

**THE IMPACT OF EROSION OF BUILDING FOUNDATION IN AKWA IBOM STATE:
INVESTIGATING THE MITIGATING STRATEGIES**

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ABSTRACT

Erosion remains a critical environmental concern in Nigeria, particularly in Akwa Ibom State, where high rainfall, poor drainage systems, deforestation, and unregulated construction practices have contributed significantly to land degradation. This study investigates the impact of erosion on building foundations across selected areas in Akwa Ibom State, with a focus on identifying the extent of structural damage, the underlying geotechnical factors, and the effectiveness of existing mitigating strategies. Utilizing a mixed-methods approach combining field surveys, soil analysis, structural assessments, and stakeholder interviews the research reveals that erosion-induced foundation failure is both widespread and severe, especially in areas with loose soil composition and inadequate storm water management infrastructure. The study also evaluates various mitigation measures, including the use of reinforced foundations, improved drainage systems, vegetation cover, and community-led erosion control projects. Findings indicate that while some strategies have shown promise, most are either poorly implemented or not tailored to the local soil and climatic conditions. The research concludes by recommending a multi-disciplinary and community-inclusive approach that integrates modern engineering solutions with sustainable land-use practices. These recommendations aim to enhance the resilience of buildings in erosion-prone zones and support long-term infrastructural sustainability in Akwa Ibom State.

KEYWORDS: Erosion, Building Foundations, Akwa Ibom State, Soil Degradation, Structural Failure, Mitigating Strategies, Geotechnical Analysis

INTRODUCTION

Erosion, a critical environmental challenge, poses a significant threat to infrastructural integrity across various regions of Nigeria, particularly in Akwa Ibom State. Characterized by the gradual removal of soil due to water, wind, or anthropogenic activities, erosion has increasingly impacted the durability and stability of building foundations in both rural and urban communities within the state. As a coastal region with diverse topography and high annual rainfall, Akwa Ibom is uniquely vulnerable to gully erosion, surface runoff, and land subsidence, all of which accelerate the deterioration of structural foundations (Nwaeze et al., 2020; Udo & Okon, 2022).

The socio-economic implications of foundation failure due to erosion are profound—ranging from the collapse of residential and public infrastructure to displacement, loss of property, and increased maintenance costs. Despite multiple interventions by government agencies and civil society groups, the menace persists, raising urgent questions about the

effectiveness, sustainability, and adaptability of current mitigating strategies. Moreover, rapid urbanization, poor land-use planning, and inadequate drainage systems have compounded the problem, demanding a more integrated and localized approach to erosion control (Etim & Udoh, 2019).

This paper seeks to critically examine the impact of erosion on building foundations in Akwa Ibom State and to investigate the strategies currently employed to mitigate these effects. By identifying the strengths and weaknesses of existing approaches, the research aims to propose more effective, site-specific solutions tailored to the unique geotechnical and environmental realities of the region.

Concept of Erosion

According to Allaby (2013), erosion is the action of surface processes (such as water flow or wind) that removes soil, rock, or dissolved material from one location on the Earth's crust and then transports it to another location. Erosion, as it affects man and his environment, is natural and as old as the earth itself (OMAFRA Staff, 2003). It is seen as the gradual washing away of soil through the agents of denudation, which include wind, water, and man (Abegunde, 2003). These denudating agents loosen, wear away, dislodge, transport, and deposit soil particles and nutrients in another location. Christine and Josef (2007),(2007), cited in Wudneh (2012),(2012), defined erosion as the wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity, or other natural or anthropogenic agents that abrade, detach, and remove soil or geological material from one point on the earth's surface to be deposited elsewhere.

The broadest application of the term "erosion" embraces the general wearing down and molding of all landforms on Earth's surface, including the weathering of rock in its original position, the transport of weathered material, and erosion caused by wind action and fluvial, marine, and glacial processes (Encyclopedia Britannica, 2015). This broad definition is more correctly called denudation, or degradation, and includes mass-movement processes. A narrow and somewhat limiting definition of erosion excludes the transport of eroded material by natural agencies, but the exclusion of the transport phenomenon makes the distinction between erosion and weathering very vague. Erosion, therefore, includes the transportation of eroded or weathered material from the point of degradation (such as the side of a mountain or other landform) but not the deposition of material at a new site. The complementary actions of erosion and deposition, or sedimentation, operate through the geomorphic processes of wind, moving water, and ice to alter existing landforms and create new landforms. Thus, the process of erosion could be slow and continue unnoticed, or it may occur at an alarming rate, causing serious loss of topsoil (Abegunde et al., 2006).

Concept of Building

A building is an enclosed area, usually immovable, with walls and a roof, such as a house or factory. There are many different sizes, shapes, and uses for buildings (Usanga and Usanga, 2024). A building is essentially any man-made structure with a roof, walls,

foundation, and interior rooms that is intended to support and shelter a variety of human activities. Usually permanent and stationary, this structural element is composed of steel, concrete, wood, and glass. Technically speaking, the building's design incorporates engineering and architectural concepts that guarantee safety, stability, and durability against external influences. A building's envelope, interior design, materials, and systems are all meticulously incorporated to satisfy performance standards, including energy efficiency, resilience to natural disasters, and thermal comfort (Bianco, 2023).

A building is a purposefully constructed structure that combines architectural form, engineering function, and cultural expression to enclose space for human occupation or activity. It is a sophisticated artifact that combines materials, environmental controls, structural systems, and spatial arrangement to serve a variety of societal functions, including worship, education, trade, and housing. The idea of a building is changing along with technology and societal demands; it is no longer viewed as a static entity but rather as a dynamic system that must adapt to user wants, digital innovation, and environmental sustainability over the course of its existence. Therefore, the contemporary definition of a building encompasses more than just its structural elements; it also takes into account its functionality, setting, and effects on people and the environment (Mohammad, Abdullah, & Ismail, 2018).

Enia and Martella (2023) define a building as any physical object that is designed for human habitation or activity, or to house symbolic cultural functions related to individual or social life. The concept embeds the building within a dual framework of autonomy and relationality: while a building has intrinsic qualities such as formal, aesthetic, structural, and material properties that give it its identity and presence, it is simultaneously conceived as existing in a network of interactions with a variety of human and nonhuman agents. These interactions include how people inhabit, perceive, and use the building; how buildings are shaped by environmental, climatic, economic, and regulatory conditions; how they affect communities socially, psychologically, and spatially; and how they interact with nonhuman entities (plants, animals, objects) and changing conditions over time.

A building is a constructed physical entity that is intended to contain space for human habitation or use. It is made up of systems (mechanical, electrical, and plumbing), finishes, and structural elements (walls, roof, and foundation) that work together to provide comfort, safety, shelter, and functional adaptability. Its physical arrangement, circulation patterns, accessibility, and utility infrastructures not only offer fundamental defense against the weather and climate but also influence human interaction and behavior. In modern architectural discourse, the notion of a building further encompasses its life-cycle performance including sustainability, energy efficiency, maintenance, and adaptability to future needs and its interaction with environmental, social, and cultural contexts, (The Editors of Encyclopaedia Britannica, 2025).

Concept of Building Foundation

The lowest structural element of a building that securely transfers the loads of the superstructure to the rock or soil below is the foundation. In order to avoid excessive settlement or tilting, it disperses dead, live, and environmental loads across a wide region. Ali, Rahman and Chowdhury (2021) define the foundation as the “critical interface” between a building and the supporting ground, ensuring stability and serviceability throughout the life span of the structure.

In addition to transferring loads, foundations shield structures from dampness, frost, and soil movement, all of which can shorten a building's lifespan. To forecast soil-structure interaction and increase safety margins, modern practice combines geotechnical studies and modeling. Yuan and Zhang (2023) emphasise that contemporary foundation design increasingly uses advanced testing methods to ensure long-term performance and resilience.

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Impact of Erosion on Building Foundations

The slow deterioration of soil brought on by wind, water, and human activity is known as erosion. The integrity of building foundations is seriously threatened by it, especially in areas with shaky soils and inadequate drainage systems. Since a building's foundation is its structural base, any changes made to the soil that supports it run the risk of causing serious damage, instability, or even collapse. There are various ways to look at how erosion affects building foundations:

- **Loss of Soil Bearing Capacity**

The bearing capacity required to sustain the loads transferred by the foundation is provided by the soil. The topsoil and subsurface layers that offer stability are washed away during erosion, which lowers the soil's ability to support structural loads. This may result in unequal settlement, wall fissures, and structural distortions as a result of uneven foundation settling (Ojo & Olowofela, 2020).

- **Exposure and Weakening of Foundations**

The protecting soil surrounding the foundation is exposed when erosion is severe. Foundations are exposed to deterioration, moisture intrusion, and loss of cover protection as soon as they are visible above ground level. Constant exposure weakens masonry or concrete components, increasing their susceptibility to spalling and cracking (Chinwokwu & Adebayo, 2019).

- **Differential Settlement and Structural Cracks**

Usually, erosion happens unevenly, impacting one area of the soil more than another. Cracks on floors, walls, and beams are signs of differential settlement of the foundation caused by this unequal soil loss. This eventually leads to structural imbalance, which warps the building's geometry and endangers its residents (Onwuka et al., 2021).

- **Foundation Instability in Flood-Prone Areas**

Because of the scouring action of flowing water around building foundations, erosion happens more quickly in flood-prone places. This type of scouring reduces the cohesiveness and compactness of the soil by washing away the small particles that hold it together. This causes foundations to become unstable and tilt, particularly for shallow foundation systems like pad footings and strip footings (Agbede & Joel, 2018).

- **Moisture Infiltration and Material Deterioration**

Water can seep into building substructures as erosion changes the natural drainage and grading surrounding foundations. In addition to weakening the soil, excessive moisture speeds up the corrosion of reinforced concrete foundation reinforcement. It may result in cycles of swelling and shrinkage in clayey soils, further weakening foundations (Okeke & Ume, 2022).

- **Increased Maintenance and Repair Costs**

Problems with erosion-induced foundations frequently lead to expensive upkeep and repairs. Building owners who are impacted are compelled to stabilize the soil, install underpinning, or rebuild the foundation entirely. These procedures need a lot of capital and could potentially cost more than the initial development budget (Adepoju & Ojo, 2020).

- **Collapse and Loss of Property**

In severe situations, ongoing erosion near foundations may cause a building to collapse. This puts people's lives in danger in addition to causing property loss. Collapses are more frequent in places where inadequate site research was done before building began and where the design failed to account for the soil's susceptibility to erosion (Nwosu et al., 2021).

The Mitigating Strategies of Negative Impact of Erosion on Building Foundation

Degradation Building foundations around the world are seriously threatened by the separation and movement of soil caused by wind, water, or other forces. The carrying capacity and support geometry beneath foundations alter when near-surface soils are lost, which can cause settling, tilting, cracking, and in severe situations, the collapse of structures. A comprehensive strategy that incorporates site evaluation, hydrologic management, soil and slope stabilization, structural safeguards, and ongoing upkeep is necessary for effective mitigation.

How erosion affects foundations

Erosion affects foundations through three general mechanisms:

- (1) Removal of supporting soils (undermining)
- (2) Increased pore pressures and reduced shear strength due to infiltration and saturation, and
- (3) Concentrated flow and scour that erode around footings and pile heads. In sloped or riverine sites, surface runoff and channel migration can rapidly remove soil from beneath foundation toes; in coastal or tidal zones, scour around piles is a major failure mode. Importantly, both gradual sheet erosion and rapid local scour can produce similar structural consequences loss of lateral and vertical support but they require different countermeasures

Site investigation and monitoring the first line of defence

A comprehensive site assessment is necessary prior to choosing mitigating strategies. Topographic surveys, soil sample and classification (grain size, density, Atterberg limits), groundwater monitoring, and flow path identification (overland flow, concentrated drains, neighboring channels) are all included in this. In order to predict erosion hotspots and identify risky areas, geospatial and remote sensing technologies such as DEM analysis and erosion-hazard mapping are useful. Before damage becomes structural, early diagnosis and maintenance are made possible by routine monitoring, visual inspections, scour probes around foundations, and instrumented piezometers.

Preventive (non-structural) strategies

1. Drainage control and runoff management

The most economical way to reduce erosion is to manage water. Techniques include installing gutters, roof downpipes, and subsurface drains; constructing swales or grassed channels to slow and distribute flows; and surface grading to redirect runoff away from foundations. Concentrated scour at the foundation toes can be avoided by lowering flow velocity by grade breaks, check dams, and energy dissipators. During construction,

temporary solutions like straw wattles and silt fences can be employed. Long-term conveyance capacity and ease of maintenance should be guaranteed by proper design (Han et al 2023).

2. Vegetative stabilization and soil bioengineering

By strengthening the root zone, enhancing infiltration, and shielding the soil surface, vegetation is an inexpensive and environmentally friendly way to lessen sheet erosion. When chosen appropriately for the site's hydrology and soil type, native grasses, shrubs, and trees offer long-term protection. By combining structural and biological components, soil-bioengineering solutions (living fascines, brush mattresses, and planted geogrids) stabilize slopes and narrow channels while lowering the erosive potential of surface flows. These techniques work particularly well on slopes and in highland regions where hard-engineered solutions are either superfluous or too expensive (Chambel, 2024).

Structural/engineering solutions

3. Riprap and revetments

On susceptible slopes, channels, or around foundation toes, applying a layer of stone revetment or well-graded rock (riprap) distributes flow energy and shields soils from direct erosive effects. To prevent loss of particles beneath the armour layer, riprap design must take into account flow velocities, stone gradation, and the underlying filter/separator (geotextile). An apron of riprap anchored into the subgrade lowers the risk of undermining for small foundations close to active flows.

4. Gabions and revet mattresses

The flexible retention and slope protection systems made of gabion baskets (wire mesh packed with stones) and reno mattresses adapt to settlements and work well for channel lining and toe protection. When some distortion is permitted and local stone procurement lowers costs, gabions are very helpful. Under embankments and around foundations, scour can be avoided by properly keyed gabion aprons.

5. Geotextiles and filters

Between the soil and the armour layer, nonwoven geotextiles serve as a filter, allowing drainage while keeping fine soils from being carried away. Permittivity and strength should be taken into consideration when choosing geotextiles; installation must prevent tearing or shifting. To maintain soil integrity, geotextiles are advised behind retaining walls and under riprap in numerous codes and guideline papers.

6. Structural slope stabilization: retaining walls, soil nailing, and crib walls

Engineered retaining structures (anchored or gravity retaining walls), soil-nailing, or open-front crib walls offer support and stop mass slope failures that could damage foundations in areas with steep slopes or thin soil. Groundwater, drainage behind the wall, and surcharge loads must all be considered in the design; weep holes and appropriate backfill filter layers are essential for lowering pipe and hydrostatic pressure.

7. Deep foundations and foundation underpinning

Use deep foundations (driven piles, drilled shafts) that shift loads to more stable, deeper strata if the site is prone to scour or if the surface soils are extremely erodible. Underpinning procedures, such as mini-piles, jet grouting, micropiles, and concrete underpinning, can restore support for existing buildings that have undergone undermining. Pile-protection techniques like rock armouring, collars, or designed mattresses reduce local scour in riverine and coastal environments.

Site-specific scour protections (for hydraulic environments)

For foundations adjacent to rivers, culverts or tidal waters, scour protection needs special attention: local scour predictions, flow modeling, and design of countermeasures (riprap aprons, toe trenches, guide bunds) are required. Recent reviews emphasize combined solutions (e.g., riprap + geotextile + structural toe) and monitoring of scour holes, because hydrodynamic conditions can change rapidly during storm events.

Maintenance, inspection and institutional measures

Mitigation is a continuous process. It is crucial to perform routine inspections (both seasonally and following significant storms), maintain drains, fix vegetation cover, and replace or repair armor. Future danger is decreased for infrastructure in exposed or public areas by including erosion control into local land-use planning and raising community awareness. Design life, maintenance costs, and inspection schedules must all be considered throughout the planning phase.

Sustainable and cost-effective considerations

Effectiveness, cost, environmental impact, and local capacity are all balanced while choosing the best measures. While engineered solutions (riprap, gabions, retaining walls, and deep foundations) are better suited for high-energy conditions or situations when urgent structural safety is at risk, vegetative and soil-bioengineering solutions are affordable and sustainable for many slopes. Resilience and ecological advantages are frequently combined in hybrid systems (such as gabion toe + vegetated slope). Adaptive, evidence-based design and the utilization of monitoring data to maximize treatments are highlighted in recent publications.

Strong structural protections (riprap, gabions, geotextiles, retaining systems, or deeper foundations) in high-risk areas, careful site assessment and monitoring, efficient drainage and runoff control, and vegetative stabilization where appropriate are all necessary to mitigate the multifaceted risk of erosion to building foundations. The framework is completed by adaptive management and maintenance. The detrimental effects of erosion on foundations can be significantly lessened when appropriate treatments are chosen based on site conditions and integrated, safeguarding people's lives, property, and long-term asset value.

CONCLUSION

In The Conclusion, impact of erosion on building foundations in Akwa Ibom State, revealing a complex interplay between environmental, geological, and human-induced factors. From foundation cracks and structural instability to outright building collapse, erosion has emerged as a silent but destructive force, threatening the safety, sustainability, and economic viability of built environments across the state. The vulnerability is further exacerbated by factors such as unregulated construction, inadequate drainage systems, deforestation, and poor land-use practices (Nwaeze et al., 2020; Etim & Udoh, 2019). While several mitigating strategies—including reinforced foundation designs, community-based erosion control, and soil stabilization—have been introduced, their implementation remains inconsistent, underfunded, and often disconnected from the realities of the affected communities (Udo & Okon, 2022). Moreover, the absence of proper geotechnical assessments prior to construction continues to compromise the effectiveness of erosion prevention efforts

RECOMMENDATION

- Poor surface water management has been identified as a major contributor to erosion. Authorities and developers should incorporate SuDS such as infiltration trenches, retention basins, and permeable pavements to reduce runoff and minimize soil displacement (Etim & Udoh, 2019).
- Engineers and developers should explore and apply advanced foundation techniques such as deep pile foundations, raft slabs, and soil stabilization methods, especially in areas with high erosion susceptibility. These technologies, though initially costly, offer long-term cost savings by preventing structural failure (Okereke & Asuquo, 2020).
- Government at all levels must allocate dedicated funds for erosion control infrastructure and integrate erosion mitigation into broader urban planning and disaster risk reduction policies. Strategic partnerships with NGOs, private sector, and international development agencies should also be pursued for technical and financial support.

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