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EFFECTIVE NOISE CONTROL IN A CONFERENCE CENTER

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Keywords

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Abstract

Noise pollution is considered to be any unwanted or distressing sound that causes the health issues and affects the well-beings of humans and other organisms. Exposure to loud noise can also cause health hazards. The evolution of noise control and sound quality are briefly discussed. Series of research work has been done seeking to provide insights both theoretical and empirical into the problems that are related to the halls and auditoriums of conference centers, however, most of these researches seem to agree that the issue of acoustics is one of the most commonly observed challenge. Therefore the motivating factor behind this work is the desire to contribute to the improvement of acoustics in a large building such as that of a conference center. Conference center are spaces of communication and due to their size and form they often suffer from flutter echoes and room resonances. To ensure that meetings take place successfully without any itch, there is the need to have a facility that will be adequate and functional. It is therefore of paramount importance that the acoustic factors be considered and methods to mitigate the noise be implemented where necessary. To achieve success in the study, qualitative research method research as well as case studies were adopted, literatures were reviewed, and physical site observations were also made. Results from the finding revealed that the use of parallel walls in the auditorium is a major cause of echo as it causes sound waves to easily bounce back and forth over the entire room which later creates an unwanted noise and echoes that could spoil the overall sound production, the shape of the building, the size of the auditorium and materials in the room, all together play vital roles in how sound was being produced, distributed and absorbed. To solve this problem, the use of a completely squared shape should avoided for the main auditorium, the use of absorptive materials on the floor, some part of the wall and ceiling were deployed to reduce echo and reverberations.

1.0 Introduction

Conference center is a building or group of buildings that is conceived, planned, designed, constructed and dedicated to host structured meetings. (Swisher, P. 2004) hinted that a conference Centre is a full-service hospitality institute that focuses on accommodating medium to large-sized meetings as its first order of business and that about seventy percent of resources obtained from the conference center is generated from conferencing. Conference according to the Merriam-Webster Dictionary (2022) is defined as a formal meeting where many people and interest groups from various part of the world gather for several days or less, (as the case may be) for the purpose of learning about new phenomenon, discussions, dialogue or debates, etc. all with the aim of proffering solutions to some trending or lingering societal issues. It is a known fact that no meaningful development and progress of any sort could take place in any society if there had been no meeting or exchange of views and ideas that could have triggered or brought about such development (Weber and Chon, 2002). The word Conference, first used in the year 1527, as described by the (Merriam- Webster Dictionary (2022), is derived from the word confer, which means to discuss, consult, etc. Conference center among many types of auditorium halls which are important buildings. Lawson F.R. (1981) in his illustration define Conference as the act of bringing together different people from different parts of the world, for discussion and sometimes for decision makings. Conferences, being large meetings are expected to be held in a very large venue that is expected to accommodate all sizes of attendees at the same time. In fact, (Ademulegun, 2014), infers that Conferences are known mostly known by the type of function they perform and by the outcome meeting.

Contributing to the development of scientific, social, and many other aspects for the employers and students. It is therefore necessary to ensure and develop proper acoustic spaces, studying all phenomena related to acoustic performance in terms of the sound pressure level, reverberation time, and the noise level, whether external or internal in a conference center. A comfortable built environment is strongly correlated with suitable thermal, lighting, and acoustic techniques. The architects must come up with a system that prevents and regulates the building's acoustic environment in order to provide comfort for the occupants. Exposure to loud noise on a regular basis could impair tenants' ability to concentrate, their degree of contentment with their surroundings, and even their cognitive function. Previous studies have focused on many aspects related to the acoustic performance of auditoriums halls (Barron,2010; Bradley, 1986; T.J,2014; Ibrahim &Hasan,2014). Conference Centers are generally known to provide a wide range of facilities that will cater for both small and large scale meetings all at the same time and most modern. Lawson F.R., (2011) hinted that the conference halls and auditorium are expected to be large enough and should be designed in such a way that they can be easily divided or extended as the need arises for smaller meetings or other activities to take place therein. Similarly, (Hall et al, 2019) also suggested that to have a good Acoustics in an

Auditorium and enjoy a good viewing sight in the Auditorium, the floors are to be raked or made to step in tiers so as to allow for flexibility in use while all other halls may be separated by movable partitions, that have high standards of sound insulation and fire resistance.

1.1 Statement of Architectural Problem

Nearly all conference centers, just like any other building type are known to be faced with one Architectural problem or the other ranging from Crowd control, to fire outbreaks, thermal discomfort in times of power-outage, or poor design and planning, as well as sound intelligibility (Acoustics), etc. This research work intends to look into how noise can be controlled in a conference center (Acoustics) for this has been observed to be a bane in most Auditorium designs.

1.1 Aim

This research work aims at examining how noise can be effectively controlled in a conference center, with a view to proposing a design strategy that will verify the acoustic performance within the facility.

1.2 Objectives

The objectives of this study are as follows:

1. To analyze noise transmission as well as the characteristics of noise inside a conference center.
2. To examine the key issues on control in a conference center.
3. To a reasonable extent, examine some design elements that can suppress airborne sound emanating from the immediate environment of the conference center such as vehicles plying along the road.
4. To examine the acoustic performance and noise control, of the selected conference center with the international and local standards which encourage a smooth conference experience.

1.3 Research Questions

1. What is noise control in a conference center?
2. What are the design factors that can be considered in the design of a conference center?
3. What are the ways of eliminating echoes and reverberations?
4. How improve the acoustic performance in a conference center?
5. How sound can be effectively produced and managed in a conference center?
6. What are the design elements that support effective sound production in an auditorium?
7. How to improve the quality of sound production in an auditorium and how it affects its users?

8. How to deal with the challenge of acoustics in the halls of a Conference Centre?
9. How Assist Architects and allied professionals in analyzing in details the methods of evaluating the acoustical quality of spaces for speech and musical programs.

2.0 Literature Review

Noise is defined as unwanted sound, a potential hazard to health and communication dumped into the environment with regard to the adverse effect it may have on unwilling ears (Nasim, 2018). Dasarathy. A, Dr. T.S. Thandavamoorthy et al Observed that the noise level at all locations exceeds the value prescribed by the competent authorities. Darathy A.K. et.al, further acknowledged that noise are paramount up from all different source in one way or another. Many research centers have developed new sustainable materials, in many cases with thought-provoking acoustical properties (Narendra, 2004). Diwakar Sahota et.al analyzed the control of noise pollution in built environment and what type of background sound should be recommended in which to keep or create a balance of acoustic around a listener. According to Azimi (2017) Acoustic absorber is the main emphasis for the control of room noise that sound absorbing materials or technologies as an effective noise reduction technology using sustainable acoustic absorbers in building. Noise are associated with a number of risks, including hearing loss or diminishing. Pelumi E Oguntemda et.al emphasized that hearing impairment is mostly classified as occupational hazards especially when the individual is affiliated with industry that propagates loud sound or noise.

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 (Nasim, 2018). 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 therefore defined as the scientific study of sound; it is characterized by its reliance on combination of physical principles drawn from other sources (Hunt, 1978). 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. 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. In buildings, the effect of temperature on sound also is negligible. 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 take 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.

Acoustical Properties of Enclosed Space

Basic factors that affect acoustical propagation in an enclosed space includes the size and shape of the enclosure as well as the materials used in the construction of the room. However, acoustic requirements for a good acoustic in an enclosed surface (McMullan, 1992) are summarized as follows:

1. Adequate level of sound
2. Even distribution of sound to all listeners in the room
3. Rate of decay (reverberation) suitable for the type of room
4. Background noise and external noise reduced to acceptable level
5. Absence of echoes and similar acoustics defects.

Sound quality evaluation

The concept of sound quality indicates 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 popular approaches to determine the sound quality of a product can be broadly classified into two domains: subjective and objective evaluations (Rossi, 2003). 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).

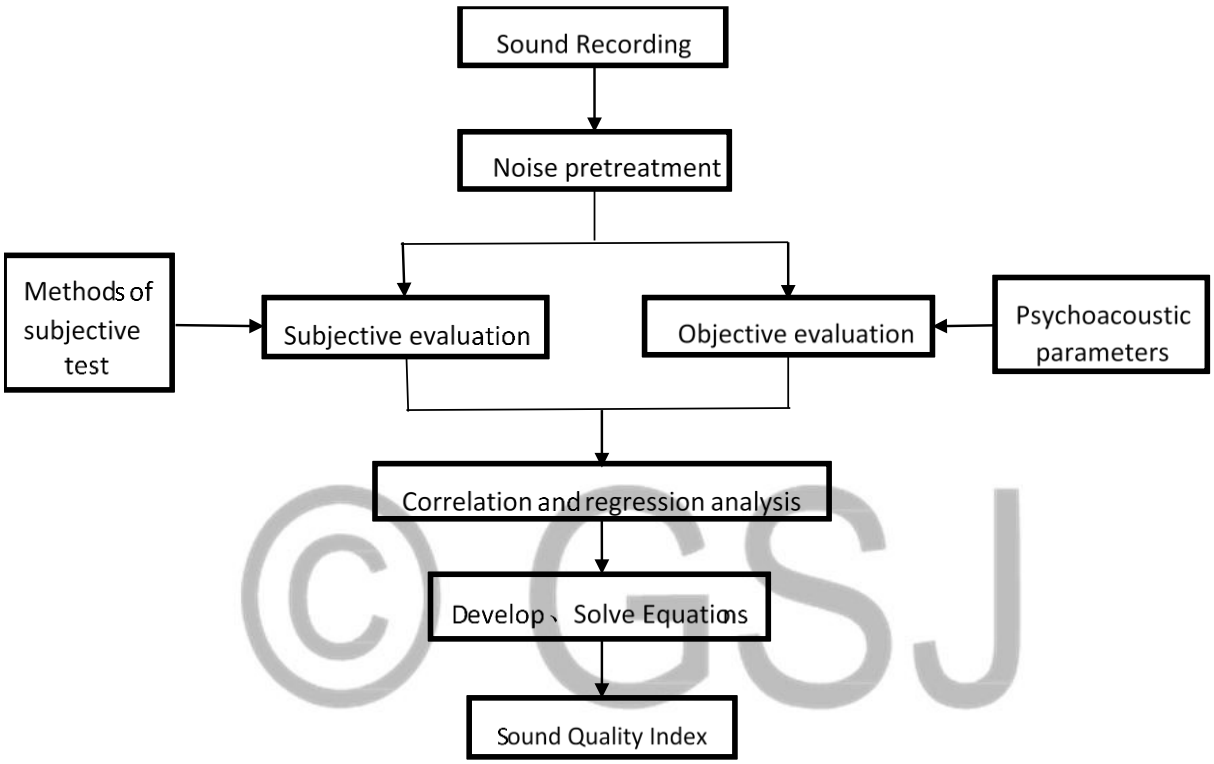

Fig. 2.1: Schematic evaluation of the Sound Quality

Source: Jiang and Li, 2018

2.2 Acoustical Design of a Conference hall

Most Auditoriums come in different shapes because the parallel walls can cause sound waves to bounce back and forth continuously creating undesirable reverberations that could muddy the overall sound clarity. Also affecting the acoustics is the size of the room, rooms for speech require a shorter reverberation time than for music. Variation in the number of people attending each program also affects greatly the total sound absorption. In 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 feature curved walls, which help diffuse sound. In addition to the general shape of a room, other architectural features like the ceiling pitch and structures in the room will affect the way sound waves behave in the space. Conference

halls usually have formal specifications that impact on the acoustics and functionality of space. According to (ANSI/ASA S12.60-2010; ISO 3382-2:2014; ASTM E1414-11; ISO 9613-2:2007), common shapes for conference halls are:

i. Rectangular: These are the most common shape and can be used for a variety of events. They are relatively easy to design and build, and provide good sightlines and acoustics for most types of events.
ii. Square: These are similar to rectangular conference halls but can be more challenging to design and build. They can provide good sightlines and acoustics for smaller events, but they may not be effective for larger events.
iii. Round: These can provide good sightlines and acoustics for smaller events. However, they may not be effective for larger events, as attendees in the back rows may have difficulty seeing and hearing clearly, it may also create sound defects (creep, concentration of sound) that need special acoustics treatments.
iv. Irregular: Irregularly shaped conference halls such as those with irregularly shaped walls or irregularly spaced columns, can be more challenging to design and build. They may also have less predictable acoustics and may be more difficult to use for any event.

The size of a conference hall can vary significantly depending on the specific needs and requirements of the space. Here are a few general guidelines for the size of conference halls based on the number of attendees.

i. Small conference hall (up to 50 attendees): may be as small as 500 square feet (46 square meters) and can accommodate up to 50 attendees.
ii. Medium conference hall (50 to 100 attendees): may be around 1,000 square feet (93 square meters) and can accommodate 50 to 100 attendees.
iii. Large conference hall (100 to 250 attendees): may be around 2,500 square feet (232 square meters) and can accommodate 100 to 250 attendees.
iv. Very large conference hall (250+ attendees): may be 4,000 square feet (372 square meters) or larger and can accommodate 250 or more attendees.

Evaluating the acoustics and noise control in a conference hall involves assessing the quality and clarity of the sound within the space, as well as the level of background noise and distractions.

2.3 Materials used for Noise reduction

Materials that are good at absorbing sound can help reduce the amount of echo and reverberation in the space. Various noise reduction techniques ranging from active to passive have been used for the purpose of reduction of noise. Synthetic and natural materials have been used as absorbers for the purpose of noise

reduction (Nasim 2018). These absorbers may either be categorized as panel absorbers or porous absorbers. The noise reduction techniques may range from traditional to innovative.

A. Green & Sustainable Materials for Noise Control in Buildings:

The use of green building materials and products represents important design strategies such as reduced maintenance/replacement costs over the life of the building. It enhances energy conservation, improved occupant health and productivity, lower costs associated with changing space configurations, as well as greater design flexibility. Asdrubali, (2007) investigated on the measurement of sound absorption coefficient of novel sustainable fibrous materials. The fibrous materials have the properties of noise mitigation and building acoustic correction.

B. Noise Reduction through Facades with open Windows

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

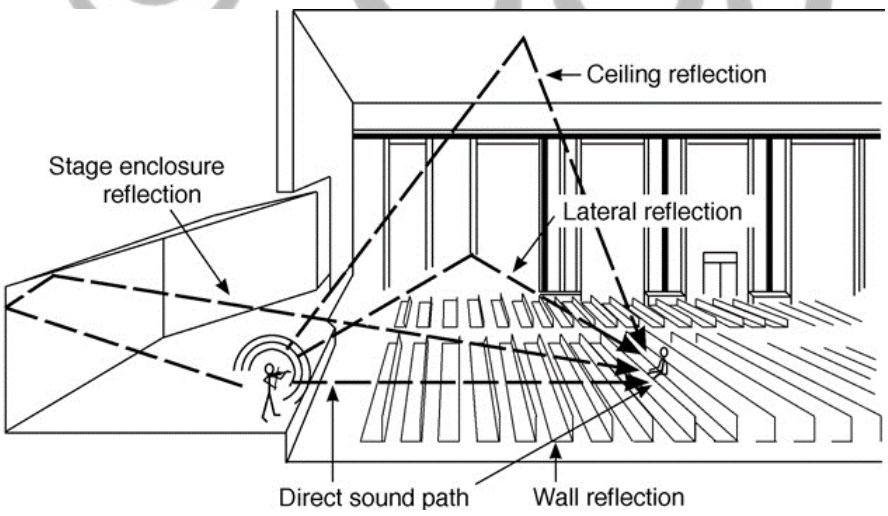

Fig. 2.2: Sound reflection in an auditorium

Source: Oniku, 2011

C. Building Acoustic Material

Acoustics deals with the construction of enclosed areas so as to enhance the hearing of speech or music. 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. It is necessary to develop sustainable acoustical materials to control low frequency and impact noise. A majority of sustainable materials for noise control can be divided into three main categories: Natural materials, recycled materials, Mixed and composited 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).

D. 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 of 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.

E. 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. Also, the general sound level in the room will decrease Faizan (2018). 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) 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. Ancuta Elena tiuc et al (2015) study on acoustic properties improvement of rigid polyurethane closed-cell foam, by incorporating various quantities of textile waste into the matrix.

3.0 Methodology

This research study seeks to explain in clear terms how relative data has been gathered for the purpose of this research and how it has been put together and analyzed.

3.1 Research Methodology

Sourcing of information is the backbone of any successful research work. This project makes use of primary and secondary sources of information. The research methods used included:

1. Visitation to existing conference center and critical analysis of some existing similar projects.
2. Use of existing literature from textbooks, publications, magazines, and unpublished materials.
3. Use of the internet for further information and data collection.

It is an accurate observation that no single research methodology is intrinsically better than any other methodology Benbasat et. al. (1987). However, given the richness and the complexity of human nature and the real world, the best approach will be choosing a methodology that best suit a given project.

3.2 Primary data collection

The primary source of data collection was carried out through informal interviews conducted with some members of the public who have been involved in one conference (both locally and internationally known of some of the required spaces needed and any other relevant information that will be useful in the course of carrying out the design. Case studies were carried out as another source of primary data collection on Conference Centers, both local and foreign.

3.3 Summary of Information and Discussions

Leading to the writing of this report, information was gathered from different professionals and people who have the technical know-how on the operations of Conference Centre and major issues that concerns Acoustics directly, through informal discussions and interviews. More so, some of the members of the expected users were also spoken to. Some of these discussions had guideline questions because some specific information was sought. People spoken to were willing to share their knowledge and more information was gathered this way.

3.4 Secondary data collection

Secondary Data: these are data that were already available and were collected for comparison and inference purposes. For this study, the secondary data that were collected include – information from the internet, journals, books (published and unpublished), records of organizations, and case studies.

3.5 Research Limitations

The following issues present a limitation to the sourcing of information for this study:

1. The level of insecurity in the state and nation was a great challenge to the completion of the project." As access was not granted to some of the important spaces of the conference centers visited for case studies, thereby obstructing the gathering of information.
2. Relevant data required from the appropriate authority, is not available
3. Most states in Nigeria do not have standard international conference centers to learn from, thereby requiring that case studies be carried out in other types of conference centers and foreign conference centers.

3.6 Data presentation and analysis

For one to execute a project of this magnitude and be successful, it is expected of one to embark on precedence studies of some of the existing conference centers so as to gain an in-depth understanding of how these centers function. Through the study, one will be able to know the various facilities that will be provided for, understand the relationship that needs to exist between the functional spaces, and finally, understudy the merits and demerits of the design. All details of the findings will be noted and the demerits taken note of to prevent a reoccurrence of existing mistakes and problems in this proposed design.

For the purpose of this study, the centers studied are not only international conference centers, as some are owned and controlled by the government and other forms of organization. The whole idea is to get the similarities and basic principles associated with and guiding the design of a conference center.

3.7 Case study 1: WALT DISNEY CONCERT HALL, LOS ANGELES, U.S.A

Fig. 3.1: Vineyard shape of Walt Disney Hall

Source: ArchDaily, 2023

Architects: Gehry Partners

Area: 185806.08sqm

Year: 2003

Project Location: 111 S Grand Ave, Los Angeles, CA

Project Information

The Walt Disney Concert Hall designed by architect Frank Gehry and acoustician Yasuhisa Toyota of Nagata Acoustics was built from the inside out, with a primary focus on functionality over design. This approach resulted in a superbly acoustically treated concert hall. Toyota opted for a "vineyard" shape layout, placing the stage in the center, surrounded by the audience, ensuring unobstructed views from all seats. The concert hall was designed as a single volume, with orchestra and audience occupying the same space.

Architecture (Building materials and Technology)

The seating arrangement features rows that gradually ascend in height and width. The hall accommodates 2,265 guests and boasts a reverberation time (RT60) of 2.2 seconds at 500Hz when fully occupied. When unoccupied, the RT60 remains at 2.0 seconds at 500Hz, thanks to custom-made absorptive seats constructed from steel, wood, polyurethane, and various fabrics designed to meet specific acoustic requirements. The Walt Disney Concert Hall is renowned for its unparalleled acoustics, offering remarkable clarity even at the softest sounds without ever becoming too loud. Its walls and ceiling are adorned with Douglas fir, while the floor is finished in oak. Together with curved wood ceiling, these surfaces contribute to the superb acoustics. There are parts of the wall behind the seats that are cleverly covered with transparent mesh through which sound travels and reflects off concave curves, and is therefore focused where needed.

Fig. 3.2: Interior view showing the Steel Truss
Source: ArchDaily, 2023

Fig. 3.3: Section of goodwill ceramics
Source: ArchDaily, 2023

4.0 Discussion

Acoustics in buildings depend mainly on the type and use of the buildings. Public and multi-functional government buildings by nature are used for public assembly, concert halls, schools, hospitals and hotels. Acoustic criteria and design parameters in such buildings should be such that it takes into consideration the room reverberation time, background noise and sound isolation to enhance speech intelligibility and privacy. Depending on the use of the building, the acoustic materials that should be used in the design of architectural surfaces should either, reflect sound, absorb sound, or diffuse sound. A common problem in most auditorium is reverberation which occurs when sound waves bounce off surfaces. In any enclosed space including auditoriums, there are some hard reflective surface which determine the outcome of the produced sound. Auditorium floor is generally left untreated, as carpet, seats, and people absorb a tremendous amount of sound energy. In a general-purpose auditorium where we want the speech to sound clearly and music to sound rich and full, the ideal reverberation time is 1.5seconds to 2.5seconds. For most auditoriums, the reverberation time will be too long unless there are sound- absorbing materials throughout the room. This includes acoustic panels, upholstered chairs, curtains, and other soft, porous surfaces. If an auditorium is full of surfaces that are hard and non-porous, like windows or wood floors, these materials will reflect sound waves and contribute to higher levels of reverberation.

Noise control device requires a combination of passive and active methods (Harris, 1991). Passive control rises absorption properties of materials to reduce high frequency noise but it becomes expensive in terms of weight and bulk at low frequencies where attenuation must be achieved with active control (Maria, 2001). Active control is based on the principle of destructive interference between the primary and the secondary sources. Barbara tiseo et al (2011) during the passive noise control are practical and most effective at mid and high frequencies. On the other hand, active noise control techniques are more efficient at the low

frequency range. Combined solutions seem to be the most appropriate key to cover the whole frequency range of frequencies. The optimum reverberation time for a conference room depends on the specific use of the space and the types of activities that will take place there. Generally, a longer reverberation time is more suitable for music performances, while a shorter reverberation time is better for speech and other types of presentations.

5.0 Recommendations and Conclusion

The conference center should have a high-quality sound system that is able to clearly amplify the voices of speakers and other sounds in the space. It is therefore important to minimize any unnecessary background noise that could distract from the main event taking place in the conference center. This could include HVAC systems or other equipment. There are various techniques that can be employed for the purpose of noise reduction. Various materials can be used as noise absorbers for reducing noise levels. These absorbers may either be used in porous form or panel form. The absorbers used may be either synthetic or natural. It is necessary to develop sustainable material to be used for noise reduction purposes. Various innovative methods like water membrane and green wall should be encouraged as they do not have any harmful on environment. Sound noise control is desirable to reduce the pressure level and enhance the auditory qualities of sound fields. Hence, suitable action will be taken to attenuate the noise levels and controlling pollution.

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