A WRITE-UP

On the

ACOUSTICAL ANALYSIS of the
SMALL LECTURE THEATRE (Small LT),
FEDERAL UNIVERSITY OF TECHNOLOGY AKURE.
AKURE, ONDO STATE.
NIGERIA

By

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ABSTRACT

This paper describes our experience with lecture halls with regards to room acoustics, external acoustic disturbance (Noise) and sound reinforcement. The optimum reverberation time and geometrical conditions for lecture halls are well known; recent research confirms this knowledge but indicates the need for shorter reverberation times. However, many existing lecture halls do not fulfill these requirements.

This write-up describes the SMALL LECTURE THEATRE, Federal University of Technology, Akure, Ondo State, in terms of its finishes and construction materials, furniture type and arrangements, as well as the noise sources (both internal and external), in order to give an overall analysis of the perceived acoustic properties of the hall.

In addition, the write up is expected to propose ways of improving the acoustic properties of the hall with respect to the outcome of the analysis carried out in order to create a noise free zone and an acoustic friendly environment for the users.
CHAPTER ONE

General knowledge of Acoustics in Architecture

10 INTRODUCTION

ACOUSTICS is simply the science of sound, which involves mainly the study of the room acoustics and the control of noise. While ROOM ACOUSTICS is concerned with the nature, properties and characteristics of sound in an enclosed space, NOISE is simply an unwanted or damaging sound that interferes with what people are trying to do or sound, which has an adverse effect on health or safety.

In order to be able to deal with the problems of noise in the Small Lecture Theatre, it would be paramount to carry out an analysis of the nature, causes and effects of the noise. These findings coupled with the knowledge of basic acoustics (the nature of sound and its physical properties) will be of significant importance in solving the noise related problems in the hall hence providing a more conducive learning environment for the users.

11 ACOUSTICS AND ARCHITECTURE (acoustics in buildings)

The question of acoustics in lecture halls has been researched internationally in recent years. MacKenzie, for example investigated the influence of poor acoustics on the students and lecturers, in an important study in 1999.

Of course, good acoustics are important in lecture halls. The background noise must be minimized and the room form and materials must be designed to support the acoustics in order to provide high speech intelligibility.

12 JUSTIFICATION FOR THE STUDY OF ACOUSTICS

The study of acoustics in relation to buildings is necessary to incorporate the knowledge gained into the early stages of design in other to achieve the following:

- To create an acoustic friendly environment for all users including hearing impaired individual.
- To ensure maximum correspondence between individuals in an enclosed space without disturbance from internal or external source of unwanted sound or noise.
- To reduce to barest minimum the physiological and psychological effects of noise on humans in the designed space.
CHAPTER TWO
General Overview of Study Building

SMALL LECTURE THEATRE,
F.U.T.A Akure, Ondo State.

2.0 BUILDING DESCRIPTION

The Small lecture theatre (Small LT.) is a 154-Seater Lecture (speech) auditorium, designed for use as lecture hall for students of the Federal University of Technology, Akure, Ondo State.

2.1 LOCATION

The Small LT. is located at the Obanla Section of the University campus, encompassed and surrounded by different school buildings on all sides.

Bounded in the North by the School of Engineering and Engineering Technology(S.E.E.T) building and CBN Library building, in the South by the School of Agricultural Technology(S.A.T) building and School of Science(S.O.S) building, by the Mechanical Engineering(M.E.E) Laboratory building on the West end and by BIG Lecture Theatre on the East.

2.2 ARCHITECTURAL DESIGN

The Small LT. is designed as a bungalow; it functions presently as a lecture hall for all students according to their fixed lecture hours, accommodating ideally at most 200 students at a time.

The building consists of the Main hall, main entrance porch, preparation space (back stage), stores and toilets.

The internal dimension of the main hall is 9mx12m long; its headroom is approximately 7m, it design is such that the seating area slopes downwards towards the stage or lecture front, giving the hall a theatrical effect. The stage is raised 0.4m above floor level.

The hall is accessible from all four sides, its main entrance located at the northern part (behind the seats), two side entrances located near the stage and an entrance to back stage.

The roof is in form of a simple gable shape covered with parapet wall slab.

2.3 FINISHING MATERIALS
The construction materials used for the various components are as follows

2.3.1 **Walls**
The walls are of plastered sand Crete hollow block with a textured paint finish.

2.3.2 **Ceilings**
The ceiling is made of suspended acoustic fiber ceiling boards with dimension of 600x600mm.
The boards run through the hall in a flat horizontal arrangement with necessary lightening and air conditioning fittings.

2.3.3 **Floor**
The floor of the seating area is finished with terrazzo; the stage is a raise timber floor, made of wood and covered with a rug.
The picture shows the stage floor and part of the seating area.

2.3.4 **Fenestrations**
The main entrance doors at the northern section are made of glass, the two side doors are made of steel (Iron mongery).
Other doors in the building such as store doors, back stage doors are paneled timber the doors.

Window openings are hinged openings made of glass and steel.

It is notable to say the windows were designed to follow the sloppy arrangement of the seats as seen in the pictures.
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Showing external sources of noise
Figure 2: Floor Plan
Showing Furniture arrangement and Finishes

Figure 3: Floor plan
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CHAPTER THREE
Acoustic disturbances (Noise) and Study Building

3.0 ACOUSTICS AND LECTURE (Speech) AUDITORIUMS

Actually, the basics of good acoustics for lecture halls are well known. Nevertheless, noisy lecture halls with excessive reverberation, echoes or flutter echoes are common. The speech intelligibility is correspondingly poor. Therefore the need to design lecture halls in accordance with acoustic guidelines to create an acoustic friendly space for the talkers and the listeners.

3.1 ANALYSIS OF NOISE SOURCES

The sources of noise have been identified and divide under two major divisions which are:

3.1.1 Internal Noise

Most internal noise is generated through human activities, which include:

i. Verbal discussions in the classroom.
ii. Occasional dragging of furniture on the hard floor finish.
iii. Movement of students in and out of the Hall.
iv. Noise from ceiling fans.
v. Noise from occasional opening and closing of fenestrations.

3.1.2 External Noise

The major constituents of external noise are:

i. Background noise from human (students) conversation and activities as they loiter on the walkways and surroundings of the building.
ii. Vehicular Noise from activities that cause engine noise, movement of the vehicles and hooting of horns from adjacent car park (S.O.S car park).
iii. Noise from student activities in the adjacent building (Big Lecture Theatre).
iv. Occasional noise from movement of trees during strong wind.
v. Noise from climatic feature such as noise caused by rainfall, wind noise.
vi. Other occasional external sources of noise such as unprecedented noise from student riots, fights or games.
Pictures of external noise sources are displayed below:

- Picture showing Big Lt. source of background noise. When the hall is in use.
- Picture showing walkways around the Small LT. Source of noise from using walkways.
- Picture showing Adjacent S.O.S car park Source of vehicular noise.
- Picture showing A tree possible source background noise heavy wind.

3.2 ACOUSTIC CHARACTERISTICS OF THE MAIN HALL.

The acoustic characteristics of the main hall in the light of background noise, Reverberation and echoes are discussed below.

3.2.1 Background Noise

The Small LT. was not provided with the necessary components that can help in successfully reducing the external or background noise from proliferating into the interior of the building hence these noises are still a major problem in the building as they have not been shielded or eliminated. Noise from student activities outside the hall as well as vehicular noise still penetrates into the building.

This also includes noise from ceiling fans, noise from audience, noise from use of fenestrations and noise from the sound system.

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<td>Low</td>
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<tr>
<td>Middle</td>
<td>35dB(A)</td>
</tr>
<tr>
<td>High</td>
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Table 1: Maximum allowable background noise levels in accordance with DIN 18041

Acoustical Analysis of Small Lecture Theatre
F.U.T.A Akure, Ondo State.
3.2.2 **Reverberation, Reverberation Time and Echoes.**

Reverberation is simply the persistence of sound in an enclosed space after the sound source has been removed or the sound has stopped while Reverberation time is the time required for a loud sound to be inaudible after turning off the sound source.

This depends on the total room absorption \( (a) \) by the seats and audience as well as the volume of the room \( (v) \). The reverberation time \( (t) \) is directly proportional to the volume of the room as:

\[
t = 0.05v/a
\]

The volume of the hall assessed by the ceiling height determines the reverberation time of sounds, which in turns determines speech intelligibility. It is recommended that heights be kept between 9ft and 12ft (2.7m - 3.6m) in classrooms. The volume of the Small LT is within this limit.

![Graph showing recommended reverberation times per room volume according to revised DIN 18041](image)

3.2.3 **Room Form (size and shape)**

The well-known rules concerning room form remain valid. The size of a room affects the reverberation time, when a room is large the reverberation time is above the acceptable limit and the surfaces should therefore be acoustically treated. The small LT. consists of flat wall surfaces, which act as reflectors bouncing waves at all angles according to its incident angle therefore reducing reverberation.

The almost SQUARE shape (rectangle) of the Small LT. is preferred as it helps to ensure even distribution of sound within the hall range.

3.2.3 **Loudness of Original Sound**

This as to do with the sound system put in place, to amplify the effect of the sound source. It as been discovered that speech intelligibility increases with loudness.

The small LT. was furnished with sound systems showing signs of acoustic considerations though the equipments are not functioning anymore.
CHAPTER FOUR
Methods of Improving General Acoustics of the Study Building

The approaches in improving the acoustical environment of the Small LT. would be discussed in relation to the two categories of noise sources in an effort to reduce both external and internal noise to tolerable or barest minimum levels.

4.0 PROPOSAL FOR REDUCTION OF INTERNAL NOISE

4.0.1 Use of Absorbent Screens and Surfaces
Absorbent materials and surfaces are efficient in reducing noise ensuing from verbal discussions by students as well as any other internally generated noise that would have been aggravated by multiple reflections from walls. The following are effective types of absorbent materials:
- Porous absorbents (best for high frequencies)
- Membrane absorbents (best for low frequencies)
- Resonant absorbers (resonators)
- Perforated panel absorbents.

The ceiling boards are acoustic ceiling tiles, which are good sound absorbing materials. Additional sound absorbing panels can be introduced in a narrow band along the upper side of the walls. The use of gypsum board ceiling above the stage area (lecturer’s location) will allow beneficial reflection from the ceiling to increase the apparent loudness of sounds for the students towards the rear of the hall.

4.0.2 Installation of Carpet on the Floor
It is an established fact that noise from impacts such as shifting furniture and footsteps are less in carpeted rooms as compared to rooms with hard floor finish. Carpets however raise questions on indoor air quality and high maintenance costs which must be balanced with acoustical benefits.

4.0.3 Use of a Sound System
This consists of a wireless microphone used by the teacher to pick up his voice, the voice is then amplified and played through a loudspeakers carefully located in the hall to increase the loudness of the speech sounds for the students in the hall, this prevents the lecturer from shouting in order to make him or her audible.
4.0.4 Full upholstery of seats
Use of foam padded and leather finished chairs will go a long way in absorption of some sound as against the effect of reflection which will be felt in the current case of the wooden furniture.

4.1 PROPOSAL FOR REDUCTION OF EXTERNAL NOISE

4.1.1 Screening of Building
In the Small LT. scenario, the noise coming from the surrounding walkways and car park can be screened-off using a fence, constructed to enclose the hall especially from the car park.

4.1.2 Insulation of Walls
The walls of the hall could be insulated with absorbent materials embedded within the block wall; the resulting insulated double skin wall offers a greater insulation from both traffic noise and pedestrian noise from walkways.

4.1.3 Use of Closeable doors and enforcement of closure
All doors should be changed to a double glazed aluminum framed door provided with door closers and it must be ensured that they are closed after each entry or exit to disallow noise infiltration.

The use of artificial air-conditioning system might also help, in order to be able to close all doors and windows to ensure that sound propagation (reflection) is kept within the hall, this also reduces the amount of external noise into the hall.

Bubble diagram:
Showing the nature, characteristics and properties of sound in an auditorium and possible solutions to acoustics problems in the hall.
CHAPTER FIVE
Final Chapter: Conclusion

5.0 CONCLUSION
Acoustic is a very important aspect to be considered in architectural designs most especially in the design of speech auditoriums. Noise control should be of prime consideration in any academic environment; learning requires a serene environment to aid concentration.
Apart from the spatial requirements, other factors such as construction materials, site selection, and design and amplification systems for large halls are equally important. An audiologist and acoustical consultant should be included in the design of learning facilities to aid a satisfactory learning environment.

This technical report has revealed some of the ways this type of environment could be achieved, though the proposals apply specifically to the scenario surrounding the Small LT, they are generally accepted principles in achieving an acoustically healthy environment.

5.1 RECOMMENDATIONS
Lecture halls should be designed according to the latest knowledge concerning acoustical requirements. This can be accomplished through the incorporation of basic acoustic knowledge into the design stage of the building and with reasonable constructive and instrumental expenditure.

5.2 REFERENCES