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**A Comparative Analysis of Acoustic Material and Effects on Event centres in
Port Harcourt, Rivers State Nigeria**

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Abstract

Acoustics is a developing science in Nigeria like elsewhere in the world. However, it is fast gaining popularity as the country is faced with acoustical challenges from industries, road traffic, power generating sets, churches, event centres etc, hence the need to proffer solution to the menace. The event centres are space meant for listening, celebrating and feeling happy. Calibration that takes place in the auditorium should be reasonably loud and clear. It therefore, necessary for an auditorium to be acoustically equipped to ensure clarity of sound within it as failure to do so could promote noise, that can impede hearing. Noise such as echo and reverberation can cause blurring on a speech within an auditorium, thereby creating difficulties for an effective communication between the listeners and the master of ceremony. The following are two major kinds of noise that could mar good communication in an auditorium e.g. background noise and acoustic noise. The continuous extraneous noise is called "background" noise, while the echo and reverberation emitted from the loudspeaker and microphones is called "acoustic" noise. This Paper critically looked at the use of acoustic materials in the old and new event auditoriums in Rivers State. It also provides a brief background of Nigeria's traditional spaces of events centres as was created by the vernacular architecture, before the introduction of modern architecture by the colonialists. The Paper actually provides opportunities for critical discussions on the influence of time, knowledge, materials, and economy on the use of acoustic materials in churches in Nigeria. Along the line of discussion, the Paper draw comparisons between the acoustic performance of auditoriums of the past and present on the basis of materials type used, spatial design arrangement, functionality/comfort and aesthetics. The benefits of this comparative analysis between old and new auditoriums on the use of acoustic materials and technologies will also not be ignored.

Keyword: Acoustic Materials, Sound, Floors, Ceilings: Doors, Windows and Fenestrations

Definition of Acoustics

Acoustics is an interdisciplinary science that deals with the study of all mechanical waves in gases, liquid, and solids. It's also deals with issues of object vibration, sound, ultra-sound and infra-sound. A scientist, who is an expert on acoustics, is called Acoustician. The application of acoustic technology in modern society is present virtually everywhere, but more common in the sound and noise control industries. The acoustics was derived from a Greek word (Akoustikos), meaning of or for hearing (Justiniano, 2011). A sound is mainly produced in a church auditorium by the loud speakers high above the stage of the auditorium as the congregation that has come to listen to the preacher is seated away from the stage. The more the congregation, the more distant the loud speakers should be from them. A congregation of 1,000 people can occupy roughly 8,000 square feet area of space. The sound transmitted by the loudspeaker move out in the form of a quarter sphere. When the waves reach the audience, they have expanded into a radius of roughly 50 feet (SlideShare, 2013).

The ear of a person takes roughly a square inch of sound. An average person in an auditorium audience takes in roughly double square inches of the sound, which is roughly 0.00017 percent of the overall sound produced by the loud speaker. The tiny amount of sound is usually called the direct-sound because as it travels directly into to the ears of the listener. Therefore, a 1000 people in the audience can only collectively receive 0.17 percent direct sound from the loud speaker. The remaining 99.83 percent of sound is called indirect-sound (Ugo, 2015). Therefore, the management of all the indirect sound is the reason for auditorium acoustics. If the indirect sound is handled poorly, the auditorium's sound quality will be very bad, and if it is handled properly, the auditorium's sound quality will be great. Therefore, it's imperative for auditorium designs or construction to consider three key areas of expertise. Firstly, the services of an architect are needed to designs a building space that conforms with established principles of Hall design to allow for good sound movement, aesthetics, and comfortability (Cao, 2017). Secondly, the site contractor must install in the auditorium good sound systems to ensure the production of a direct sound that could reach all parts of the church auditorium. Lastly, since over 90% of sound produced in an auditorium remains unused by the audience, it is important; the sound engineer picks up the stray sound and processes it properly to ensure good sound quality within the auditorium. The study of Acoustics centres on generation, propagation and reception of sound waves and vibrations.

SOUND

Sound can be defined as a wave motion in air or other elastic media (stimulus) or as that excitation of the hearing mechanism that results in the perception of sound (sensation) (Ding, 2014). Sound may also be described as a simple form of mechanical energy (Arenas, & Asdrubali, 2019) and can be described by the mathematics associated with the generation, transmission, and control of energy. Almost any moving, vibrating, oscillating, or pulsating object is a potential sound source. Usually, vibratory sources radiate enough energy to be audible to humans or felt by them. Sound waves in air (or other gases or fluids) travel outward from the source, transmitted by air molecules, like a rapidly expanding soap bubble. Any particular group of molecules behaves like a pulsating balloon, moving only slightly, while the wave progresses swiftly to great distances.

Transmission (flow) or prevention of transmission of sound, and conversion of sound energy to a non-audible form are the function of so-called acoustical materials (Arenas, & Crocker, 2010). Sound above 300–400 Hz is best considered as traveling in rays. A ray of sound may undergo many reflections as it bounces around a room. The energy lost at each reflection results in the eventual demise of that ray.

Statement of the Problem

Ever since, events Architecture in Nigeria has evolved over time from very simple forms and spaces to highly complex buildings with huge auditoriums for usually large crowds. However, these halls of events have been known to grapple with horrific issues of sound control. These issues of poor sound management in events have rendered many event gatherings rather discomfoting and discouraging as opposed their primary objective of providing users with good health and comfort.

The architectural problem is identifying the key areas in cultural centres that are susceptible to sound. For the purposes of this research, the major areas of concentration which the author intends to solve are the floor, ceiling and walls of the auditorium for effective sound control and

management. This can be achieved through architectural designs with the use of proper form and shape for the auditoria, adoption and application of good absorbent materials and seating arrangements with raked floors. Hence, the need to critically study this problem, analyze it and recommend lasting solutions.

Aim of the Study

The main aim of the study is to investigate into the Comparative Analysis of Acoustic Material and Effects on Event centres in Port Harcourt, Rivers State Nigeria

1. Application of appropriate passive and active noise defense mechanisms in building design
2. Application of architectural acoustics design principles and criteria that impact the choice of acoustical control technologies.
3. Provide sufficient room volume to allow the natural development and support of sound.

Materials Types and their Characteristics

The types of materials used in the above church auditoriums can only be effectively assessed against the background of the following factors, e.g. Auditorium shape, walls, floors, ceiling, windows/doors, seats and the surrounding environment. The following are some of the most commonly used acoustic materials in the average Nigerian church auditorium: acoustic paint, glass windows with aluminium frames, metal doors and glass, woods, floor tiles, textile fabric window blind and stage decoration, asbestos ceiling materials, mud, stone, bricks and sandcrete blocks, chip boards, cork and foams materials, rug carpet and aluminium shading devices.

Findings on Acoustic Materials Application in Old and New Events Auditoriums:

The walls: the walls of the old event auditoriums were mainly made of either local, wood, stones or bricks as time progressed. Whereas, the average Nigerian event hall of today is built with sandcrete blocks and rendered with concentrated sand-cement mortar. However, the building walls are finally finished with thick emulsion absorptive paint in most cases.



The floors: Auditorium floors of past churches were merely made of either sand, compressed red mud or at best concrete as time progressed. Whereas, in today's churches, floors are usually finished with tiles or rug carpet for either sound reflection and absorption purposes respectively.

The ceilings: the present day event halls make use of assorted kinds of ceilings materials e.g. ply board materials, pvc material, plaster-of-Paris (P.O.P) material and 600mm x 600mm white perforated asbestos ceiling boards. The old event auditoriums were rarely covered with ceiling materials.

Doors, windows and fenestrations: Regarding openings and fenestrations, the old events had very good windows and fenestration as they relied mainly on natural ventilation. Whereas, the present day auditoriums run more on HVAC systems and as result pay less attention to openings and fenestration.

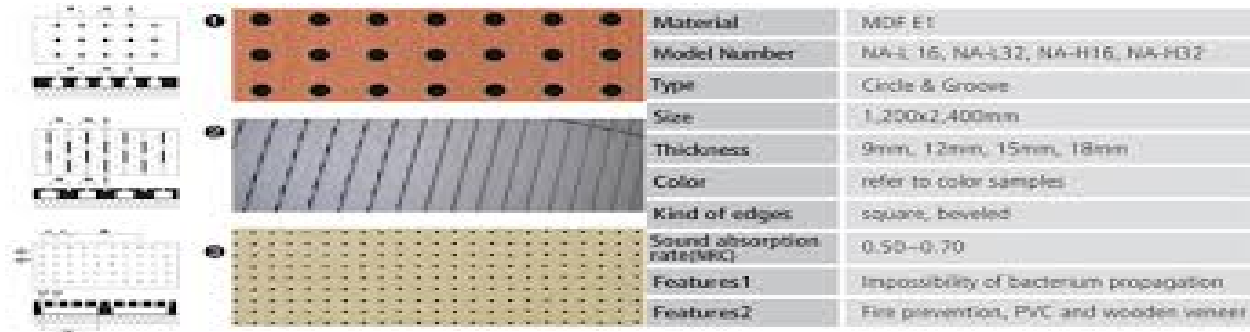
However, many old event halls never bothered much about doors. The choice of materials used for the windows and doors in the present day auditoriums also contribute to the general acoustic effect of the space. The doors are usually made of glass, wood or metal with either wooden or aluminium frames. The events auditoriums vary in shapes, however a good number try to allow for a good seating pattern which provides good visual and acoustic environment for both audience and the talker. The closeness of the seats to the podium is sometimes a deliberate acoustic design to ensure early reflection of sound. Good sightline is required for the event halls with a descending sitting arrangement.

Geometric Forms of Auditoriums (Shapes)

The event halls auditoriums in Nigeria are usually large spaces designated for worship and speech functions only. They are usually bounded by other service buildings as children units, canteens, book shops, etc, as well as both green and concrete landscaped surroundings. The key acoustic challenges of these auditoriums include their sizes, shapes, material types and finishes used within [8]. therefore, in a bid to analyse the overall acoustic effect of these buildings, the above mentioned factors and others must be put in proper perspectives.



Auditorium sizes and shapes usually affect acoustic condition within the auditoriums. This is due to the fact that reverberation time increases depending on the size of the auditorium. As the size of the auditorium increases, reverberation time could grow beyond acceptable limits (Ulrich, & Arenas, 2020). Most church auditoriums in Nigeria have an average ceiling height of 5100mm at the lowest levels while the highest levels are at 3600mm. They are mostly rectangular in shapes with few triangular, circular and hexagonal ones. Below is a typical church auditorium plan in Nigeria. The shapes of Halls of the past were mainly rectangular irrespective of the capacity. They also had curved ceiling shapes. Materials application techniques were crude as opposed to technology aided application techniques of today. The new Halls come with varieties of shapes depending on size and capacity of the Hall, e.g. semi-circular shape, Hexagonal shapes, sloppy floors and ceilings, etc. Materials application techniques are technology aided and of high quality.



Performance and durability of materials

The acoustic materials used in the old churches were mainly stones, Mud and Bricks. These items were the wall materials for the Halls but had ability to absorb and control sound as well. The new Halls are mainly built of blocks and concrete and padded with sound insulation /absorptive materials, Sound barriers and Reflectors, e.g. acoustic foam panels. Materials of the old were largely very natural with little or no proper industrial chemical treatments to improve their quality and prolong life span. However, materials used in new church auditoriums are of quality and durable as they are mostly factory treated with a guaranteed life span.

Function of acoustic materials used: Old materials were to some extent performing well, but were largely limited by the quality of production and installation. Obviously, the new materials perform better due to well calculated architectural designs and technological equipments such as microphones, loudspeakers to amplify and control sound. The use HVAC (Heat, ventilation, and air-conditioning) technology for comfort.

Aesthetic value of materials

Walls were mostly bare with little or no decorative touches and where it existed were old fashioned. The new Halls are better decorated and comfortable as some of the acoustic materials also double as decorative elements. The church auditoriums, besides being places for assembly, communication and visual interaction between the preacher and the audience, they are also expected to provide a calming and soothing aesthetic effect to the users.



Background noise: this is a common feature around church auditoriums in Nigeria. It often originates from the surrounding environment and interferes with the speech of the preacher as it is left unshielded in most cases by either reflectors or shading devices except for a few standard hall buildings like the Obiwali cultural centre in Rivers State.

Reverberation: the persistency of sound after it has stopped is termed reverberation. This results in what is known as echo. Reverberation, echo, sound diffusion, background noise are some of the commonly noticed issues in the church auditorium in Nigeria. The seat arrangement, the form and shape of auditorium, nature of material used all jointly enhance the quality of sound in the

auditoriums. Reverberation time (the time required for loud sound to remain inaudible after leaving its source) in most auditoriums is longer than the acceptable one (1) second. This is influenced by the space volume, the shape and sound frequency. The use of reflective materials like floor tiles, glossy wall surfaces etc affects reverberation time as well in many auditoriums. The use of absorbing materials such as floor rugs, perforated ceiling, textile window blinds, etc as surface finishes reduces reverberation time.

Loudness of sound: the sound produced in the church auditorium from the original source is always amplified by the use of public address systems as microphones, loud speakers, amplifiers, etc. Ideally, the sound produced from the original source ought not to be distorted via the use of equipment like that.

Categorization of acoustic materials based on function

Sound absorbers: the sound absorbing acoustical materials commonly used in Nigerian churches are Textile window blinds, Textile wall covers, perforated asbestos ceiling panels, wood, chip boards, cork, foam materials, stones, blocks and bricks. These sound absorbing materials help in eliminating sound reflection to improve speech intelligibility, reduce standing waves and prevent comb filtering in the auditoriums. A wide variety of materials can be applied to the church walls and ceilings depending on your application and environment. The materials mentioned vary in thickness and in shape which distinguishes them from each other on the bases of absorption rating and performance in handling sound within the auditoriums (Toyoda, Funahashi, Okuzono, & Sakagami, 2020).

Sound diffusers: these devices are hardly seen in the Nigerian church auditoriums. However, there are locally produced diffusers that were commonly used in church auditoriums of the past in the form of burnt bricks. The way and manner the bricks are laid with obvious indentations between them, its a deliberate attempt to reduce the intensity of sound by scattering it over the entire hall. Types of local diffusers that were commonly used in the past and occasionally in the new halls are stones, unrendered sandcrete blocks, and bricks.

Sound barriers: these materials range from dense materials to block the transmission of sound to devices and compounds used to isolate structures from one another and reduce impact noise. Some examples this in the Nigerian church environment are trees, stones, bricks, concrete walls/columns and sandcrete blocks.

Sound reflectors: Certain acoustic materials with the ability to reflect sound that are commonly seen in Nigerian churches are polished floor tile, window glass covers, and metal doors. While on the exterior, we sometimes see aluminum reflectors which also double as shading devices. Within the average Nigerian church auditorium like any other around the world, direct sound travels towards the walls and boundaries of the room, this gets reflected on hitting the wall surfaces. These reflections can travel back towards the source of the sound as well as to the audience as an indirect sound. When the waves of the reflected indirect sound become too many within the auditoriums, it makes them quite noisy sometimes thereby making it difficult for listeners to hear the preacher from the pulpit (Sakagami, Okuzono, Suzuki, Koyanagi, & Toyoda, 2020).

Noise sources in a typical Nigerian church auditorium: Noise is commonly defined as an unwanted sound which calls for acoustic considerations in an architectural design. There are different kinds of noise in the church auditorium like any other enclosed public space e.g. outdoor noise, indoor noise, etc. these noise types often interfere with the ability of the audience to clearly hear the voice of the preacher on the pulpit. **Outdoor Noise:** this usually comes from the activities going on in the surrounding of the church e.g. vehicular traffic, mechanical equipments, pedestrians, kids, etc.

Indoor Noises: this results from conversations between members of the audience, which produces different patterns of speech at varying frequencies and amplitudes that render the auditorium acoustically uncomfortable, if left unchecked. This kind of noise brings about interference in communication as one conversation between two people may be affected by another and so on. this is further made worse by their closeness. Appliances like air-conditioners, ceiling fans, electrical switches and shoe noise also contribute to the noise generation problem within the auditorium. It is noteworthy that the volume of noise produced by these appliances can be highly disturbing. Door openings and windows as well as the movement of furniture also contribute to noise generation within the church auditorium.

Discussion on the Use of Acoustic Materials in Old and New Event Hall

In my discussion, i will be basically be analysing my findings in the course of this study as it relates to the use of acoustic materials in the old Nigerian church auditoriums and how it has evolved over time as seen in the new churches. Having gone through the journey of looking at the use of acoustic building materials in Nigerian church auditoriums from the past to present, i discovered many interesting issues to talk about. However, i will be discussing these interesting findings on the basis of the following headings:

The Walls of the old church auditoriums, like i stated in my findings, were commonly built with local materials such as, woods, stones and bricks. While, churches usually have their auditoriums built with sandcrete blocks and rendered properly with concentrated sandcement mortar. The building walls are finally finished with thick emulsion absorptive paint in most cases and in a few cases with hightech absorptive.

Reflective and diffusing acoustic materials. The Floors of the old church auditoriums were made of sand, compressed red mud and at best concrete in a few cases. But today's churches build their floor finishes with tiles, rug carpets, foam underlay, etc, for either sound reflection and absorption purposes. The use of these acoustic materials on the floor helps in the regulation of reverberation time. The Ceiling materials used in present day churches are of different kinds with different qualities and levels of performance e.g. ply board materials, pvc material, plaster-of-Paris (P.O.P) material and 600mm x 600mm white perforated asbestos ceiling boards. These perforated ceiling surfaces allow for sound absorption and diffusion when it comes in contact with the ceiling surfaces. The old church auditoriums were rarely covered with ceiling materials. Doors, Windows and Fenestrations of the old churches were very good as they allowed the inflow of a lot of natural air into auditorium spaces. On contrary, the present day auditoriums run more on technological devices as HVAC systems and as result depends less on natural ventilation methods. However, many old churches never bothered much about doors. Materials choices of the present day auditoriums also contribute to the general acoustic effect of the auditorium space. The doors are usually made of glass, wood or metal with either wooden or aluminium frames. The churches auditoriums vary in shapes, however a good number try to allow for a good seating pattern which provides good visual and acoustic environment for both audience and the preacher. The closeness of the seats to the pulpit is sometimes a deliberate acoustic design to ensure early reflection of sound. Good sightline was observed in the churches with a descending sitting pattern. In the analysis, one will say that the acoustic materials used in the old churches were mainly stones, Mud and Bricks. These items though had ability to absorb and control sound as well, but in relation to modern materials used in most present day Nigerian churches, were of inferior performance quality, durability and aesthetics. Therefore, the new auditoriums which are mainly built of blocks, concrete and equipped with sound insulation /absorptive materials, Sound barriers and Reflectors, e.g. acoustic foam, perforated ceiling panels, rug carpet, glass etc, are a great improvement on what existed earlier in the old church auditoriums. However, there are still a lot of acoustic challenges noticed in most new church

auditoriums. In other words, there is still plenty of work to be done in the new church halls so as to give worshippers the required comfortable acoustic environment.

Benefits and harm in the use of acoustic materials:

Comfort Acoustic materials create a comfortable listening environment for audience as they not only diffuse unwanted sound, but also help to hinder thermal energy transfer.

Materials Acoustic knowledge has led to the development of series of high performing acoustic materials that are in widespread use today.

Effective communication: the use of acoustic materials ensures effective communication between the Talker and his/her audience.

Creates employment: Being a special area of construction highly specialized skilled men and labour is required for the execution for projects are growing in their numbers.

Aesthetic and Ornamentation: the use of acoustic materials adds to the aesthetic value of most Auditoriums.

Recommendations

1. the cultivation of an effective acoustic culture.
2. the use of effective acoustic materials in surface finishing in church auditoriums in Nigeria e.g. absorbtive and diffusing materials.
3. Sound reflecting and shading materials be used both within and on outer walls of the auditoriums to ward off unwanted sounds.
4. Auditoriums floors be mostly rugged rather than tiled.
5. Auditoriums be painted with acoustically treated paints both on the interior and the exterior surfaces.
6. Trees and other landscape elements be adopted externally as sound breakers around the auditoriums.
7. Doors and windows be constantly closed or blind be put in place to absorb and mitigate harsh sounds.

Conclusion

Regarding the use of the church auditorium in Nigeria over the years, it has been observed that the church auditoriums have served their purposes without serious complaints from the teeming users, even though the hall having in most cases fallen short of the ideal acoustic function of a hall. This may be due to the fact that most of the worshippers are accustomed to noise, therefore can hardly tell the difference between a normal and an abnormal acoustic environment.

There is also failure on the part of architects and other building professional, who undertake designs and construction of projects without actually giving premium to the acoustic performances of their eventual products. The academia has also not done enough to popularize acoustic practice in Nigeria, in spite of the fact that they are statutorily better positioned to champion the course. The Academia ironically is one of the worst hit groups by this problem as their teaching and learning environments have largely been infested with noise, thereby making learning difficult for students. A proper public enlightenment on how to properly manage the relationship between sound and buildings and the environment as well as humans will undoubtedly minimize a lot of acoustic challenges currently bedeviling a number of public gathering spaces as the church auditoriums, lecture halls, event halls etc.

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