reinforced steel bars.	Poor materials
[13]	Low quality reinforced steel bars.	Poor materials, corruption
[14]	Lack of pre-construction investigations. Ignoring structural subsurface settings.	Management, corruption, structural defects, Geophysical
[15]	Lack of pre-construction investigations.	Management, structural defects
[16]	Lack of pre and post construction investigations, under design, improper supervision, use of substandard material, poor quality funding and construction.	Management, structural defects, construction defects, poor materials, Geophysical.
[17]	Use of substandard building materials, incompetent craftsmen, use of incompetent or unlicensed contractors, structural defects, flawed construction methodology, heavy downpour and flooding, violation of building codes, non-enforcement of building codes by regulating agencies, lack of supervision, defective design, illegal conversion,	Management, structural defects, construction defects, poor materials, Geophysical, corruption, legal.

	alterations or additions to the existing building structure, overcrowding, dilapidating structures and deviation from approved use.	
[18]	Poor soil bearing capacity and improper foundation design.	Structural defects, Geophysical
[19]	Non-implementation of government policies on building and insurance.	Legal, corruption
[20]	Poor quality concrete and concrete materials.	Poor materials
[21]	Subsurface geology.	Geophysical
[22]	Flaws in the structure, poor quality materials, construction defects, improper design and dilapidation, foundation issues in buildings on reclaimed lands.	Structural defects, Geophysical, poor material, construction defects
[23]	Illegal and unsupervised mining activities.	Geophysical
[24]	Lack of adequate building survey.	Management, construction defects
[25]	Incompetent construction workers, low quality of construction materials.	Management, poor materials
[26]	Substandard materials, design errors, flawed construction methodology, use of uncoordinated components.	Structural defects, poor material, construction defects
[27]	Tension resulting from heavy shrinkage of the soils.	Structural defects, Geophysical
[28]	Passive earth processes or natural hazards.	Geophysical

6. SUMMARY OF THE SUGGESTED RECOMMENDATIONS OF THE SURVEYED ARTICLES

The summary of the recommendations by the surveyed articles are based on their major findings as regards to the cause of building failure and collapse in Nigeria. The suggested recommendations, when adopted can be helpful in minimizing the menace of building collapse in Nigeria. These are summarized in **Table 4.**

Table 4: Major Recommendations as Proposed by the Authors in the 28 Surveyed Papers.

Authors	Major Recommendations by the authors
[1]	Quality materials must be used. Seismic effects reports must be incorporated in building designs.
[2]	Enhance quality production of concrete.
[3]	Training sessions are recommended for building professionals on the application of different classes of cements.
[4]	Special structural tests must be performed on reclaimed lands when building is anticipated.
[5]	Proposed the development of innovative process that will incorporate building information management in construction management.
[6]	An urgent need for the regulatory agencies to ensure strict compliance to stated standard specifications of building materials and penalize defaulters to discourage the use or local production of substandard building materials.
[7]	Deep seated foundations are preferable in cases where higher loadings (storey) are expected.
[8]	Improvement of the existing concrete technology. Tests on the quality of cements has to be conducted regularly by the concerned regulatory agencies.

[9]	Soil characterization must be conducted before building is done. Government should assist people in cases where smectite contents are high.
[10]	Soil characterization must be conducted before building is constructed, especially for high rise buildings.
[11]	Continuous random test of building materials is done to determine when specifications are deviated.
[12]	Continuous random test of building materials is done to determine when specifications are deviated. Tests are to be conducted on the materials to ensure that they are of the required standards.
[13]	Ensure that quality steel bars are used and sanctions are prescribed for observed corrupt practices as it regards to local production of reinforced steel bars.
[14]	Pre-construction investigations and geotechnical information must be available before commencement of buildings.
[15]	Pre-construction investigations and geotechnical information must be available before commencement of buildings. Emphasis on subsurface investigations are highly recommended.
[16]	Geotechnical reports must be available before, during and after construction of buildings.
[17]	Awareness and trainings on the dangers and causes of building collapse should be regularly conducted for stakeholders in the built environment and landlords, property developers and contractors. Safety measures are to be ensured during the building process.
[18]	Deeper foundation structure is highly desirable.
[19]	Compulsory insurance for buildings.
[20]	Strict adherence to specifications must be emphasized. Closer collaboration among the professionals in the built environment is very key to ensure quality control and assurance.
[21]	High resistivity can be achieved by sand filling and high resistivity concrete must be used for buildings in reclaimed lands.
[22]	Compressive investigations of the geophysical characterization of building sites are highly recommended.
[23]	Develop strategies to eliminate illegal mining and promotion of other income generating activities.
[24]	Government and professional buildings should regulate the practice of building survey.
[25]	Recruitment and effective supervision of skilled and competent workers. Quality checks on, and sanitization of the building materials before incorporation into the building works.
[26]	Pre-investigation of building materials before incorporation into the building works.
[27]	Adequate footings of foundations.
[28]	Close monitoring of areas while natural hazards are evolving or anticipated based on historical records or projections.

7. SUMMARY OF FINDINGS

Based on the analysis of the surveyed papers. The followings are summary of the findings as it relates to possible causes of building failure and collapse in Nigeria.

7.1 Major Findings

The major findings from this review are enumerated.

- ✓ The quality of building materials used in construction in Nigeria are often poor.
- ✓ The local producers of building materials are not compliant to stated standards.
- ✓ People patronizing poor materials because they are cheap and affordable.

- ✓ People patronize unskilled craftsman because they want to optimize their resources and the workers work with little or no supervision.
- ✓ Geophysical, geotechnical and soil characterization information before, during and after building construction is almost non-existent in Nigeria.
- ✓ There is absence of effective government monitoring to ensure compliance with stated building codes.
- ✓ Corrupt practices are prevalent in the building industry.

7.2 Causes of Building Failure and Collapse in Nigeria

The causes of building collapse in Nigeria can be grouped into seven broad areas.

- ✓ The use of poor building materials.
- ✓ Geophysical and geotechnical.
- ✓ Structural defects.
- ✓ Lack of effective management of construction processes.
- ✓ Construction defects:
- ✓ Corruption.
- ✓ Legal and regulatory failure.

8. RECOMMENDATIONS

The following recommendations are proposed for the ionization of building failure and collapse in Nigeria.

- ✓ Soil characterization must be conducted before building is done.
- ✓ Government should assist people in cases where smectite contents are high.
- ✓ Geotechnical reports must be available before, during and after construction of buildings.
- ✓ Government must subsidize the cost of building materials to reduce the incidence of patronizing poor building materials.
- ✓ Government must ensure strict compliance with the building regulations and revisions to existing laws must be done in line with the current building trend and technology.
- ✓ Government should enlighten the populace on the importance of building insurance.
- ✓ Government and private sectors should partner to invest on new building technologies that can help reduce the cost of building construction and inevitably ensuring quality.
- ✓ Task force which must include the professionals in the built environment must be set up by the government to ensure strict implementation of building codes and penalty must be meted out on defaulters.
- ✓ Government must ensure that continuous random test of building materials is done on both locally made and imported building materials to determine when expected standard specifications are deviated.
- ✓ The use of low skilled craftsmen should be discontinued and effective supervision must be done during every process of building construction.
- ✓ Only approved construction methodology must be used.
- ✓ Houses that failed stress test must be marked for demolition.

- ✓ Illegal conversion, addition and alteration of approved buildings must be penalized

9. FURTHER RESEARCH

The systematic review has brought to bear different causes of building collapse in Nigeria. Recommendations have been proposed. Moreover, different aspects of this line of research have not been considered. Some suggested areas are listed.

- ✓ Stress tests have not featured in the literature.
- ✓ Comparative analysis on the various causes of building failure and collapse have not been investigated.
- ✓ Economic implications of building collapse remain unexplored.
- ✓ Details on Government intervention as it regards to reducing the incidence of building collapse has been rarely reported.
- ✓ Building collapse research are often limited to the urban centers of Nigeria.
- ✓ The role of poverty in building collapse have not been reported.
- ✓ The in-depth analysis of the occurrence of building collapse in reclaimed lands have not been done.
- ✓ Research on new building technology that will reduce building costs are needed to address the issue of poor funding.
- ✓ The psychological analysis and psychiatric evaluation of survivors of collapsed buildings in Nigeria are rarely reported.
- ✓ The role of religious and superstitious beliefs concerning building collapse have not been studied.
- ✓ The health implications of debris resulting from collapse buildings in Nigeria have not featured prominently in the literature.
- ✓ The detailed epidemiology of building collapses and deaths and injuries arising from such collapse have not been studied.

10. CONCLUSION

The systematic review of the building failure and collapse in Nigeria revealed seven major causes of the reported collapse. It can be seen from the review that poor construction materials and lack of geophysical investigation are the two major causes of building collapse in Nigeria. The recommendation will serve as a policy statement and when adopted and implemented, would help to reduce the incidence of building collapse. Some areas of further research endeavors were proposed.

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