Sound Quality Enhancement and Noise Control in The Auditorium Interior of a Convention Centre

MARYFAITH MICHAEL OGOLODOM[1], ARC. T. LAWSON[2], I. T AMAKIRI[3]
[1,2,3]*Department of Architecture, Faculty of Environmental Sciences, Rivers State University, Nkpolu-Orowuruokwu, Port Harcourt, Nigeria.*

Abstract- ***Prevention of transmission of sound and conversion of sound energy to non-audible form are the function of acoustical materials. As a ray of sound undergo several reflections of bouncing forth and back within a space, the energy lost at each reflection eventually dismisses the ray. Sound and vibration sources are usually speech, music, mechanical equipment and traffic. Absorption, reflection and transmission of sound occur during sound transmission in a building due to the nature of the building materials and furnishings. Sound absorbing materials such as mineral wool or glass wool are usually light weight, porous, consist of matrix of fibers with interconnecting pores and capillaries. This study was designed to identify design features and elements that can improve sound quality, noise control, and reduce echoes and reverberation in the convention centre facility located in Rumuoda, Aluu, Port Harcourt, Rivers State, Nigeria. The author adopted a mix research method which includes qualitative and quantitative techniques for the collected data. Various operational convention centers were selected as case studies. The criteria for case study selection include; Architectural merits, adequate planning of the facilities, building materials used, design elements and features used. The deduction from the entire study assisted in the design of the convention centre, which are design elements that help absorb sound energy; walls, ceiling, and floors, design features; acoustic panels, upholstered chairs, soft porous surfaces, carpets, solid core doors, fiber glass, acoustic tiles, curtains. Also, size and shape of a space (auditorium) , seating arrangement, audience capacity, materials in the room , balcony are generally factors that affects the acoustics of an auditorium. In conclusion, the use of appropriate design elements and features which can absorb sound energy in an auditorium will help improve sound quality, noise control, and reduce echoes and reverberations in the facility. Therefore, it is essential that Architects and Builders put into consideration on how to improve sound quality, control noise, and reduce echoes and reverberations, to achieve sound clarity, for the comfort of the seated audience.***

Indexed Terms- ***Auditoriums, Building form, Convention Centre, Noise Control, Sound quality***

I. INTRODUCTION

A convention centre is a large building that is designed to hold a convention, where individuals and groups gather to promote and share common interests (Peter and Pepple, 2020). Convention centres have adequate space to accommodate thousands of attendees. Very large venues, suitable for major trade fairs are sometimes known as exhibition halls (Peter and Pepple, 2020). The Convention centres are usually made up of the following spaces, at least one auditorium, concert halls, meeting rooms, lecture halls and conference rooms and centres can also be found in large resort area hotels (Peter and Pepple, 2020). This facility is commonly used for large-scale events such as public shows (performances and conferences and its purpose is to provide a space for attendees to exchange information, showcase products, and hold meetings or conventions (Devi Wijiyanto, 2020). Conventions are of different types, they are political or negotiating and non-political conventions (Amachree and Enwin, 2022). Political conventions are legislative, diplomatic, technical, periodic and adhoc conventions (Amachree and Enwin, 2022). Non-political conventions are,

administrative, economic, social, scientific, educational and cultural (Amachree and Enwin, 2022). According to Amachree and Enwin, (2022), a political convention is said to be legislative if it leads to the formulation of law, and diplomatic/technical if it is being attended by diplomats and technical experts. This classification is irrelevant as some peace conferences have several objectives and includes diplomatic along with technical representatives (Peter and Pepple, (2020).In addition, convention centres also have an economic impact on the local community by generating tax revenues and job opportunities as this attracts attendees who spend on lodging services, shopping, and food services, thereby benefiting the local economy (Devi Wijiyanto, 2020). Convention centers are multifunctional facilities as such can be used for any gathering such as; concerts, film festivals, weddings ,anniversary ,trainings , religious functions and the likes (Sumeet Dua 2020). Increase in the demand for meeting spaces and locations where people can exchange information and knowledge on how to solve problems, are the main factors that contributed to the increase in convention centres (Peter and Pepple, 2020). According to Peter and Pepple (2020), the convention industry is constantly changing and growing very fast, though its new, but yet to have sufficient training process, sufficient marketing intelligence and clear terminologies.

Acoustics is the science that deals with sound production, control, transmission, reception, and its effect (Chougule et al., 2023). Architectural acoustics has to do with reflections of sound in a given space, or room. The noise or unclear sound alters the quality of sound we hear in a room. Sound in a room depends on the quantity absorbed by design elements such as walls, ceilings, and floors. The more sound is absorbed, the less sound reflections, which will result to reduced noise (Chougule et al., 2023). Standards for auditorium acoustics; High degree of acoustics gain, provision of reverberation time and absence of echoes.

1.1 Statement Of Architectural Problem

One of the major challenges of huge or large singular space or hall such as auditorium within a convention centre is how to control noise, speech clarity, and acoustic gain (Vijay Purandare, 2020). For an auditorium to have good sound quality the design of the space must ensure evenly distribution of sound waves across the space, for the comfort of the seated audience. According to Vijay Purandare (2020), acoustics in auditorium design is divided into noise control, and/ or soundproofing, internal acoustics of the space which deals with absorption, reflection and diffusion, and electro acoustics which require the use of audio-system. Some of the challenges facing large singular building or auditorium of a convention centre are determined by the factors affecting the acoustics of the auditorium such as reverberation, reflections (echoes), noise, loudness, echelon effect, sound foci and dead spots, diffusion and design defects (Vijay Purandare, 2020). Therefore, it is important to put into consideration auditorium acoustics in design, to achieve speech clarity, noise elimination and acoustic gain. The auditorium should be designed so that the speaker's voice can be clearly and widely heard throughout the space no matter the position of the seated audience. This study was designed to identify design features and elements that can improve sound quality, noise control, and reduce echoes and reverberation in the convention centre facility located in Port Harcourt, Rivers State, Nigeria.

1.2 Aim of the Study

The aim of this project is to design an international convention center that can host medium to large-scale international conventions for exhibitions, seminar / lecture creative displays, and conferences, and also to identify ways of enhancing sound quality, and noise control in order to reduce echoes and reverberations within the auditorium.

1.3 Objectives

1. Investigate the current design elements that support effective sound production in an auditorium.
2. Determine design feature that enhances effective noise control in a convention centre design.

3. Incorporate the use of design elements that reduce echoes and reverberations within the auditorium of the convention centre.
4. Provide a venue for presentation, social and cultural gatherings.

1.4 Research Questions

This research was designed to address the following questions:

1. What are the design elements that support effective sound production in an auditorium?
2. How can noise be controlled in a convention centre?
3. What are design elements that can eliminate echoes and reverberations?
4. How to solve the problems of acoustic defects in the halls of a convention centre?

II. LITERATURE REVIEW

Sound is a form of energy which is emitted by a vibrating body and on reaching the ear causes the sensation of hearing through nerves (Everest F. Alton (2001); Nasim, 2018; Martins and Dimkpa, 2023). Sound in air consists of a series of compressions and rarefactions due to air particles set into motion by a vibrating source. An elastic medium returns to its normal state after a force causing the vibration is removed. Acoustics is the art and scientific study of sound; it is characterized by its reliance on combination of physical principles drawn from other sources (Martins and Dimkpa, 2023). Sound travels at a velocity that depends primarily on the elasticity and density of the medium. Sound may travel at a very fast velocity of 3,900 m/s along steel pipes and duct walls (Martins and Dimkpa, 2023). It is therefore important to block or isolate paths where sound energy can travel through building materials (called structure-borne sound) to sensitive areas great distances away where it may be regenerated as airborne sound (Martins and Dimkpa, 2023). In buildings, the effect of temperature on sound also is negligible (Martins and Dimkpa, 2023). Sound reflections create standing waves that produce natural resonances that can be heard as a pleasant sensation or an annoying one (Glen, 1981). In order to obtain a good audio quality in building design it is good to use the Oscar Bonello criteria of modal density (Oscar, 1981)

2.1 Architectural acoustics

Architectural acoustics deals with the science of sound in buildings. McMullan (1992), stated that acoustics planning concept for buildings include, locating noisy activities away from activities that require relative quietness and noise sensitive activities away from major sources of noise. Every building type has its own acoustical requirement; therefore, it is proper to know the use of a building for good acoustic considerations. In a multi-functional public building with a wide range of activities and different acoustic requirement, care must be taken in the choice of materials to ensure a balance between reverberation, reflection, absorption and isolation of sound (Karabiber, 1999). Short reverberation time in stressing speech intelligibility and long reverberation time in spaces where music is played is fundamental in these types of buildings (Khaiyat, 1996; Antonio, 1992). DJ Oldham et al a combined experimental and theoretical approach to the interaction of airflow and sound transmission through ventilators for natural ventilation applications is described. A key element of the investigation have been the development of testing facilities capable of measuring the airflow and sound transmission losses for a range of ventilation noise control strategies. Lakavath Ravinder et al observed that a sound insulation of the order of 30 to 35 dB is possible in a given building. The devisable partition is made up of glass wool, laminate of both sides with wooden panels. The application of acoustics is present in almost all aspects of modern society with the most obvious being the audio and noise control industries.

2.2 Acoustical characteristics of an enclosure

The main factors which influence the acoustical properties of an enclosed space include but not limited to the size and shape of the enclosure as well as the materials used in the construction of the room(Martins and Dimkpa, 2023). Also , Seating Arrangement, Audience capacity, Auditorium Use, Balcony (with shallow depth and high opening) (Chougule et al., 2023). and orchestral pit, Doors and buffer zone, and External/Background Noise (Illuminated Integration,

2020). On the other hand, acoustic requirements for a good acoustic in an enclosed surface (McMullan, 1992) include but not limited to;

- Adequate level of sound
- Uniform distribution of sound to all listeners in the room
- Rate of decay (reverberation) suitable for the type of room
- Background noise and external noise reduced to acceptable level
- -Absence of echoes and similar acoustics defects (Martins and Dimkpa, 2023).

2.3 Sound Quality evaluation

The idea of sound quality implies that the noise control is not simply to reduce the pressure level of sound, but more importantly, the products can be adjusted according to the subjective feeling of the consumers (Jiang and Li, 2018). The most common approaches to determine the sound quality of a product can be categorized into two domains: subjective and objective evaluations (Rossi, 2003, Martins and Dimkpa, 2023). The former emphasizes that sound can be subjective and sensitive for a person, the latter expresses the sound in terms of an objective numerical value such as the physical acoustics and psychological acoustics (Zwicker, 1999). In addition to the frequency and intensity, other psychoacoustics factors should be considered. Psychoacoustic parameters are used to describe different noises caused by the different subjective feelings about objective physical quantities. In the objective test, there are four international general main parameters: loudness, sharpness, roughness and fluctuation strength (Wang, 2006 and B&K, 2007).

2.4 Acoustical considerations for the design of a Convention Centre

A good number of the Auditoriums come in various shapes because the parallel walls can cause sound waves to bounce back and forth continuously creating unwanted reverberations that could muddy the overall sound clarity (Martins and Dimkpa, 2023). Likewise, affecting the acoustics is the size of the room as rooms for speech require a shorter reverberation time than for music (Martins and Dimkpa, 2023). The amount of sound absorption can be affected by the number of people attending a programme in the convention centre. Therefore, during design, it is expected of one to avoid square rooms or narrow; rectangular rooms and this explains why many auditoriums have more of a fan shape. Some auditoriums also include curved walls, which help diffuse sound (Martins and Dimkpa, 2024). In addition to the general shape of a room, other architectural characteristics such as the ceiling pitch and structures in the room will affect the way sound waves behave in the space.

Assessing the acoustics and noise control in a convention centre entails evaluating the quality and clarity of the sound within the space, as well as the level of background noise and distractions

2.5 Materials used for Noise reduction

Any good sound absorbing materials can automatically help to reduce the amount of echo and reverberation in the space (Martins and Dimkpa, 2023)

The methods used for noise reduction ranges from active to passive approach of noise reduction (Martins and Dimkpa, 2023). Synthetic and natural materials have been used as absorbers for the purpose of noise and these include but not limited to;

i) Noise reduction through Facades withWindows

Reverberation is the collection of reflected sounds from the surfaces in an enclosure like an auditorium (Oniku, 2011). It is a good characteristic of auditoriums to the extent that it helps to overcome the inverse square law drop off of sound intensity in the enclosure (Martins and Dimkpa, 2024). The presence of absorbent ceilings can help to reduce reverberating noise and the global mean acoustic level. According to Mitchel ryan et al (2011) in their study, determined that no overall noise reduction can be estimated based only on façade construction type and that the noise level variations from outdoors to inside is a result of numerous incident noise and individual room characteristics.

ii) Building Acoustic Materials

Enhancement of hearing of speech or music is made possible with acoustics pattern of construction of enclosed areas. It could as well be regarded as the

branch of architecture that deals with the control of sound which showcases the reflective, absorptive properties of sound(M.Ramesh kumar et al (2013) Sustainable building acoustic materials made from either natural or recycled materials are getting popular to reduce the carbon footprint (Martins and Dimkpa, 2024). It is necessary to develop sustainable acoustical materials to control low frequency and impact noise (Martins and Dimkpa, 2024). A majority of sustainable materials for noise control can be divided into three main categories: Natural materials, recycled materials, mixed and composite materials. There is a great variety of natural fibers which can be used for thermal and acoustical applications. These are commercially available in the form of coconut, kenaf, hemp, mineralized wood fibers (Mitchell, 2011).

iii) Sound Insulation

Soundproofing relates to the overall ability of a building element or building structure to reduce or to minimize the amount of noise that can enter the space from outside sources. Two types ofAcoustics deals with the construction of enclosed areas so as to enhance the hearing of speech or music sound insulation might be referred to – airborne sound insulation and impact sound insulation. Maaz allah khan et al By increasing wall thickness and isolating one side of the construction from the other is another way to increase the transmission loss of a panel or construction. Sandesh G. jharbade et al (2016) to increase the transmission loss of a panel or construction, such as a wall, is by increasing its thickness and isolating one side of the construction from the other. Shikha choudry et al (2015) stated that several natural materials are commonly used as thermal and acoustical insulation in multilayered walls among these flax, coconut, cotton, sheep wool and kenaf mats. Their sound and thermal insulation performance are in many cases as good as those of traditional materials. Arno Pronk et al (2009) in their work have presented water as a sound insulation material. Use of 200mm thick water layer with a membrane can be effective in reducing the noise as much as 100mm concrete wall. Water being cheap can be better alternative to synthetic sound absorbers.

iv) Sound Absorption

Room acoustics describes how sound behaves in a space. If the room has nearly no sound absorbing surfaces (wall, roof and floor), the sound will bounce between the surfaces and it takes a long time before the sound dies out. If the surfaces instead are covered with sound absorbing material, the reflected sound will decrease much quicker and the listener will only hear the direct sound and this as well lead to reduction in sound level in the room. Natural fibers are generally good absorbers Shweta Jain et al (2015). Materials used are rated using Noise Reduction Coefficient (NRC), which is basically a type of average of sound absorption coefficients from 250 Hz to 2 kHz, the primary speech frequency range. (Azimi ,2017; Martins and Dimkpa, 2023) .Porous materials obtained from synthetic fibers, such as mineral wool or glass wool, are commonly used for thermal insulation and sound absorption, because of their high performance and low cost.

III. RESEARCH METHODOLOGY

The research methodology adopted for this study is a mixed - method research approach. This research study makes use of different sources of information ; primary and secondary sources of information. The research methods used include:

1. Use of the Internet to obtain information and data collection
2. Visitation of existing convention centre and critical analysis of other existing similar projects
3. Use of available literature such as textbooks, articles/publications, and unpublished materials

3.1 Primary Data Collection

The source of primary data collection was through unstructured interviews with few individuals who have attended conventions (usually locally or internationally), about the design features and characteristics of the spaces required. Both local and international case studies were carried out as another primary source of data collection on the convention centre.

3.2 Secondary Data Collection

Secondary data that were collected includes; use of available literature from textbooks, journals, information from internet, publications, magazines and unpublished materials, record of corporate organizations and case studies. This data were basically collected for comparism and inference.

3.3 Research Challenges

Access to literature on Convention facilities in Nigeria posed a major challenge as there is a very limited amount of existing literature on the subject. Greater knowledge thus had to be drawn from research considerations from foreign countries which were dutifully recorded.

3.4 Data Presentation And Analysis

In order to carry out this study successfully, one need to review existing international convention centres in line with architectural standards, criteria and recommendations. The reason for these case studies is to understand the facilities to provide, functionality of the spaces, their relationships and get facts from similar existing designs as regards some certain relating concept, Acoustic material types used, and taking notes of the merits and demerits of the design. These aids analyzing the study and the ability to propose solution to problems in such facilities similar to the proposed design.

IV. FINDINGS AND DISCUSSION

A convention centre provides a venue for various events such as performances, exhibition and conferences etc, making it essential to optimize the Auditorium design of the facility. Effective Auditorium should ensure that speech , performances and music sound clear, loud enough for the audience to hear and see clearly what is happening on the stage irrespective of their seated position Acoustics in buildings depend majorly on the type and purpose of the building. Most buildings use as convention centres are places where public assembly for meetings etc and the acoustic criteria and design features in such kind of buildings takes into consideration the background noise, the room reverberation time and sound isolation to enhance speech intelligibility and privacy (Martins and Dimkpa, 2023). The acoustic materials that should be used in the design of architectural surfaces in convention centres should be able to reflect sound, absorb sound or diffuse sound. The major challenge faced in most auditoriums is the reverberation effect, which occurs when sound waves bounce off surfaces (Martins and Dimkpa, 2023). In the auditoriums, there are usually some hard reflective surfaces, which determine the outcome of the produced sound (Martins and Dimkpa, 2023). Auditorium floor is generally left untreated, as carpet, seats, and people absorb a great amount of sound energy. The ideal reverberation time is normally 1.5seconds to 2.5seconds in most general-purpose auditorium where you want speech to sound clearly and music to sound rich and full. Generally, auditoriums usually have long reverberation time, which also requires the installation of sound-absorbing materials throughout the room(Martins and Dimkpa, 2023).

The acoustic panels, curtains, upholstered, chairs and other soft porous surfaces are very useful in noise control in convention centre (Martins and Dimkpa, 2023). Higher levels of reverberation can be noticed in an auditorium the moment most of the surfaces are made up of hard and non-porous materials that can easily reflect sound waves (Martins and Dimkpa, 2023). Two major approaches for noise control are passive and active methods and the combination of the two techniques by noise controlling devices accelerates the drastic reduction of high frequency noise.

V. CONCLUSION AND RECOMMENDATIONS

A standard convention centre should have an improved sound quality system that allows for speaker' voice amplifications and with other sounds in the building. Based on this, it is very pertinent to reduce any unwanted background noise that could interfere with main event taking place in the convention centre. In architecture, there are numerous methods used for the reduction of noise in the building especially in an auditorium of a convention centre and these approaches involves the use of noise absorbers, which may come in porous or panel forms. The noise absorbing materials maybe either artificial or natural. Architect and building engineers should always put into consideration

design elements for enhancing sound quality and reduction of noise in a convention centre to promote conducive environments for meetings and decision-making debates.

Through a thorough investigation and understanding of the proposed site, there is the need for a convention center in the state. A project of this kind is necessary to promote social and cultural interactions. The absence of a space such as a convention center can impose some urban issues on the city and it's environment. This research is structured towards the development of a new convention center that will integrate public gathering space.

For a convention center design , there are three integral parts to consider; administration area , The administrative area is the center of the facility. It is located around the entrance of the facility for accessibility and controlling of activities in the facility. convention area, is the hub of the facility, It is accessible from the entrance. The convention area is made of different independent spaces that allows for different events to be held simultaneously and independently and finally, support facilities , This earns revenue to the facility and state at large. It includes the business centre, fitness centre etc. . There should be a connection between the recreational areas with similar activities for easy movement across the site.

ACKNOWLEDGEMENT

I wish to sincerely appreciate and acknowledge the encouragement and support of these people who were there for me all through the period of this project, and the entire M.Sc. students; I am grateful having you all.

My Supervisor, Arc. T. Lawson, and the Assistant Supervisor, Arc. I. T. Amakiri for their assistance in the course of writing this project report, also special thanks to the head of department: Dr. Ferdinard .F. Daminabo , and Arc. T. D. Pepple.

I appreciate all you did for me. Thank you and God bless you.

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