

Adaptation of Ceramic and Porcelain Building Materials to Climate Conditions in Akwa Ibom State, Nigeria

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Abstract

Ceramic and porcelain materials play crucial roles in the building industry, notably in roofing, flooring, cladding, and decorative applications. Their mechanical performance and durability are heavily influenced by local climatic conditions, especially in regions with high humidity and rainfall such as Akwa Ibom State, Nigeria. This study examines the adaptation of ceramic and porcelain building materials to the tropical monsoon climate in Akwa Ibom. Through literature review and climate analysis, we identify climatic stressors affecting performance, adaptation strategies in material selection and design, and implications for sustainable construction practices. Informed by climate resilience literature and Nigerian construction studies, this research contributes to improved material suitability and sustainable building practices in coastal tropical environments.

Keywords— *Ceramic materials; Porcelain; Climate adaptation; Akwa Ibom State; Tropical monsoon; Building materials*

I. INTRODUCTION

Ceramic and porcelain become immanent in building construction for thousands of years because of their long lasting, beautification and opposition to environmental abasement. This is in line with (Abiola, 2023) view presently, these materials are very useful in production of tiles, roofing, floor finishes, wall claddings and architectural details in habitable and commercial structures throughout Nigeria. In a mangrove swam forest like Akwa Ibom and Cross River, these areas are characterized by intense humidity, frequent rainfall and occasional high temperature. Wesolowska et. Al (2021) considered the usefulness of materials production of ceramic and porcelain as being affected by environmental factors. The materials need adaptation technically, structurally and architecturally. This research investigate the adaptation of ceramic and porcelain construction materials to climate factors in Akwa Ibom combining climatic data, material.

II. PERFORMANCE FINDINGS AND SUSTAINABILITY OF ADAPTED CERAMIC AND PORCELAIN MATERIALS TO ENVIRONMENT.

A. Climatic situation in Akwa Ibom

Akwa Ibom situates in the tropical rain forest under the coppen classification. Akwa Ibom experience repeated high temperature, high dampness and notable yearly rainfall frequently greater than 2000mm in coastal areas with regular hydrometer or cloud cover (Wikipedia, 2025). The region also experience a high temperature of about 28. 50c with dampness throughout the year of about 275 rainy days yearly. These affect production of construction of materials.

Regular Dampness and Showers.: This encourage water penetration in permeable material, destroying the shape and value the material with time. Wesolowa et al (2021) notes that these environmental factors promote the growth of algae,

moss, and growth of macro organism on the material leading to defacy and deciduousity

Thermal conditions: Haute and steady temperatures raise thermal expansion that affect materials use in production of porcelain and ceramic continuous exposure spoiled the beauty of the material.

Climatic conditions in Akwa Ibom affect both sustainability and value thereby necessitating careful selection of materials.

III. CERAMIC AND PORCELAIN MATERIALS IN BUILDING CONSTRUCTION.

A. *Definitions and properties*

Ceramic materials do not contain carbon thereby making them inorganic and cannot Last due to heat in the process of manufacturing. They contain refined clay that have been processed and passed through heating. Porcelain is a mass-density ceramic for its low porosity, haut mechanical strength and excellent resistance to moisture absorption.

B. *Ceramic Tile Production in Nigeria*

Findings on ceramic tile manufacturing in Nigeria features the relevance of quality materials on climate performance. (Abiola, 2023) carried out a research on Nigerian ceramic tile production and stressed on quality control, raw material selection and firing control as essential to producing tiles suitable to resist environmental pressure. The research highlights difficulties faced by local ceramic industry concerning inconsistencies in supply of raw materials and processing technology which hinders tiles lifespan and competitiveness in market (Abiola, 2023)

Climate stimulate performance challenge: Ceramic and porcelain materials in frequent rainfall and damp environments encounter serious difficulties:

C. *Texture*

Preamble ceramics deteriorate and become weak due to frequent dampness and rainfall which permits water absorption into the ceramic bodies, making it to lose intensity as a result of humidity. Secondly

of soluble salts affect the ceramic surface. Thirdly, a hollow and inherited composition on damp surface occurs.

Findings on polymer and recycled ceramic materials show that material formulation and porosity control are fastidious to dampen ceramics. Wesolowska et al (2024) discovered that environmental exposure relatively changes the microstructure of ceramic bits in recurs to time and stressing on the need for – processing bodies in damp climate.

D. *Thermal and mechanical fatigue*

Thermal stress arises from internally generated heat as a result of daily changes in temperature within different tropical climate; mechanical stress comes from outside and surrounding loads such as tension or compression. A combination of these two causes deformation of ceramic. The thermal extension in ceramic tiles gives rise to debonding and cracking which stimulate moisture ingress. In addition, serious solar radiation multiplies surface temperatures thereby aggravating thermal stress gradients in ceramic tiles leading to lasting micro-structural degradation.

D. *Biological weathering*

Biological growth on humid ceramic tiles devalues degradation and surface disintegration. Glazing reduces water penetration in ceramics but rough and porous surfaces provide room for moss, algae and lichen growth.

IV. ADAPTATION STRATEGIES FOR CERAMIC AND PORCELAIN MATERIALS.

The process of adaptation of ceramic and porcelain materials in Akwa Ibom state takes various techniques:

Selection of material and processing, materials selected have of high density: With mechanical strength and low porosity. This characteristic allow such ceramic to resist and adapt easily to the situation in Akwa Ibom. Besides porcelain tiles with low water retention of less than 0.5% are mostly

adapted to dampen climatic condition than high porosity ceramics.

High Firing Temperatures: Solanki and Shah,(2016) noted that the increase in firing temperature optimizes vitrification but lowers porosity and raise strength of the material.

Optimize Mineral Mix: Mixing fluxing agents such as feldspar and silica modifies the ceramic matrix, giving rise to solid humidity resistance to porcelain and ceramics. Borges et al (2020) admits that the availability of aluminium oxide in ceramic ameliorate thermal performance and mechanical resistance.

Surface Treatment and coating: Smoothing notably decreases water penetration and sharp by surface. Smooth porcelain allows easy cleaning and moisture resistance which is a major characteristic of moisture climate. Smoother porcelain with high lasting finishes affect biological growth and decrease staining. Porcelain clothing system with smooth finishing makes it convenience and lengthen life span of the product

Design Integration and passive building considerations: Suitability of raw material in construction gives rise to integration of these materials industries.

Orientation and Mounting: Exposure of tiles to direct rainfall expediate the life of tiles in the name of ventilation. To impand and expose tiles to ventilation actually decrease permeability of water and encourage drying.

Thermal Mass and Ventilation: Provision of sufficient insulation to keep the tiles warm reduces room temperature by engulfing, protecting, and allowing heat gently from tiles thereby extending it lifespan. Obamoh et al (2024) support that combination different ventilation strategies in protecting tiles in tropical climate promotes natural comfort without application of artificial method.

Local material Resources and sustainability: Clay materials in Nigeria is convenience for production of ceramic everywhere couple with deposition of kaolin in Akwa Ibom State (science, Nigeria 2025). Natural clay from region of Nigeria is a good source for ceramic tiles when properly processed. In

consideration of the lifespan of the product produced internally with Nigeria alleviate cost of transportation and encourage recycling of different materials such as palm kernel which align with sustainable building practice case considerations in Akwa Ibom.

V. CASE CONSIDERATIONS IN AKWA IBOM

From experience it is gathered that Akwa Ibom ceramic adaptation is rare while wider research outside Akwa Ibom within Nigeria considers adaptation of material within humid regions. Unegbie et al (2025) pin point climate flexibility all over Nigerian building cases stressing on selection of material that is suitable to climatic condition. Equally, the lifespan consideration shows that local climate considerably improves energy consumption and quality of the products. (Unegbu et al (2025). To Ngware and university studies, inactive cooling and climate-responsive design decrease the level of energy in tropical region thereby strengthening the desire for ceramic materials outside beautification purposes but for sustainability and usage.

A. Porcelain and ceramic Roofing Tiles:

Tiles for roofing should be adaptable to heat and humidity. Porcelain tiles is more adaptable to ceramic tiles given their low porosity which resist moisture penetration. Adequately smoothen porcelain tiles reduces water penetration decrease thermal movement and limit biological growth. In locations such as Uyo and Eket in Akwa Ibom ceramic roofing system with adequate slanting, impand and allow adequate ventilation performances than bumpy materials.

B. Walls, Cladding and Flooring

Ceramic wall tiles especially smoothen porcelain used in kitchens, bathrooms which are areas with high moisture reduce growth of micro-organism and dirt. Humid environment require porcelain flooring to diminish a reversible reduction in size.

VI. DISCUSSION

Balancing performance with cost and availability: The major contention in tropical areas especially Akwa Ibom is the ability to afford these products in

local markets. Though porcelain are highly durable, the cost effectiveness serves as a major hindrance for people's choice within the local markets. The locally produced materials could be improved by application of Kiln technologies and processing the raw materials effectively for use.

Importance of integrated Design Approach: Combing different methods and integration of different design of ceramic products allow for adaptation inactive design techniques should be considered in terms of demand for the product to decrease depending on mechanical ventilation for users.

VII. FUTURE RESEARCH NEEDS

There is a gap on empirical research on ceramic material performance in Akwa Ibom climate conditions, laboratory durability testing simulating high humidity, regular rainfall and temperature cycles would give a clear and price performance data guide choices. Equally, researching into locally ceramic production.

VIII. CONCLUSION

Porcelain and Ceramic are good products for construction in Akwa Ibom. The most important thing is considering the environment and location where the material will be used. The comfort of the

occupants should be highly considered. In recurs to climate condition in Akwa Ibom with high humidity, frequent rainfall and high temperature material selection should consider all the conditions highlighted in the research. The contributions of material scented, architects, and builders are very vital for progress in ceramic and porcelain industries to improve upon their products.

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