

A Comparative Analysis of Acoustic Material and Effects on Church Auditoriums: Old and New Churches in Nigeria

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Rec date: Dec 31, 2015; Acc date: Feb 17, 2016; Pub date: Feb 28, 2016

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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 etc, hence the need to proffer solution to the menace. The church auditorium is a space meant for worship, listening and preaching the word of God. This makes it a spiritual environment, that requires serenity to enable the audience hear and understand what is being preached from the alter (stage). A sermon preached 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 a church auditorium, thereby creating difficulties for an effective communication between the listeners and the preacher. The following are two major kinds of noise that could mar good communication in a church 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 will be critically looking at the use of acoustic materials in the old and new Church auditoriums in Nigeria. It will also provide a brief background of Nigeria's traditional spaces of worship as was created by the vernacular architecture, before the introduction of modern church architecture by the colonialists. It includes an outline of various church architectural Forms and the use of acoustical materials and technology spanning a long period in Nigeria. 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 will 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 church auditoriums on the use of acoustic materials and technologies will also not be ignored.

Keywords: Nigeria; Vibration; Sound; Ultra and infra-sound; Insulation; Reflection; Echo; Reverberation; Ambient noise; Auditorium; Delayed-reflection; Sound-shadow; Sound-concentration

Introduction

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 [1,2]. 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 [2].

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. This 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 [2]. 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 [3]. 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.

The Problem

Nigeria covers an area of about 1,000,000 square kilometres as shown in Figure 1 with approximately 200 million people of which, 40% is Christians. The traditional people of Nigeria had their vernacular religion in pre-colonial times, which had its unique kind of architecture. However, they were coerced to embrace the church culture on the arrival of the colonialist in the 19th century alongside its modern architecture.



Figure 1: Showing Nigeria's total land coverage and boundaries.

Ever since, church Architecture in Nigeria has evolved over time from very simple forms and spaces to highly complex buildings with huge auditoriums for usually large crowds of worshippers. However, these halls of worship have been known to grapple with horrific issues of sound control. These issues of poor sound management in church auditoriums have rendered many church gatherings rather discomfiting and discouraging as opposed their primary objective of providing worshippers with good spiritual health and comfort. Hence, the need to critically study this problem, analyze it and recommend lasting solutions.

Research question

1. How can stray and unpleasant sound or noise be reduced to the barest minimum in the Church auditoriums in Nigeria?
2. Why is it necessary to apply acoustic materials and technology to address the problem of stray sound generation in Nigerian church auditoriums?

Literature review

Acoustic control is fundamentally important to the success of any building especially in auditoriums. In the evaluation of buildings in relation to the environment in the past decades, the importance of providing good acoustics has become a predominant issue in the search for a model architectural environment. As such; the issue of noise, its sources and methods of control has been subjected to intense study as shown in Figure 2 below.

A person's ability to hear and understand a speech depends on the signal-noise ratio. We humans want direct signal that is safe to receive and little or no noise. It appears, if the noise is too loud then simply raising the volume of direct signal from the loudspeaker can settle the problem. Unfortunately, this doesn't work well as expected. Loud sound is known to be discomfiting. Loud sound can improve the roughly constant background noise-signal ratio. But does not improve the acoustic noise-signal ratio due to the loudness of noise, which depends directly on the sound pich of the loudspeaker. For intelligibility, t at least 20 dB is required between the quietest parts of the desired signal and background noise as the most quiet parts of a speech are in the 40 dB-A range and even less. Background noise levels in a standard auditorium can be as low as 20 dB-A. There should also be at least 10 dB between sound signal and the background noise. Background noise can be said to be the overall sound a person hears when the preacher is not saying anything. There are three basic types of background noise. As you sit and listen in most meeting spaces, you will be able to distinguish noise from operational systems, intruding noise from outside and self-generated noise from the audience. To achieve a strong signal in an auditorium, the background noise should be reduced to as low as possible.

The noise Intruding from outside is allowed into the auditorium through the windows, doors and the walls of the building. Traffic noise penetrates into auditorium from the street. Noise from Parking lot door shutting and conversations contribute to intruding noise. Rain and wind can also cause noise as they hammer and scrape the building. Stationary equipments outdoors such as heat exchangers and sprinklers can cause noise as well. The HVAC systems installed in and around the building can also generate noise that penetrates into the building [4]. Events in other sections of the building get into the auditorium passing through the walls and also by air. Others come through the corridors, doors and air-conditioning ducts. Some noise produces other noise. This quiet scenario of a library can testify to this claim. When background noise is at a very high level, everybody feels like making a little noise and thinks it won't be noticed by others. Unfortunately, a collection of this kind of noise from a thousand people and we will have a reasonably loud people generated noise in that space. An auditorium with a background noise level that starts low at 20 dB-A range remains quiet as the audience arrives [5].

Case Studies: Their current acoustical conditions and Analysis

The need to reduce noise levels has led to the development of guidelines to ensure acceptable noise levels in various space types. The acoustical challenges in church auditoriums in Nigeria have prompted the need for the use of acoustic materials and planning [6]. An example is the Akaniobio Church, Old Calabar, Cross-river state, Nigeria shown in Figure 3a and b below. It was built in 1905 with no particular acoustic control mechanism in mind except for the use of local building materials like woods and mud which have natural ability to absorb sound. The second example which is shown in Figure 4a and b, is the Ikoru community church, Ekiti state, Nigeria, built in early 20th century. Like the first case study, it was also built with no particular acoustic control plan except for the use of materials like bricks and woods. There is no information as to the architect that built it and his acoustic vision. The third case study is the Christ Church Cathedral, Lagos, built in 1946. This compared to the earlier mentioned examples is a fairly modern church. It was built with blocks and even has ceiling cover as shown in Figure 5a and b. The fourth example is the ecumenical centre in Abuja, Nigeria shown in Figure 6a and b was designed and built by Gitto Nig. Ltd, 2004. It is a non-

denominational worship centre for all churches in Nigeria. Its auditorium was built with state of the art acoustical materials and equipments.



Figure 2: Typical sound flow pattern to the audience from the sound source.

Lastly, is the House on the Rock Church and fountain of life church both located at Lekki, Lagos, which were built in 2012 and 2014 respectively with an average auditorium capacities of 20,000 people as in Figures 7a,b and 8a,b. They have features like galleries and balconies to help diffuse and reduce noise. They are as well equipped with state of the art acoustic materials and technical equipments. Their semi-circular hall geometry can create a reasonable delay between direct and reflected sound. This can cause slap-echo that could interfere with the

acoustic performance of the space. In the auditorium, the surfaces are expected to interact with sound to create an acceptable sound level [7]. The acoustic planning of the above chosen case studies was to provide a comfortable acoustic environment as well as maintain the aesthetic vision of the architects. The above mentioned case studies were chosen to show the acoustic effect and materials used in the Nigerian church auditoriums and the evolutionary trend from old ones to the new as shown in the comparative analysis in Table 1.

Acoustic Items	Old Halls	New Halls
i) Materials Used	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.
ii) Design and Materials Application Techniques	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, slopy floors and ceilings, etc.. Materials application techniques are technology aided and of high quality.
iii) Quality and Durability of Materials Used	Materials were largely very natural with little or no proper industrial chemical treatments to improve their quality and prolong life span.	Materials are of quality and durable as they are mostly factory treated with a guaranteed life span.
iv) Materials Functionality in terms of Sound control and Amplification	Materials were to some extent performing well, but were largely limited by the quality of production and installation.	They perform better due to due to well calculated architectural designs, the use of microphones, loudspeakers to amplify and control sound. They use HVAC (Heat, ventilation, and air-conditioning) technology for comfort.
v) Aesthetics of Materials Used	Walls were mostly bare with little or no decorative touches, and where it existed was old fashioned.	The new Halls are better decorated and comfortable as some of the acoustic materials also serve as decorative elements.

Table 1: Showing the comparative analysis of the acoustic elements of old and new halls.

Old church auditoriums and their acoustic properties



Figure 3a: Akaniobio Church, Old Calabar, Nigeria, built in 1905 Presbyterian church.



Figure 3b: The interior view of the church.



Figure 4a: Anglican Church in a rural community in Ikoro, Ekiti-State, Nigeria, built early 20th century.



Figure 4b: The interior view of the church.



Figure 5a: Christ Church Cathedral, Lagos, 1946.



Figure 5b: The interior view of the church.

New church auditoriums and their acoustic properties



Figure 6: Ecumenical Centre, Abuja, built 2004.



Figure 6b: Interior view of the church.



Figure 6c: Interior view of the church.



Figure7a: House on the Rock Church, Lagos, built 2012.



Figure 7b: Interior view of church auditorium.



Figure 8a: Fountain of Life Church, Lagos, Nigeria, 2014.

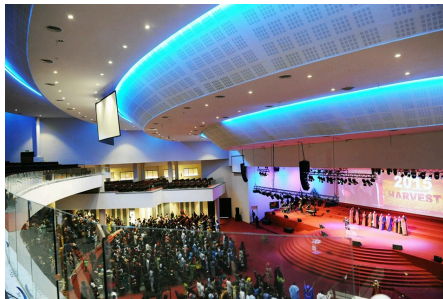


Figure 8b: Interior view of the church auditorium.

Aims and Objectives

This Paper seeks to explain some important qualities of acoustic materials, which are relevant for the effective acoustic performance of church auditoriums in Nigeria drawing from a comparative analysis between the old and new church halls. It intends to promote a proper understanding and use of acoustic materials amongst building professionals, contractors and acoustic engineers as this will not only create increased acoustic performance of church auditoriums, but will as well ensure increase in spirituality due to clear messages and sermons that will be heard by the audience. It also seeks to promote a culture of acoustic awareness in the society through the religious houses. Other objectives are as follows;

1. To also serve as a guide on proper spatial and acoustic designs for Hall projects to ensure proper functionality
2. To reduce poor sound quality to the barest minimum.

3. To highlight reasons for human health considerations in Halls project planning.
4. To highlight the need for qualified and highly skilled labour in executing auditorium projects.

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:

1. Acoustic Paint
2. Glass windows with aluminium frames
3. Metal doors and glass
4. Woods
5. Floor Tiles
6. Textile fabric window blind and stage decoration
7. Asbestos ceiling materials
8. Mud, Stone, bricks and sandcrete blocks.
9. Chip boards
10. Cork and foams materials
11. Rug carpet
12. Aluminium shading devices

Acoustic materials application in old and new churches

Findings on Acoustic Materials Application in Old and New church Auditoriums

The walls

The walls of the old church auditoriums were mainly made of either local, wood, stones or bricks as time progressed. Whereas, the average Nigerian church 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 (Figure 9a).

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 (Figure 9b).

The ceilings

The present day churches 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 church auditoriums were rarely covered with ceiling materials (Table 2).

Doors, windows and fenestrations

Regarding openings and fenestrations, the old churches 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 churches 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 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 talker. The closeness of the seats to the pulpit is sometimes a deliberate acoustic design to ensure early reflection of sound. Good sightline is required for the churches with a descending sitting arrangement (Figure 10 a-c).



Figure 9a: 600mm x 600mm perforated ceiling boards.



Figure 9b: Showing a rug carpet on the church floor.

	125HZ	250HZ	500HZ	1KHZ	2.5KHZ	5KHZ	STC
1"	6	5	7	8	10	15	9
2"	9	8	10	10	17	22	13
1" w/ 5/8" Gypsum both sides	27	27	29	31	32	45	32

Table 2: Showing sound transmission loss of acoustic ceiling [6].

Geometric Forms of Auditoriums (Shapes)

The church 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 (Figure 11).

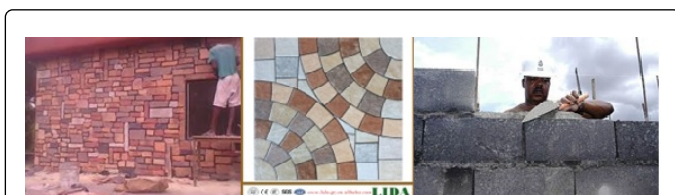


Figure10 a-c: Application of local acoustic materials in Nigeria.

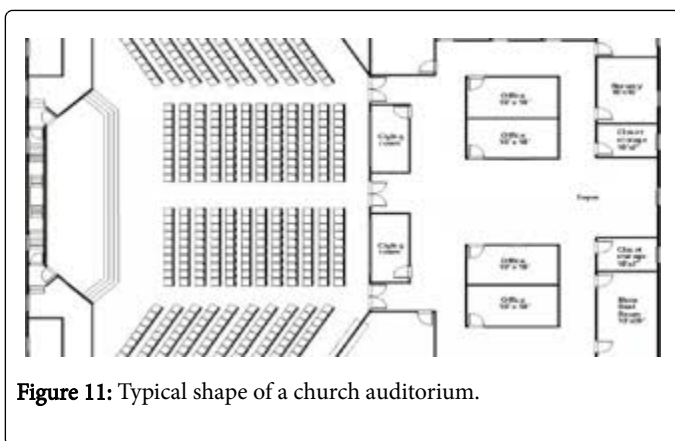


Figure 11: Typical shape of a church auditorium.

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 [8]. 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, slopy floors and ceilings, etc. Materials application techniques are technology aided and of high quality (Figure 12).

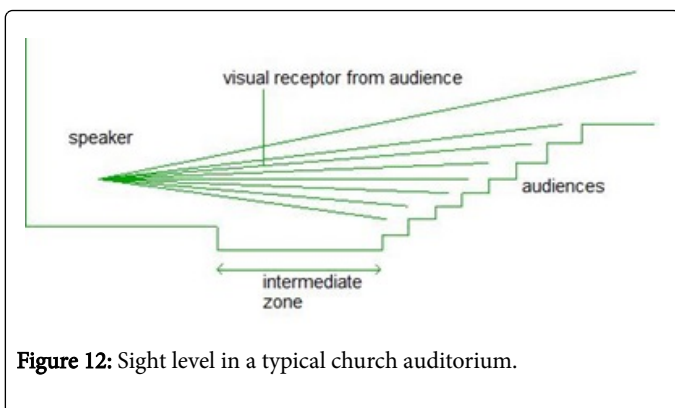


Figure 12: Sight level in a typical church auditorium.

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. They 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 originate 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 church buildings like the ecumenical centre in Lagos.

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 enhances 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 (Figure 13). 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 [8].

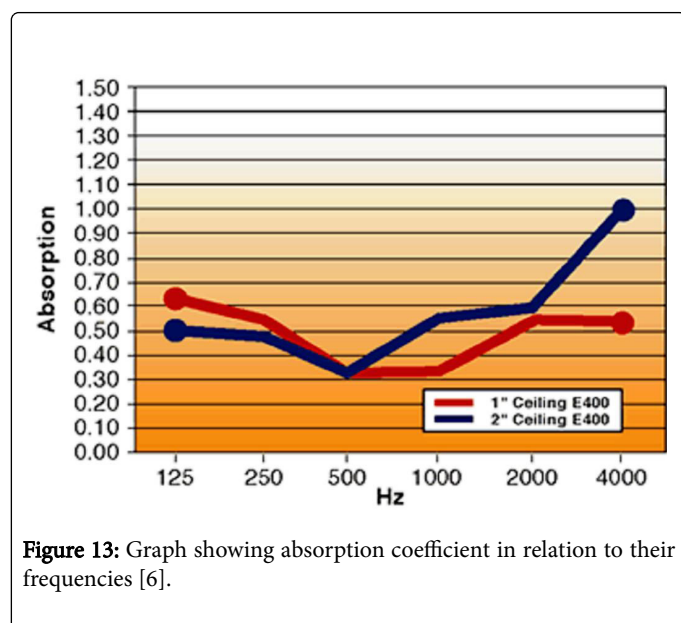


Figure 13: Graph showing absorption coefficient in relation to their frequencies [6].

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 (Figure 14).

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 [2].

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 [2].

Indoor Noises

This results from conversions 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 church

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 sand-cement mortar. The building walls are finally finished with thick emulsion absorptive paint in most cases and in a few cases with high-tech absorptive,

Reflective and diffusing acoustic materials as seen in Figures 7 and 8. 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.



Figure 14: Acoustic diffusible wall made from local building materials.

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 as shown in my case studies above.

Recommendations

In view of the study and analysis made on acoustic materials used in church auditoriums in Nigeria (past and present), there is need for a widespread enlightenment campaign on the importance of developing an acoustic culture amongst religious bodies. This is in view of the fact that noise has the ability to negatively impact the health of the church members, especially in the areas of hearing and brain disturbances and also coupled with the fact that, churches grow in congregation sizes daily. This paper also recommends the use of the right acoustic materials and the right application for maximum performance. Other recommendation in respect of eliminating background noise and the application of the appropriate acoustic materials in places necessary to ensure safe and tolerable noise levels are as follows:

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. absorptive 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.

8. Acoustic skilled workers be trained to enthrone a maintenance culture of acoustic equipments.

Conclusions

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 bedevilling a number of public gathering spaces as the church auditoriums, lecture halls, event halls etc.

Lastly, I like to say, that the following lessons were learnt in the course of the study

1. Sound is reflected, transmitted or absorbed by the materials it encounters while in motion especially in large enclosed spaces as was observed in the case of the Nigeria church halls.

2. Soft surfaces, such as textiles, and insulation materials tend to absorb sound waves, thereby preventing them from further movement.
3. Hard surfaces like floor tiles, gypsum board, wood, tend to reflect sound waves, causing echo and reverberation.
4. Materials like concrete and Bricks have the ability to transmit or absorb sound waves through them as was observed in the old church auditoriums in Nigeria.
5. High frequency sound waves like a whistling sound can hardly be transmitted through a dense material such as concrete or Bricks, while low frequency sound waves can be easily transmitted through them (Bass).

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