Functional Performance of Islamic Geometry in Mosque Design in Osogbo, Osun State

Babalola Oladayo Abdullateef., Paul Bethels Uchenna., Akani Chizy Chukunyere

Department of Architecture, Rivers State University, Port Harcourt, Nigeria

***Corresponding Author**

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ABSTRACT

This research investigates the functional Performance of Islamic geometry in contemporary mosque design. It demonstrates how geometric principles go beyond ordinary ornamentation and focus more on functionality, such as environmental performance, cultural expression, spatial organization, and structural stability. It balances the visual identity, spatial arrangement, and environmental impacts with divine belief. To address this gap, this research uses a qualitative research methodology based on the principles of symmetry, repetition, tessellation, and proportionality. A qualitative method design was employed through literature review, case studies analysis of the following mosques: camlica mosque (Turkey), Education city mosque (Qatar), and Ilorin Central Mosque (Nigeria). This mosque showcases the strong use of Islamic geometry and how a modern, contemporary mosque blends with traditional Islamic architecture, from the early monumental to aesthetic innovation. The study is based on three key elements (environmental responsiveness, symbolic meaning, and spatial functionality), which reflect how Islam expresses its ideas through the use of shapes and patterns., Islamic geometry was used in analyzing every aspect of this study to explore different cultures and historical contexts, ranging from the early mosque to the modern contemporary mosques. This research also highlights the key challenges, including the high cost of construction, the lack of skilled craftsmen, and cultural misinterpretation, and suggests that to solve these problems, this study recommends improving education and training in geometric design, adopting cost-effective methods of construction, and that architects should collaborate more with historians for a proper understanding of Islamic geometry. This research concludes that Islamic geometry is not static and it evolves with time, and they are key part of mosque design and not just for aesthetic purposes but also to ensure functionality, sustainability, and to promote Islamic symbolic tradition.

Keywords: Islamic geometry, Functional performance, Spatial organization, Structural Stability, Environmental Performance.

INTRODUCTION

Islamic geometry started in the 7th century and has been one of the most exciting and distinctive attributes of Islamic architecture. The Islamic traditional architecture of mosque design is more than just decoration; every shape has what it symbolizes, represents, and its area of application. Islam in general doesn't believe in the use of images or any figurative expressions, as it could lead to idolatry. Hence, they believe in the use of shapes and patterns, and just like mathematics, Islam also believes in the principle of "Golden ratio / Divine proportion," which means balance or order.

This geometry can be seen as a bridge between the physical and metaphysical, and it has been the way Islam communicates and expresses their spiritual ideas. Historically, all these shapes and patterns have been used to beautify, illuminate, solve design problems, ventilate, and also to improve the structural stability of the mosque.

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As the advancement in technology is taking over the place and also the evolution of modern materials, there is a need to integrate and implement Islamic geometry in mosque design to maintain the cultural, aesthetic, and spiritual beliefs of what these shapes and patterns stand for and represent

Statement Of The Problem

Most mosques in Nigeria are largely limited to decorative purposes, which makes most mosques rely heavily on mechanical means for ventilation and lighting; also, there is an issue of Spatial organization. Most traditional mosques apply geometry to their domes, courtyards, arches, ventilation, spatial organization, and Structural stability. Contemporary mosques in Nigeria tend to rely on mechanical ventilation, reinforced construction structures, lighting, etc., which makes the prayer hall experience heat gain, poor lighting and ventilation, and high energy consumption. There is little research on how Islamic geometry can be introduced to contemporary mosque than its just being for aesthetics, and rather for them to be used for other purposes like environmental function and structural stability in Nigerian mosque design.

Aim

The aim is to demonstrate how Islamic geometry can be used in contemporary mosque design to enhance functional performance while preserving their Islamic architectural identity.

Objectives

a. To examine the functional performance requirements of contemporary mosques, focusing on structural stability, spatial organization, and environmental functions

b. To examine the principles of Islamic geometry and their usage in traditional and contemporary mosque design.

LITERATURE REVIEW

Islamic geometry started in the 7th century and has been one of the most exciting and distinctive attributes of Islamic architecture. It was created through the combination of shapes and patterns, which is the way Islam express their belief and arts instead of using figurative expression. Every shape and pattern has its own divine meaning and functions.

Recent studies have explained how Islamic geometry has contributed to structural efficiency, environmental function, acoustic and spatial organization. One of the key functional contributions of Islamic geometry is its influence on structural performance; geometric forms are derived from Islamic tessellations, grids, and repetition of modules, which helps in distributing structural loads across domes, roofs, and shell structures. Rather than serving only as ornamentation, Islamic geometry contributes to the organization and identity of sacred spaces while reinforcing Islamic beliefs through abstract, non-figurative forms (Broug,2019; Omer, 2018).

The environmental performance helps in regulating the prayer hall by reducing solar heat gain and improving natural ventilation. Sustainable mosque design should integrate traditional Islamic architecture principles with passive environmental strategies such as daylighting, natural ventilation, shading devices, and climate-responsive geometric forms (Sobri et al, 2021)

Spatial organization of mosques, particularly the organization of mosque prayer halls, courtyards, domes, and transitional spaces, significantly affects environmental performance, thermal comfort, and users' overall experience; they recommended integrating spatial planning with passive environmental design to improve the functional performance of contemporary mosques (Azmi and Ibrahim, 2020).

Islamic geometry uses symmetry, hierarchy, repetition, and modular grids to organize and arrange mosque design, which helps in improving movement and circulation around the prayer hall and mosque buildings.

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Research also confirms that Islamic geometry contributes to acoustic performance with the use of patterned walls, muqarnas, and repetitive geometric surfaces, which helps to reduce echo effects and improve sound transmission during prayer. The shape of the mihrab and other geometric elements can influence sound reflection and reduce echoes, creating a more comfortable listening environment for worshippers (Hossameldien & Alshawan, 2019; Rossad Yudhana & Sutikno, 2025).

Studies confirm that Islamic geometry can also help in sustainable design, and patterns can be used in controlling daylight, reducing heat gain, and improving energy efficiency.

Functional Performance Of Islamic Geometry In Mosque Design

a. Spiritual symbolism: The use of shapes and patterns is used in reflecting Islamic ideas, and they symbolize the unity of Allah, infinity, and order in creation.

b. Spatial Organization: Geometry has helped in ensuring proper coordination and organization of spaces within the mosque by:

i. Designated column space and spacing; the use of circles, octagons, and squares is used to support the building and also to maintain proper sight lines

ii. They are used to show qibla orientation

iii. It helps to keep the whole building in proportion.

c. Aesthetic: It helps in beautifying the mosque and making it visually appealing.

d. Cultural Identity and Promotion: It explains the concept behind Islamic architectural heritage and connects mosques across different regions through the use of shapes and patterns.

e. Structural and Environmental Function: The use of geometric shapes like rectangles, squares, and circles for columns helps in distributing the building load evenly. Also, the use of patterns on facades and on the roof to :

i. The use of a dome helps in reducing the effect of heat, since hot air rises. The use of a dome serves as a heat buffer

ii. Helps in improving natural ventilation; the open vents on the dome let hot air escape, and cooler air gets to enter the mosque through windows and doors

iii. The use of the courtyard also helps in improving natural ventilation.

f. Improving Acoustics: The dome helps in sound transmission, and it makes sound delivery easier to the users**.**

Challenges In Applying Islamic Geometry

a. **Lack of skilled craftsmen**: Islamic geometry requires a proper understanding of symmetry and proportion. It is best done by skilled artisans and craftsmen to create these intricate designs. El-Said & Parman (1976) explain that without a proper understanding of how these patterns are created, architects might produce a design that is inaccurate, which might reduce the influence and quality of the design.

b. **High cost of construction**: The construction of this required skilled labourers, time, and some special materials, e.g., carved stucco, glazed ceramic tiles, brick, etc. Many mosque projects avoid the use of patterns and shapes in order to save money during construction. This has made clients prefer the use of structural elements or other means of ornamentation over the use of symbolic details.

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c. **Cultural misinterpretation:** The use of a clerestory window and perforated screens (mashrabiya) is traditional in Islamic geometry to help in controlling and regulating temperature, sunlight, and airflow within a mosque, while in modern mosque designs, some of these were used for aesthetics, neglecting the main principle behind it.

Strategies For Addressing These Challenges

a. Improving education and training in geometric design.

b. Adopting cost-effective methods of construction; the use of laser-cut designs can be used in place of patterns that are made from tiles or brick, and also reducing geometry to surface ornamentations in contemporary mosque designs

c. Collaboration between architects and historians: many mosque designs are being done without a proper understanding of Islamic geometric shapes and patterns

RESEARCH METHODOLOGY

This research will adopt a qualitative design-based approach methodology which will be supported by descriptive analysis. The word “Islamic geometry” can't be well explained using numbers alone. The qualitative approach will be used to examine the architectural forms, design principles, and the relationship between Islamic geometry and its functional performance. Also shows how Islamic geometry goes beyond mere ornamentation.

The qualitative approach methodology involves data collection and analysis from journal articles, interpretive analysis, architectural documentation, visual and photographic analysis, and would be used in analyzing the Comparative Approach, which will help in comparing traditional and modern-day designs of mosques**.** Visual Analysis this entail the examination of Geometric Patterns the Spatial and Environmental functions.

This study would make use of a case study approach and would analyze three mosques based on their modern architectural design, functional performance, and their application of geometric principles. These case studies are the Ilorin central mosque, the Camlica Mosque, and the Education city mosque

Case Study Selection Criteria

a. Geographical and Cultural diversity: This study would help in comparing Middle Eastern and African interpretations of Islamic geometry.

b. Contemporary Architectural Expression

c. Relevance to the research objectives

d. Extensive use of Islamic geometric principles.

e. Innovative structural and environmental design

DISCUSSION

Case Study 1 – Ilorin Central Mosque

The mosque was opened in 1981 in Ilorin, Kwara State. It has a capacity of 20,000. It is one of the largest mosques in Nigeria, and it has now been renovated and upgraded between 2007 and 2012. This renovation embraces modern contemporary style while still maintaining Islamic identity.

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Figure 1 Aerial View of Ilorin Central Mosque displaying domes and minaret

Source: https://oldnaija.com/wp-content/uploads/2020/04/Ilorin-central-mosque-650x480.jpg

The functional roles this geometry plays can be seen in the symmetrical planning, window patterns, and dome placement. The use of repeated geometric forms serves as visual harmony; the central dome provides the mosque with more strength and stability by transferring the loads of the building to the perimeter walls and also with the help of the columns.

Figure 2 Interior View of Ilorin central mosque showing spatial arrangement

https://muslimvoice.com.ng/wp-content/uploads/2023/02/FB_IMG_1676193046981.jpg

The environmental impact of the mosque can be seen in the high dome and large window openings, which allow natural daylight and improve air circulation within the prayer hall. The geometry displayed in the mosque contributes to the aesthetic and structural performance.

Case Study 2 – Camlica Mosque (Istanbul, Turkey)

This mosque was opened and completed on 7 March 2019; the camlica mosque shows how Islamic geometry can be integrated into a modern mosque and at the same time not alter the traditional Islamic design. The central dome, arches, symmetrical layout, and geometric patterns contributed massively to the structural stability of the mosque.

Figure 3 Exterior of camlica mosque

https://images.pexels.com/photos/14587733/pexels-photo-14587733.jpeg?auto=compress&cs= tinysrgb &w= 1260&h=750&dpr=1

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The geometry can be seen on the giant central dome, which is supported by pendentives, semi-domes, piers, and arches, which help in creating a vast column-free interior; the domes and the arches help in transferring the loads of the building to the perimeter walls.

Figure 4 Interior view of camlica mosque showing the column arrangement and clerestory windows

https://thumbs.dreamstime.com/b/camlica-mosque-inside-istanbul-turkey-camlica-mosque-largest-mosque-turkey-interior-mosque-was-designed-321963049.jpg

The Camlica mosque shows how Islamic geometry can support structural stability, spatial organization, and also enhance environmental performance.

Case Study 3 – Education City Mosque (Doha, Qatar)

This mosque was completed in 2013, also; it is also known as the Minaretein mosque. The education city mosque shows a modern interpretation of Islamic architecture through the use of geometric forms and structural design.

Figure 5 Exterior of Education city mosque

https://images.ctfassets.net/2h1qowfuxkq7/4O6KRuEGPJRAixTVORaxw2/05cd59e7f4810b61c6b55c518cb9bc3b/Education_City_Mosque_Outdoors_3.jpg

Structurally, the mosque uses geometric planning to achieve stability. The building also made use of reinforced concrete and a steel structural system; the repetitive geometric arrangement of structural members ensures balance.

The spatial organization can be seen in the prayer hall, which is large and free from visually impairing barriers. The environmental performance is one of the mosque's strongest qualities through the use of skylights and a glazed façade for natural daylighting; the building also made use of passive cooling strategies such as shading devices and controlled solar penetration, which helps to improve indoor comfort.

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Figure 6: Interior of Education city mosque

https://365adventures.me/wp-content/uploads/2017/08/education-city-mosque-visit-04-1200x800-1-1536x1024.jpg

Comparative Study Of Case Studies

The comparative matrix of this study is based on three major factors: spatial analysis, environmental and climatic response, and symbolic-cultural expression; it explains the flexibility in Islamic geometry and its adaptability. Camlica mosque combines traditional Islamic geometry with a modern way of construction to create a balanced design, they made use of a symmetrical arrangement for domes and arches to achieve balance and stability over a large prayer hall.

Education city mosque adopts a more modern structural system, using reinforced concrete, steel, and inclined columns to create stable yet innovative forms.

The Ilorin central mosque is more culturally grounded, as it shows the strong connection of the Ilorin people to Islamic culture and values, and the geometry focuses more on functionality and spatial organization for easy air circulation. This case study shows how global design principles can adapt to local traditions.

All three mosques provide a clear and well-organized layout that supports congregational worship; Camlica has a hierarchical arrangement of spaces, with the central prayer hall serving as the focal point. Education uses an open plan layout, and Ilorin organizes its prayer hall, ablution area, and supporting facilities in a logical manner.

The environmental performance of each mosque responds to its climate using passive design strategies through the use of high ceilings, large windows, and natural ventilation to improve indoor comfort; shading devices were also incorporated.

This comparison shows that Islamic geometry is more than a decorative feature and it enhances structural performance, improves spatial planning, and supports passive environmental design.

CONCLUSION AND RECOMMENDATION

The study of Islamic geometry reveals a design philosophy that is based on balance and purpose. The case studies show the evolution of Islamic architecture and cultural expression as seen in Ilorin central mosque, Camlica mosque, and Education city mosque, respectively.

Part of the main conclusion is that Islamic geometry is not static, and it is more than aesthetics; it evolves with time and culture. In the traditional mosque of later years, geometry was solely for functionality, spatial arrangement, and how it responds to the climate.

Why modern contemporary mosque geometry is more simplified: furthermore, Islamic geometry has proven to be able to adapt to modern contemporary evolution, where, through the use of perforated screens, domes, and simple grids. It has helped in providing solutions for thermal comfort, ventilation, structural stability, etc.

The main challenges for contemporary architects are the use of geometry without knowing what it represents.

Recommendation

To prolong the functional performance of Islamic geometry in mosque design and to preserve Islamic spiritual divine heritage, these recommendations are to be considered:

1. Maximizing the use of modern technology: The involvement of modern technology can help architects modernize traditional patterns without losing the credibility of the old ones, and this could be done with the use of modern tools like building performance simulation, use of laser cut and digital fabrication, etc.

2. Climate-responsive design: mosques should be constructed and designed in a way that they would be self-sustaining, with special consideration for passive cooling. Geometric elements like courtyards, shading devices, perforated screens, etc, can be introduced.

3. Prioritizing function over decoration, the first consideration of every mosque design should focus on proportions, grids, balance, and orientation before considering aesthetics.

4. Enabling and supporting local craftsmanship and materials, to ensure Islamic geometry remains intact and authentic artisans need to be trained on geometric techniques, and also the use of local materials to promote culture.

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