Effectiveness and Sustainability of Acoustic Measures in Palms Mall, Ota

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Abstract

In this report, some of the acoustic properties and features of a shopping mall in Ogun state, Nigeria were observed and documented. The study looked into the Sustainability of materials employed for acoustic measures and the effectiveness of the acoustic measures within the mall. Under consideration were the size and shape of the space, volume, location, spatial organisation, noise zoning, insulation and isolation techniques adopted and the presence of acoustic enhancements such as banners, mufflers and absorbers. The study employed the use of qualitative field research and found that the palms mall has quite a bit to improve on in terms of acoustic treatment and that although noise pollution is not effectively combated, the materials employed can be deemed sustainable

Keywords: Acoustics, Sustainable Acoustics, Shopping mall,

1. Introduction

Excellent acoustic properties are part of the most important criteria which we place on objects or spaces, and some of the most important activities such as concerts, conferences, and shopping take place in various enclosed spaces. The multiple methods of protection against noise in building acoustics include protection against airborne noise between exterior and interior spaces, protection against airborne noise from one interior space to another, protection against impact noise, protection against noise from machines and protection against interior space devices. One of the acoustic protection methods being looked at in this study is the protection against noise within the same interior space, also known as noise isolation [13]

A direct relationship exists between noise pollution and Sustainability in cities. One of the negative consequences of urbanisation in Nigeria is environmental noise pollution, and this is in direct conflict with Sustainability. The study also recommends that at the environmental level, there is a need to implement noise mapping or zoning and the Governing bodies have a crucial part to play [12]. Sustainability is defined as development in the present that does not mitigate further development. On the building scale, the use of sustainable building materials for acoustics is also needed. Materials like bamboo, Kenaf, Sisal, coco fibres – natural materials- push the agenda of Sustainability, as opposed to synthetic materials such as many mineral fibres [1]

In this paper, the focus was on investigating the acoustic properties and features of a shopping mall – The palms- located in Ota, Ogun state Nigeria. The study looked at the different features aiding noise control and discussed the Sustainability of the acoustic
measures in place briefly. Thus the paper assessed the effectiveness of acoustic techniques and the Sustainability of same.

2. Literature Review

In a typical retail space or mall in this instance, the customers, employees and sales have been found in studies, to be affected by adequate or inadequate designs for acoustics. In the 21st century, the bid to attract customers using rich multi-sensory experiences has to involve a look at the acoustics in the retail space [9].

Shopping malls are large modern spaces that typically feature some architectural elements that all mandate acoustic inquiry. Shopping malls are constructed to facilitate large amounts of commercial activity. Usually, shopping malls have features such as atriums, vaults, domes, galleries, spaces with high head-rooms and, so on. All these are essential to the richness and visual appeal of the spaces, but they invariably affect the Acoustic quality [4].

Two main factors cause noise around atria. Firstly, external noises from natural ventilation systems and, secondly, hard surfaces. The two factors can sometimes combine to produce a continuous reflection of sounds (noise) from the interior as well as exterior sources [14].

The volume and space of a building will always affect the way sound travels in the space. Larger volume spaces cause an increase in reverberation time. The spaces also produce more background noise and reduce sound intelligibility [5].

Malls, shopping centres, and showrooms are designed to be busy. In some cases, change of building use can result in acoustic challenges if sufficiently, the acoustics were not taken into consideration at the design stage. More research [8] argues that inappropriate soundscapes can make potential customers leave shops or malls faster.

Designers prefer using hard surfaces such as polished wood, glass, metal and stone for aesthetic reasons. The hard surface has a tendency to be cleaned easily, but they also reflect sound to a confined area which often results in a noisy space. If acoustic design strategies are considered at the design stage, acoustic problems would be reduced in buildings. Still, it is an argument that architects and interior designers could be doing a lot more in terms of self-education and application in practice. When owners or operators of stores rent a space for their business activities, they would need to create a comfortable acoustic environment with the help of at least one acoustic specialist [2].

When evaluating the acoustic performance of a space; buildings are classified as either acoustic spaces (auditoria, concert halls, and theatres) or non-acoustic spaces (malls, residential buildings and office buildings). Non-acoustic spaces include buildings that have primary functions that are not related to music or unique acoustic indices [11].

Some standards exist for public spaces like The TSE (Turkish Standards institution) and ISO (International Organization for Standardization)standards, Noise Control Regulation, Environmental Impact And Evaluation Regulations, And Environment Noise And Control. The sources listed take mainly sound pressure into consideration when evaluating the acoustic quality and recently, studies providing guidelines at initial design stages have become more and more relevant.

In a study by Caliskan, using simulations in several shopping mall typologies, the researcher was able to create a simplified index of specific features that provided negative or positive feedbacks as regards acoustic quality [3].
Table 1: Architecture features and their effects on acoustics [3].

| Feature                                      | Negative effect | Positive Effects |
|----------------------------------------------|-----------------|------------------|
| High Volume/Area Ratio                       | o               | o                |
| Lower Volume/Area Ratio                      | o               | o                |
| Circulation Around Single Gallery            | o               | o                |
| Convex Surface Geometry of Atrium            | o               | o                |
| Existence of Central Gallery                 | o               | o                |
| Circulation connected to central Gallery     | o               | o                |
| The closeness of Entrance to Central Gallery | o               | o                |
| Less Connection with central Gallery         | o               | o                |
| Circulation with Narrow Gallery              | o               | o                |
| The close positioning of Food-Court to Gallery| o             | o                |
| Absorptive Surface Materials                 | o               | o                |

Also, in practice, various materials are usually specified as having better acoustic qualities than others. One of the most flexible acoustic materials is gypsum because it can be used in almost any type of building, ranging from hospitals to libraries, to churches, concert halls and many more [7]. Gypsum is the most flexible of acoustic materials, enabling it to be used in virtually every type of building, from concert halls to hospitals, libraries to performance spaces. However, the need for exceptional acoustic quality is essential to the success of shopping centres, showrooms and malls which are often designed to be busy: a lot of people, distraction and noise. To control noise in these spaces acoustically, the acoustic ceiling expression is such that it should be neutral and discreet. Acoustic considerations should also be taken in the design and strictly adhered to. For meeting these requirements, acoustic gypsum ceilings are cited as ideal by experts. They can serve as absorbers and, gypsum is also durable; easy to maintain and relatively easy installation is possible across malls, shopping centres and showrooms. [6]

Gypsum is a recyclable material and is termed sustainable in multiple studies. The recycling process is energy demanding, but even the wastes from pure gypsum can be used in construction and agriculture. Any use of this material for acoustic control can be termed as an application of sustainable acoustic material [10]

3. Methodology
To carry out this study, the case study was visited once in a period between 10 am and 2 pm on a weekday—a period of moderate human traffic in the area. The researchers employed the use of sketches to document observations. Mainly the acoustic measures based on different criteria were observed, and the Sustainability of the materials employed was also noted.

4. Findings
The Palms Mall, Ota, Ogun State served as the subject of this study which was carried out to assess the methods of acoustical management implemented (in the supermarket area mostly). The mall is located on an elevated site along a major highway; it has a ground floor and a basement floor on one side as the land it is sited slopes down from the front to the back. The
largest store space in the mall belongs to Shoprite, where some of this study was carried out, and the findings were duly documented.

**Observations and assessment of the Palms mall, Ota**

*Assessment based on room shape:*

![Figure 1: Sketch of Floor Plan](image)

The shape of the Palms Mall, Ota (as seen in Figure 1) takes that of a rectangle which is morphed with different other shapes to attain the desired look, which is mainly due to the topography of the site and its undulating nature. The circulation space of the mall takes a rectangular shape, which has a semi-circular form fused towards the end of the mall, and this is a significant factor in how sound travels within the mall's circulation space.
The mall's hot spots, as shown in Figure 2, are the portions of the mall that receive continuous reflections of echoes. The sound intensity within the mall, generated from people (Sound Source) is relatively high, and as such, there are more hotspots present within the mall's circulation space. The mall's dead spots are the portions of the mall where the sound is not predominant or heard at all as a result of the geometry. The majority of the dead spots located within the mall are around the corners or edges of the walls, most of which are chamfers or depressions.

**Volume**

The acoustic assessment of the mall, in terms of volume, looks at the height, width and length of the circulation space.
Figure 3: Ceiling of mall acting as an absorber

The headroom is about +4,000m and has an inclined ceiling which has a sound concentrating effect. The inclined ceiling is also designed in a way to absorb sound that reaches the ceiling.

Figure 4: Ceiling of mall acting as an absorber

The width of the interior walls in the circulation space is about 9,600mm apart, and these walls are made up of both glass (Shop Fronts) which act as a reflective material and white paintable panels, which are sound-absorbing materials.
Figure 5: Ceiling of mall acting as an absorber

Figure 6: Stairwell with high a headroom
Due to the shape of the mall, the interior space has an extensive length which is predominantly rectangular. As a result, lateral reflection occurs in the entire space, due to the generation of sound from people (Sound Source) in the mall.

It is worth noting that, the sound absorbers in the ceiling absorb a lot of sounds, and as such, the reflections from the glass walls (Shop Fronts) are made even less audible. As a result, white paintable walls were used as a form of absorptive treatment, to absorb as much reflected sound as possible.

**Location (Site Acoustics)**

![Figure 7: Sketch of site Layout](image)

The site is located in Ota, Ogun State along Ojokoro Road. The topography of the site is naturally sloped upward from the express road, and then gently slopes down from the boundary of the property line. The undulating nature of the site was used as a means to orientate the mall. The longer side of the mall was designed to follow the undulating landscape of the site.
The site is designed such that the entrance is located close to the parking lot, and the shorter side of the mall (without openings) faces the express road. The type of absorbers used to buffer the sound generated from the express highway included iron grills, used as fencing on the site (Acoustic Fencing), deciduous trees which were used as a form of absorbers, and also the naturally steep slope of the land from the express road to the site.

**Spatial organisation**

The headroom of Shoprite is 4 metres approximately (double the standard minimum of 2.2 metres), and an open ceiling system was implemented. The members of the roof are exposed with the piping and ductwork showing, as well as electrical systems. The area of the space is relatively wide (9.6 metres apart) and as such the sound generated would travel far. Due to the high headroom, the echo and reverberation time would also be longer.
Figure 9: Shoprite shopping space

Shoprite makes use of baffles as absorptive material. The distance at which the baffles are placed is wider and larger (6 metres) due to its high headroom, and as such, a large amount of sound will be absorbed.

Fig 10: Ductwork revealed in Shoprite shopping space

The exposed piping and ductwork were given acoustic treatment by making use of mufflers as a means of sound isolation. The mufflers were used to suppress the sounds that were generated from the ducts or pipes. The system of masking was used as a form of sound isolation. There is constant music played within the shop, used as white sound, to ensure that people outside the shop do not make sense of the sound within the shop and to mask the sound within the shop.
Effectiveness of Acoustic Measures and Sustainability

From the basic descriptions by Caliksan, the research checked for some features that would impact acoustics negatively or positively. From the list, a simplified checklist was prepared, and in specific spaces, there was clapping to check for echoes [3]. Table 2 below shows the simplified checklist for the Palms Mall. The field survey showed that the only active acoustic measures in place were the absorbent ceiling, the baffles in the Shoprite complex. The measures in place were both effective in reducing echoes and reducing noise pollution in the spaces of application. The other means such as zoning and volume and shape of space were less successful.

Furthermore, Sustainability in terms of acoustics is defined in this paper as the use of measures that reduces noise pollution and employs sustainable materials. Sustainability was looked at in terms of the materials used to improve or control sound in the mall. They were marginally sustainable in terms of noise pollution control of the environment, but the materials employed (principally gypsum and paper) are sustainable.

Table 2: Simplified list of negative and positive features aiding or combating good acoustics in the mall

| Present (Negative) | Absent (Positive) |
|--------------------|-------------------|
| High Volume/Area Ratio | o |
| Lower Volume/Area Ratio | o |
| Circulation Around Single Gallery | o |
| Convex Surface Geometry of Atrium | o |
| Existence of Central Gallery | o |
| Circulation connected to central Gallery | o |
| The closeness of Entrance to Central Gallery | o |
| Less Connection with central Gallery | o |
| Circulation with Narrow Gallery | o |
| The close positioning of Food-Court to Gallery | o |
| Absorptive Surface Materials | o |

5. Conclusion

This paper involved the field survey of the Palms mall, Ota in the bid to assess the acoustic measures in place and to give feedback on the Sustainability of the different materials and methods applied. The acoustic treatments were assessed as unsustainable; they do not control noise effectively. However, the materials employed primarily are gypsum and paper for the acoustic devices. These materials were deemed in the literature to be sustainable as they are readily recyclable. To improve the current state of acoustic behaviour building, there should be an addition of better absorbers near hotspots, planting of trees on-site in strategic locations and spaces like the Shoprite mall should employ more banners, mufflers and baffles to reduce the impact of noise pollution and render the acoustic treatment more sustainable.
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References
[1]. Asdrubali, F. (2007, September). Green and sustainable materials for noise control in buildings. In proceeding: 19 the International Congress on Acoustics. Madrid (pp. 2-7).
[2]. Bauer, M., Mösle, P., & Schwarz, M. (2009). Green building: a guidebook for sustainable architecture. Springer Science & Business Media.
[3]. Caliskan, E. B. (2010). Acoustical evaluation of shopping mall typology. Master Degree of Middle East Technical University, Ankara, 9.
[4]. Champion, E. (2019). Organic Design in Twentieth-century Nordic Architecture. Routledge.
[5]. Hopkins, C. (2012). Sound insulation. Routledge.
[6]. Jaroslav V. (2013) Acoustic Comfort Evaluation in the Assessment of Internal Spaces using the Methodology SBTool CZ: Czech Technical University in Prague-Faculty of Civil engineering, Department of Building Structures
[7]. Jester, T. C. (Ed.). (2014). Twentieth-century building materials: History and conservation. Getty Publications.
[8]. Krasnic, A. (2018) Acoustic design and control in the 21st-century retail environment. Hyllinge Sweden, ECOPHON
[9]. Krishna, A. (2012). An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behaviour. Journal of consumer psychology, 22(3), 332-351.
[10]. Lushnikova, N., &Dvorkin, L. (2016). Sustainability of gypsum products as a construction material. In Sustainability of Construction Materials (pp. 643-681). Woodhead Publishing.
[11]. Nowicka, E. (2020). The acoustical assessment of the commercial spaces and buildings. Applied Acoustics, 169, 107491.
[12]. Olayinka, O. S. (2013). Effective noise control measures and sustainable development in Nigeria. World journal of environmental engineering, 1(1), 5-15.
[13]. Topa M., Toma N., Kirei B., Saracut I. & Farina A. (2012) Experimental Acoustic Evaluation of an Auditorium. Advances in Acoustics and Vibration Volume 2012, Article ID 868247 DOI:10.1155/2012/868247
[14]. Urban, D., Zmeková, J., Zat'ko, P., Maywald, C., &Rychtáriková, M. (2016). Acoustic comfort in atria covered by novel structural skins. Procedia Engineering, 155, 361-368.