International Journal of Multidisciplinary Research and Growth Evaluation.

Reducing negative impact of sound on human in an event center through passive design strategies

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Article Info

ISSN (online): 2582-7138
Impact Factor: 5.307 (SJIF)
Volume: 05
Issue: 02
March-April 2024
Received: 10-02-2024;
Accepted: 12-03-2024
Page No: 796-800

Abstract
An "event center" is any publicly or privately owned building with more than 50,000 square feet or 5,000 seats that is utilized for public performances, athletic events, corporate meetings, or similar gatherings. This study investigatesthe critical significance of an event centers in the society, which operate as hubs for social, and recreational activities. The study focuses on passive strategies to reduce the negative impact of sound on human in these settings. Addressing the evolving needs of users, the research emphasizes the importance of reevaluating the design and functionality of event centers. Drawing on global literature, including studies in Nigeria, the research underscoresthe significance of culturally sensitive design and sustainability practices. The literature review establishes a foundation for the mixed-methods approach, combining literature analysis. Key findings highlight the crucial role of building material, shape of building, height of building in enhancing acoustic comfort.

Keywords: Event center, Sound transmission, Passive design, social inclusion social interaction

Introduction

Originally, the study of acoustics focused on tiny air pressure waves that human ears can detect— sound. Ultrasound and infrasound are two newer, lower frequency ranges that have been added to the field of acoustics. Acoustics today frequently takes structural vibrations into account. Another aspect of acoustical research is sound perception. We will stick to the original definition and the spread in fluids like water and air in this introduction. Acoustics is a component of fluid dynamics in this scenario.

Non-linear effects are ignored in a first-order approximation such as acoustics. Sound generation is regarded as a boundary condition problem in classical acoustics (Francis *et al*., 2012). The sound generating process in classical acoustics can be exemplified by the sound produced by a loudspeaker or any irregular movement of a solid barrier. Heat transport and turbulence are two other aero- acoustic mechanisms of sound generation that we will cover in this course. The chaotic motion known as turbulence is primarily caused by non-linear convective forces. There isn't a precise deterministic explanation of turbulent flows. A differential equation is not a good tool to introduce approximations; instead, an integral equation is the key to the well-known Lighthill theory of sound creation by turbulence.

In summary, acoustics has expanded from its beginnings in the study of sound waves that humans can perceive to include a wider range of frequencies, such as ultrasonic and infrasound, in addition to structural vibrations and sound perception. Although the field of acoustics was originally centered on linear effects and boundary conditions, it now explores non-linear phenomena like sound creation caused by turbulence (Goetz *et al*., 2020). The interdisciplinary character of acoustics is highlighted when viewed in the context of fluid dynamics, with ramifications that span from real-world engineering applications to theoretical frameworks such as the Lighthill theory. We appreciate the complexity of acoustics and the continuous search for more profound understanding of its fundamental principles and applications as we continue our investigation.

This research aims to identify and active and passive strategies to reduce negative impact on occupant in event centers. By understanding the preferences and experiences of users in these spaces, this study seeks to contribute valuableinsights to the ongoing dialogue about optimizing event center environments for enhanced socialinteraction and community engagement.

2. Literature Review

2.1. Event Center

Any space that is contracted, leased, or subleased and used in connection with the Event Center's operations is also included in the term "Event Center." The purpose of an event center is to boost social interactions

The significance of an event venue cannot be overstated because it sets the tone for the event and impacts the guest experience. A well-selected venue can improve the theme of the event, create the ideal atmosphere, and facilitate guest comfort and convenience. The location, size, and amenities of the venue can have a major impact on the success of the event. For instance, a wedding venue in Long Beach may need to reflect the couple's style and preferences and accommodate the number of guests. If the event is a business conference, the venue should have sufficient seating, audiovisual equipment, and catering facilities. Ultimately, the significance of an event venue lies in its ability to be in line with the event's purpose and create an enjoyable and memorable experience for those attending.

Nigerian and international event centers have long existed in a variety of forms, including town halls, community centers, conference halls, stadiums, convention centers, planetariums, and coliseums, to name a few. These traditional event centers differ from the contemporary ones in terms of ownership and construction motivation. In contrast to the contemporary ones, which were constructed as financial investments, the traditional ones in Nigeria, especially the stadiums, town halls, and others in that category, were generally constructed by the government or the community with the intention of mobilizing for social progress. The ownership of contemporary event venues is varied, ranging from private citizens to institutions and authorities. Similarly, some utilities are independent, stand-alone units, while others are extensions of lodging facilities. Their corporate aim and targets would undoubtedly be impacted by the observed identity disparities, particularly with regard to whether they prioritize social or economic contribution to the community they serve.

2.2. Social Interaction

Social interaction is a fundamental aspect of the human experience, and its significance in the context of an event center cannot be overstated. Research consistently demonstrates that positive social interactions contribute significantly to various dimensions of human life, including personal development, and overall well-being.

People leave the cycle of unemployment by attending events. Put another way, it generates employment opportunities for both skilled and unskilled workers and is recognized as a labor- intensive sector that offers more jobs per unit of investment than any other. In order to foster innovation and economic activity, the industry allows for collaboration and entrepreneurship within the framework of the event center business idea (Morrison, Rimmington, and Williams 2019).

"A unique place where people celebrate ceremony and ritual to satisfy specific needs" is how Joe Goldblatt describes a special event center, drawing on the work of anthropologist Victor Turner (Goldblatt, 2020). Thus, an event serves a purpose beyond simple functions or meetings: it allows a group of individuals to come together to work toward a particular set of goals.

Social engagement, as a critical component of this broader concept, plays a pivotal rolein shaping the holistic development of individual.

Additionally, Pascarella and Terenzini (2019) suggest that social engagement enhances cognitive development, meaning that learning occurs outside of the traditional classroom (Cuseo, J. 2019). Engaging in social activities, working together on projects, and being exposed to different viewpoints all contribute to a rich learning environment that transcends typical academic bounds. Good social relationships improve mental health, lower stress levels, and build a community of support that raises the standard of each person's experience as a whole.

2.3. Design Strategies

The World Health Organization's (WHO) Environmental Noise Guidelines offer suggestions for safeguarding human health against noise pollution that comes from a variety of sources, including wind turbines, vehicles, trains, and airplanes. It is well known that exposure to environmental noise pollution results in both important and critical health outcomes, including poor birth outcomes, quality of life, wellbeing and mental health, and metabolic outcomes. Critical health outcomes include cardiovascular disease, effects on sleep, annoyance, cognitive impairment, hearing impairment, and tinnitus. Urban acoustic environments with dense populations and high-rise structures composed of metal, glass, and stone with a hard reflective façade are the primary sources of elevated ambient noise levels.

All structural elements that divide a structure's indoor and external spaces are collectively referred to as the building envelope. It is made up of the roof, walls, foundations, windows, thermal insulation, and exterior shading mechanisms (Goetz *et al*., 2020). Regardless of the ephemeral exterior conditions, it is the primary aspect that establishes the building quality and regulates the inside conditions. Building envelopes have changed over time to interact with the air, water, climate, light, and sound, all the while preserving attractive design, cost-effective construction, and minimal energy consumption for operational management.

The sound insulation qualities of building envelopes are given priority when evaluating their acoustic qualities since they are closely linked to the reduction of indoor noise, which promotes occupant acoustic comfort. Compared to indoor acoustics, the impact of building envelopes on the urban acoustic environment has received less attention. However, interest in the impact of building envelopes on urban acoustic environments has increased due to the significance of education, welfare, and health in the outdoor environment. The endeavor to enhance the acoustic comfort and soundscape should also not be disregarded.

2.4. Sound Transmission

Sound travels through an elastic material medium as a mechanical disturbance from an equilibrium state. It is also possible to define sound as only what the human ear perceives, but this definition is too narrow and not very illuminating since it is useful to discuss sounds that are produced by devices other than the human ear, like dog whistles and sonar equipment. The characteristics of sound waves should be studied first in the study of sound. Waves can be broadly classified as either longitudinal or transverse, depending on how they propagate. A transverse wave is created when one end of a stretched rope is wiggled back and forth. This type of wave is created when the motion that

makes up the wave is perpendicular, or transverse, to the direction that the wave is traveling (along the rope). Electromagnetic sources, like light and radio, produce a significant family of transverse waves, in which the oscillation of the electric and magnetic fields that make up the wave is perpendicular to the direction of propagation. In addition to being helpful in explaining, the concept of noise is crucial to the sound of many vibrating systems (Tuo *et al*., 2020). White noise is the combination of equally powerful sound waves at all audio frequencies, just as white light is the mixture of all the colors in the rainbow. Noise is characterized by its lack of periodicity, which prevents it from producing any distinguishable musical pitch or tone, making it resemble the static heard between FM radio stations.

A different kind of noise known as "pink noise" is a range of frequencies whose intensity drops three dB each octave. Since many musical and natural sounds have spectra that decrease in intensity at high frequencies by around three decibels per octave, pink noise can be beneficial in sound and audio systems applications. When there is a broad noise spectrum but a focus on a specific narrow range of frequencies, such as when wind whistles through trees or over wires, other types of colored noise arise. In another example, when water is put into a tall cylinder, the pitch rises as the rising water effectively shortens the tube by resonating specific frequencies of the noise made by the gurgling water.

3. Methodology

The current study thoroughly examines the passive design techniques to support consumers' acoustic comfort in event centers using a rigorous mixed-methods approach as its methodology. This methodology consists of a thorough evaluation of the literature supplemented by an examination of multiple case studies written by various authors.

The initial phase involves a comprehensive review of the literature to identify and assess the key design elements associated with improved acoustic comfort in event venues. A wide variety of academic publications, including books, conference proceedings, scholarly journals, and pertinent reports published between 2019 and 2024, are included in this assessment of the literature. An analysis of this collection of work provides a solid foundation for identifying both established concepts and novel strategies for recreational landscaping in academic settings.

4. Findings and Discussions

4.1. Key Design Strategies

In order to maximize the auditory experience in a place and guarantee that residents are not only free from undesired noise disruptions but also enjoy an atmosphere that fosters productivity and well-being, a variety of techniques known as "acoustic comfort design strategies" are employed.

4.1.1. Building Height

Sound waves travel in all directions through the atmosphere. Taller structures can therefore function as barriers, preventing sound waves from directly transferring between spaces on opposite sides of the structure. Lower sound levels in the shadow zone behind the structure may result from this. Depending on the materials used for their surface, tall structures can either absorb or reflect sound waves. Hard, smooth surfaces have a tendency to reflect sound, whereas porous, squishy materials absorb it. The way sound behaves both inside and outside a building can be influenced by its design and construction materials.

Taller structures can also obstruct direct sound waves from the source, creating shadow zones with reduced sound levels. In some places, such as residential districts close to major roads or industrial regions, this effect can be helpful in lowering noise pollution levels. The height of the area can affect reverberation time, or how long it takes for sound to become inaudible after the sound source stops, in interior tall building spaces like atriums or lobbies. Longer reverberation periods in taller areas may have an impact on overall acoustic comfort and voice understandability.

4.1.2. Shape of the Building

The way sound waves interact with a building's surfaces depends on its shape. Rough, squishy surfaces absorb sound waves, whereas smooth, hard surfaces tend to reflect them. The arrangement of reflecting and absorptive surfaces within a building can have an impact on how sound reflects across the entire space. Building reverberation characteristics, or the persistence of sound reflections in the space after the sound source has ended, are influenced by the internal shape and volume of the building. Longer reverberation periods in larger, open areas with high ceilings can have an impact on the environment's overall acoustic quality and speech understandability.

Certain architectural firms have the ability to concentrate or focus sound waves in particular directions, raising the volume of sound in those places. On the other hand, because they obstruct direct sound waves, architectural forms can also produce shadow zones with reduced sound levels. This may have effects on acoustic environments that are both indoor and outdoor. By serving as a barrier or shield, a building's shape can also be intentionally created to reduce noise from outside sources. Buildings with setbacks or angled facades, for instance, might lessen the impact on their residents by helping to disperse and deflect incoming noise from nearby streets or roads.

Considering everything, a building's form greatly influences the internal and external acoustic environment. During the design process, architects and acoustic designers generally take into account the acoustic implications of a building's shape in order to maximize sound quality, reduce noise disruptions, and create spaces that are appropriate for their intended purpose.

4.1.3. Materials Usage

Sound transmission coefficient (STC), noise reduction coefficient (NRC), and sound absorption coefficient (α) are used to rate the sound-absorbing materials. Fiber size, volume, porosity, tortuosity, air flow resistance, thickness, density, compression, and material placement/position all affect absorption and transmission loss. Among these, the most important parameters for sound absorption are fiber size, porosity, thickness, and density. There is an inverse relationship between the diameter/width of the fiber and sound absorption. There isn't, however, a study that details how different fiber widths affect absorption. Another significant factor that is directly correlated with absorption is volume porosity. The other two main elements influencing the frequency of absorption are thickness and density. Increasing the thickness of the material effectively absorbs the low frequency sound. However, high density materials perform better for mid- and high-frequency frequencies,

while lower density materials tend to absorb low frequencies. (Castagnede, *et al*., 2020) detailed how compression affects absorption. There are three common methods used to assess sound absorption. The three methods are the tone burst method, impedance tube method, and reverberation room method. Despite being a very successful grading system, the reverberant field approach is not widely employed due to its high cost and vast space requirements. For this reason, the impedance tube method is frequently used to rate the materials acoustically.

The majority of sound-absorbing materials are made of synthetic fibers, and using them will have a negative impact on the environment and public health. Therefore, it's imperative to create environmentally friendly, sustainable products that won't negatively impact occupational health. "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs," states a United Nations report on sustainability. As a result, sustainable materials should be created with little energy use using recycled or natural materials, leaving a small carbon footprint. Life Cycle Assessment Procedures (LCA) are a common method used to evaluate the environmental impact of building materials. These procedures cover every step of the process, from material extraction to disposal and reuse.

5. Conclusion

In conclusion, the application of passive design techniques presents a viable option for mitigating the adverse effects of noise on the acoustic environment of event venues. Event centers can create environments that prioritize acoustic comfort and improve attendees' overall well-being by utilizing architectural and acoustic design principles, such as the thoughtful placement of sound- absorbing materials, careful consideration of building shape and layout, and integration of natural elements.

In addition to reducing noise pollution, passive design techniques help attendees have more engaging and pleasurable experiences. These techniques guarantee that music resonates authentically, ambient noise levels stay favorable to engagement and relaxation, and speech remains clear and comprehensible by improving space acoustics, limiting reverberation, and managing sound transmission.

Furthermore, by lowering the need for mechanical systems and the energy used for active noise control measures, the inclusion of passive design solutions is consistent with sustainability goals. Using daylighting, natural ventilation, and vegetation not only improves acoustic comfort but also lowers the carbon footprint of event facilities and fosters a healthier interior environment.

Passive design techniques are becoming more and more necessary as event centers develop into multipurpose venues that can host a wide range of events and audiences. Event centers may set themselves apart as places that value the attendance experience, encourage innovation and productivity, and make a good impact on the social and cultural fabric of their communities by giving careful consideration to acoustic comfort in design. Thus, the combination of acoustic principles and passive design provides a comprehensive method for designing event venues that are respectful to the environment and human senses.

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