

DESIGNING EFFECTIVE ACOUSTIC SOLUTIONS FOR ECUMENICAL CENTRES IN OWERRI, IMO STATE

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Abstract

Architectural acoustics is central to the functionality of ecumenical centres, where worship, music, and speech must be experienced with clarity and resonance. This study investigates acoustic optimization strategies for the design of a proposed ecumenical centre in Owerri, Nigeria. Existing worship spaces in Nigeria often suffer from excessive reverberation, echo, poor sound distribution, and acoustic shadows, which undermine worshippers' experience. Using a case-study methodology to evaluate strategies to improve sound quality in large congregational spaces. Findings indicate that absorptive and diffusive materials, strategic stage design, seating arrangement, ceiling geometry, and hybrid acoustic systems can significantly enhance worship experiences. The paper integrates insights from global best practices and recent research in architectural acoustics, highlighting materials such as, recycled polyester panels, and digital sound processing technologies. The proposed solutions create a balance between liturgical requirements, architectural aesthetics, and acoustic comfort. Ultimately, this work contributes to the growing discourse on acoustics in multi-purpose worship spaces and offers practical design recommendations for the Owerri context.

Keywords: Architectural acoustics, Ecumenical centre, Reverberation, Echo, Diffusion, Speech intelligibility, Sustainable materials.

INTRODUCTION

Worship spaces have historically posed complex acoustic challenges due to their large volume, reflective surfaces, and symbolic architectural forms (Beranek, 2014). In ecumenical centres, these challenges are intensified by the need to accommodate diverse liturgical practices, spoken word, and music simultaneously. Owerri, the capital of Imo State, lacks a dedicated ecumenical centre despite its cultural and religious significance in southeastern Nigeria. Most churches and multipurpose auditoriums in the city often suffer from poor sound clarity caused by prolonged reverberation, echo, and inadequate sound isolation.

The World Health Organization (2022) emphasizes that poor acoustic environments negatively impact speech intelligibility, concentration, and emotional well-being. For religious contexts, these deficits reduce participation, spiritual immersion, and inclusivity. Echoes, flutter reflections, and excessive reverberation distort sermons and music, making worship less engaging (Kuttruff, 2017). Thus, optimizing acoustics in a proposed ecumenical centre in Owerri is both a technical and spiritual imperative.

This paper explores design-based acoustic solutions to address these issues. It integrates lessons from international case studies with field-specific recommendations for Nigerian contexts, particularly Owerri's climate and cultural conditions.

LITERATURE REVIEW

Ecumenical centers, by virtue of their large spatial volumes, face persistent problems of long reverberation times, echoes, and uneven sound distribution (Bradley, 2017). Excessive reverberation (>2.5 seconds) compromises speech intelligibility while too little reverberation reduces musical richness (Marshall, 2013). Flutter echoes from parallel reflective walls further degrade listening quality (Rossing, 2007).

Reverberation time (RT) is one of the most widely used metrics in evaluating worship spaces. Studies indicate that excessive reverberation, particularly values exceeding 2.5 seconds, significantly diminishes speech intelligibility, especially in settings where spoken word dominates (Marshall, 2013). Conversely, spaces with very short RTs risk creating a “dry” auditory environment that strips music of its resonance and emotional depth. Flutter echoes caused by parallel reflective surfaces exacerbate these issues, producing repeated sound reflections that interfere with both speech and music (Rossing, 2007). Kuhlmann (2020) emphasized the psychoacoustic consequences of such poor conditions, demonstrating that worshippers in highly reverberant spaces reported lower comprehension and reduced engagement with liturgical activities. By contrast, moderate RTs in the range of 1.5–2.0 seconds have been consistently associated with improved congregational immersion and enhanced choral experiences (Blessner & Salter, 2007).

Poor acoustics not only distort sound but also disrupt the emotional and spiritual atmosphere. Research by Kuhlmann (2020) showed that worshippers in highly reverberant spaces reported reduced comprehension and engagement. Conversely, moderate reverberation (1.5–2.0 seconds) enriches choral music and fosters congregational immersion (Blessner & Salter, 2007).

Design approaches include absorptive wall panels, and wooden surfaces for warmth (Beranek, 2014). More recent solutions include hybrid materials such as perforated gypsum boards combined with mineral wool (Wang et al., 2021), adjustable acoustic systems (Huang et al., 2022), and nonrectangular geometries (Cox & D'Antonio, 2004).

Recent research highlights the use of bamboo composites, recycled polyester, and cork as sustainable acoustic panels with high absorption coefficients (Xie et al., 2023).

DEFINITION OF TERMS Acoustics

The branch of physics that deals with the study of sound, its production, transmission, and effects. In architecture, acoustics refers to the science of designing buildings to achieve optimal sound quality within enclosed spaces.

Architectural Acoustics

A specialized area within architectural design focused on controlling sound within a building. It includes strategies for enhancing desirable sound (such as speech or music) and minimizing unwanted noise or distortion through material choice, spatial geometry, and surface finishes.

Reverberation Time (RT60)

The time it takes for sound to decay by 60 decibels after the source has stopped. It is a key metric for assessing acoustic quality in spaces. Long reverberation times often reduce speech clarity, while moderate times can enhance music.

Speech Intelligibility

The degree to which spoken words are clearly understood by listeners. High intelligibility is crucial in religious spaces where sermons, prayers, and readings are central activities.

Flutter Echo

A repetitive, high-frequency echo that occurs when sound reflects rapidly between two parallel hard surfaces. It creates an unpleasant ringing effect and reduces clarity in a room.

Sound Diffusion

The even distribution of sound energy within a space. Good diffusion prevents dead spots and echo hotspots by scattering sound reflections in multiple directions.

Sound Absorption

The process by which materials reduce the energy of sound waves. Absorptive materials—such as acoustic panels, fabrics, and perforated wood—help control reverberation and improve clarity.

Ecumenical Centre

A religious facility designed for interdenominational Christian worship and fellowship. Unlike traditional churches, ecumenical centers aim to be inclusive of various Christian doctrines, practices, and worship styles.

Simulation Modelling

The use of digital tools and software to predict the behavior of architectural spaces under different acoustic conditions. In this research, simulation modelling was used to test different design scenarios and measure acoustic performance metrics.

Sound Pressure Level (SPL)

A measure of the intensity or loudness of sound in a space, typically expressed in decibels (dB). Balanced SPL ensures that sound is neither too loud nor too faint across the seating area.

Reflective Surfaces

Architectural finishes such as tiles, concrete, or glass that bounce sound waves rather than absorbing them. Excessive use of reflective materials can lead to echo and poor acoustic performance.

Absorptive Materials

Surface finishes or building elements that reduce sound reflections. Common examples include acoustic ceiling tiles, fabric wall panels, and foam treatments.

Vaulted Ceiling

A ceiling that is arched or curved rather than flat, commonly used in sacred architecture. It helps to improve sound diffusion and reduce direct echoes.

Zoning (in Site Planning)

The spatial arrangement of functions within a building site to reduce noise interference and improve usability. In acoustic design, zoning can help isolate worship areas from noisy external or internal activities.

Worship Space

The primary gathering area within a religious facility where communal prayer, singing, teaching, and liturgical activities occur. Its acoustic quality directly impacts the effectiveness and comfort of worship.

STUDY LOCATION

The study was conducted in **Owerri**, the capital city of **Imo State**, situated in the southeastern region of Nigeria. Owerri is one of the most prominent urban centers in the Igbo-speaking region and has grown rapidly in both population and physical development over the past two decades. It functions as a major political, economic, and cultural hub in the South-East geopolitical zone and is characterized by a high concentration of educational institutions, government establishments, hospitality infrastructure, and a vibrant religious community.

Owerri is geographically located between latitudes 5°24'N and 5°30'N and longitudes 7°01'E and 7°06'E. It lies on relatively flat terrain, with an average elevation of about 200 meters above sea level. The city's tropical rainforest climate is marked by high relative humidity, frequent rainfall between March and October, and average daily temperatures ranging between 26°C and 32°C. These environmental conditions have architectural implications, especially regarding material durability and sound insulation, which are key factors in acoustic design.

From a socio-cultural perspective, Owerri is predominantly Christian, with a broad representation of various denominations including Roman Catholic, Anglican, Methodist, Baptist, and numerous Pentecostal churches. The spiritual life of the city is vibrant, and religious gatherings form a core aspect of social life. The growing ecumenical movement has created a demand for multi-faith worship spaces that foster unity among diverse Christian traditions. Consequently, new church buildings and multi-purpose religious halls are emerging, often designed with large volumes and open-plan layouts to accommodate large congregations.



This research adopted a qualitative case study methodology, evaluating acoustic performance in selected ecumenical centres (Abuja, Bayelsa, Akwa Ibom). The study combined field data (reverberation time, material properties), architectural analysis (ceiling heights, seating arrangements, wall geometries), and secondary data from acoustic literature (2020–2024).

Reverberation		and	Absorption		Materials
Material	Frequency	Range	(Hz)	Absorption	Coefficient
Fabric-covered	fiberglass		500-4000		0.70-0.90
Bamboo	composite	panels	250-2000		0.60-0.85
Mineral	wool		125-4000		0.50-0.95
Recycled	polyester	panels	250-4000		0.65-0.90

Staggered seating layouts improved sound distribution compared to linear arrangements.

Curved ceilings effectively diffused sound in Taizé and Abuja. In Bayelsa, flat reflective walls worsened echoes, requiring retrofitted absorbers.

The findings emphasize that hybrid strategies yield the best acoustic outcomes. Excessive absorption dampens musical richness, while overreliance on diffusion leaves speech unclear. A balance must therefore be struck: absorptive panels on side walls, diffusive curved ceilings, and absorptive stage insulation. Moreover, sustainable acoustic materials (bamboo, cork, recycled polyester) provide affordable alternatives to costly imports. Recent advances in digital acoustic enhancement systems (Huang et al., 2022) allow real-time adjustments of RT60, making ecumenical centres acoustically flexible for sermons, choral music, and interfaith events.

6. Conclusion and Recommendations

This study highlights the persistent problem of excessive reverberation and echo in Nigerian worship spaces, including the proposed ecumenical centre in Owerri. By adopting architectural acoustic solutions—curved geometries, sustainable absorptive panels, stage insulation, and digital enhancement systems—worship spaces can achieve balanced acoustics.

RECOMMENDATIONS:

To achieve optimal acoustic performance in large halls, it is recommended that reverberation times be maintained between 1.5 and 2.0 seconds, sustainable absorptive materials such as bamboo composites and recycled polyester be utilized, hollow stages be insulated to reduce low-frequency resonance, ceilings and walls incorporate curved or angled geometries, adjustable acoustic systems be integrated for flexibility, and early collaboration be established between architects, acoustic engineers, and liturgical leaders.

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