USE OF BUILDING FORMS AS ACOUSTICAL TREATMENT

IN THE DESIGN OF AN IDOMA CULTURAL CENTRE, OTUKPO.

By

OGWUCHE BENJAMIN ENOKELA

DEPARTMENT OF ARCHITECTURE,

AHMADU BELLO UNIVERSITY, ZARIA,

NIGERIA

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BY

Ogwuche Benjamin ENOKELA, BSc (UNI-JOS)

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NIGERIA

AUGUST, 2014

DECLARATION

I, Ogwuche Benjamin Enokela declare that the work in this Thesis entitled 'USE OF BUILDING FORMS AS ACOUSTICAL TREATMENT IN THE DESIGN OF AN IDOMA CULTURAL CENTRE, OTUKPO' has been carried out by me in the Department of Architecture Ahmadu Bello University. The information derived from the literature has been duly acknowledged in the text and a list of reference provided. No part of this project thesis was previously presented for another degree at this or any other institution.

Name of Student	Signature	Date

CERTIFICATION

This thesis entitled "USE OF BUILDING FORMS AS ACOUSTICAL TREATMENT IN THE DESIGN OF AN IDOMA CULTURAL CENTRE, OTUKPO" meets the regulations governing the award of the degree of Master of Science, M.Sc, Degree of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Dr. M.L. Sagada Signature _____

Chairman, Supervisory Committee Date_____

Dr. S.N. Oluigbo Signature_____

Member, Supervisory Committee Date_____

Dr. M.D Ahmed Signature_____

Head of Department Date _____

Prof. A.Z Hassan Signature_____

Dean, School of Postgraduate Studies Date_____

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ABSTRACT

Acoustic is an important factor in theatre that had not been given extensive concern during architectural design under building form, eventually Architects during the conceptual design stage had barely paid attention to building form that affect the acoustic environment inside theatre halls. Eventually the importance of a dead sound became more important given the use of building forms to minimize sound reverberation in it.

For the building form acoustic. A computer model employing the ray tracing theory was employed to investigate the three configurations, different acoustic treatments were tested relatively to the building forms disposition of each design finally, basic recommendation and design guidelines were presented that a hexagonal building form is best for a music theatre. Since the making of architecture occurs in a social construct, architecture must be viewed within the context of complicated issues surrounding class, race, nationality and gender. Every culture generates and maintains systems of meaningful forms – symbols, rituals, and places of collective importance – that are reflected in its buildings and collective spaces.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

The arts of music, drama, and public discourse have both influenced and been influenced by the acoustics and architecture of their presentation. Randy(1990) theorized that African music and dance evolved a highly complex rhythmic character rather than the melodic line of early European music to it being performed outdoors.

Cultural centre's are venues where cultural activities are carried out in order to keep on the trend of one's culture by its performing arts, it can be obtained by ones cultural activities like songs, dance and the exhibitions of it's materials and in so doing the need for proper planning and acoustic consideration to increase acoustic quality of the structure to facilitate a conducive theatre for art performance.

Acoustics is the science of sound. It deals with the production of sound, the propagation of sound from the source to the receiver, and the detection and perception of sound. There are various perceptions to sound, the disturbance in a medium that can cause disorder and an auditory sensation in the ear (Thomas,2007). Sound is explained by Donald, (1997) as vibration in an elastic medium such as air and water, most building materials and the earth.

Cultural centre's have the problem of long reverberation times Sabine (2008). This is detraction in an environment where users need to be attentive and also need to hear or listen to clearly exactly to what the performers are presenting. Poor hall acoustics will make listeners suffer vestibular disorder and voices will be drowned out by echoes that will make music sound as noise virtually to the listeners Pigeon (2007). Transmission (flow) or

prevention of transmission of sound, and conversion of energy to a non-audible form are the function of the kind of building form used (Sabine, 1922).

1.2 PROBLEM STATEMENT

Most cultural centres in Nigeria were accidentally created (Lasisi, 2000).Acoustical treatment by the use of inadequate building forms, amongst which are sound reflections and reverberation to listeners' affects the general performance of the users. The use of conventional building forms for cultural centre's has it resulting effect, if not properly chosen and designed, such effects are reverberation of sound on the users which will in turn make it difficult to getting clearly whatsoever musical performance that will be performed and also causes vestibular disorder. This occurs basically due to the fact that attempts by architects in previous works lay too much emphasis on cultural element(s) to express their creative ideas and in so doing neglecting the building form which these structures are to take in order to have a lasting acoustical treatment for such theaters. This approach to cultural centre design creates a void between the structure and it's listeners, a void that can only be effectively filled with an architectural idea that have high regards for culture. The irony is that most architectural designs are often counterproductive to its purpose.

The approach employed in this study would give rise to a cultural centre which would be more than just a mere container to house or bring together people of different culture, but a theater that would be part of the story and a story that begins with seeing and interacting with the structure.

1.3 RESEARCH AIMS AND OBJECTIVES

The aim of this research is to explore and harness the potentials in the use of building form as an acoustical treatment, and also identifying the appropriate building form suitable in the design of a theatre in a cultural centre.

The objectives are as follows:

i. Identifying the quality of sound and also analyzing the principles of the application of building forms to achieving the reduction in reverberation time in the world of acoustical treatment.

ii. Studying the evolution of cultural centre's up to this present day. Studying how the application of building forms have been effectively used by previous architects on cultural centre designs.

iii. Identifying the basic causes of sound reverberation and sound generated in around the cultural centre.

iv. Propose solutions to problems commonly found in cultural centres.

1.4 SCOPE

This research shall encapsulate the concept and evolution of the use of building forms as an acoustical treatment on cultural centre's which would then lead us to its principles and how it can be effectively applied in cultural centre design, in so doing, the study shall analyze acoustics on building forms to solving acoustical issues of the building envelope which would showcase itself in the building's overall form, in such a way that it would connote the power of building forms and how it can be translated on the design of cultural centre's.

In this research, the study shall focus on, the approach to cultural centre design with regards to the building form of such structures. Evolution, current trends, along with how they relate to exhibition and display of works, and in addition to this, attempts and approach used by previous architect in the design of cultural centre would be studied.

1.5 JUSTIFICATION

Building form is a very vital approach in the treatment of acoustical problems in cultural centre's, hence it is necessary that a place be provided where this evidence of cultural wealth can be properly exhibited also considering its building form so as to minimize the impact of acoustical problems there in. This is important because the usage of building forms serves as a mother solution to the rest of approaches employed to solving these problems of acoustics. There is need to establish a good cultural centre considering the use of building forms to solving acoustical problems which will lead to the provision of dead sound required by it users to impacting themselves positively.

Finally, the present cultural centre in the state, coupled with the fact that it is just a small one that is inadequate in taking all cultural troops when such occasions are staged, is also too small and is in a bad shape. Thus, as a result of the aforementioned points, the researcher has strong justification to propose a cultural centre for Benue state capital.

CHAPTER TWO

LITERATURE REVIEW

2.1 SOUND

Sound can be defined as a wave motion in air or other elastic media (stimulus) or as that excitation of the hearing mechanism that results in the perception of sound (sensation) (Harry, 2000). Which definition applies depends on whether the approach is physical or psychophysical. The type of problem dictates the approach to sound. If the interest is in the disturbance in air created by a loudspeaker, it is a problem in physics. If the interest is how it sounds to a person near the loudspeaker, psychophysical methods must be used.

2.2 SOUND PRODUCTION AND TRANSMISSION

Sound may also be described as a simple form of mechanical energy (olson,1999) and can be described by the mathematics associated with the generation, transmission, and control of energy. Almost any moving, vibrating, oscillating, or pulsating object is a potential sound source. Usually, vibratory sources radiate enough energy to be audible to humans or felt by them. Sound waves in air (or other gases or fluids) travel outward from the source, transmitted by air molecules, like a rapidly expanding soap bubble. Any particular group of molecules behaves like a pulsating balloon, moving only slightly, while the wave progresses swiftly to great distances. Transmission (flow) or prevention of transmission of sound, and conversion of sound energy to a non-audible form are the function of so-called acoustical materials (Fenedy, 2002). Sound above 300–400 Hz is best considered as traveling in rays. A ray of sound may undergo many reflections as it bounces around a room. The energy lost at each reflection results in the eventual demise of that ray. Even the ray concept is an oversimplification: Each ray should really be considered as a

"pencil" of diverging sound with a spherical wave front to which the inverse square law applies. The mid/high audible frequencies have been called the *specular* frequencies because sound in this range acts like light rays on a mirror. Sound follows the same rule as light: The angle of incidence is equal to the angle of reflection.

In addition to the longitudinal (compression or ''squeeze'') waves by which sound travels, there is another type of vibration motion to which most building materials and construction systems are subjected, a transverse wave (see Fig. 1). This is the familiar motion of a vibrating string or reed. This type of wave, too, transmits energy that can be felt or heard, or both. Sheets or panels, studs and joists, hangers and rods, and similar slender and somewhat flexible members are particularly apt to vibrate in a transverse mode and to transmit sound energy along their length, as well as radiating it from their surfaces to the surrounding air.

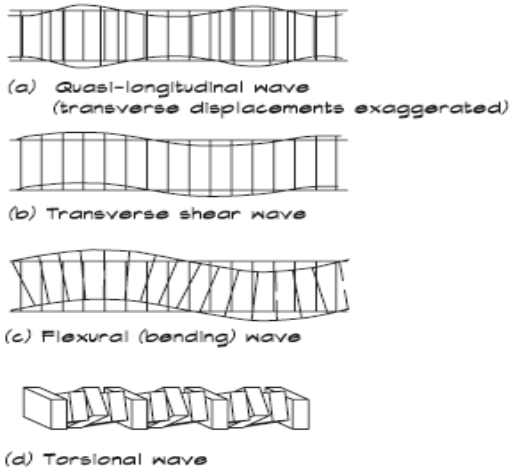


Figure 1: Transverse Displacement Sound Wave.

2.2.1 SOUND WAVE PROPERTIES AND CHARACTERISTICS

Sound waves are often simplified to a description in terms of sinusoidal plan, which are characterized by these generic properties:

- Cycle: A complete single excursion of a vibrating molecule.
- Frequency**:** The number of cycles of vibration in a given unit of time, usually cycles per second (cps) or hertz (Hz).
- Sound Wave: The portion of a sound between two successive compressions or rarefactions.
- Wavelength: The distance between two successive rarefactions or compressions in a sound wave.
- Wave number**:** The spatial frequency of a wave. It can be envisaged as the number of waves that exist over a specified distance (analogous to frequency being the number of wave oscillations that take place in a specified time).
- Amplitude: Maximum displacement, beyond its normal, or rest, position, of a vibrating element. In most audible sounds, these excursions are very small, although low-frequency sound may cause large excursions (as would be observed in the motion of a loudspeaker cone reproducing very low frequency sounds at audible level). Amplitude of motion is related to the increased pressure created in the medium, and to the intensity of the energy involved.
- Velocity: Speed at which a sound impulse travels (not the speed of movement of any particular molecule). In a given medium, under fixed conditions, sound velocity is a constant. Therefore, the relationship between velocity, frequency, and wavelength can be expressed by the equation:

- Dead Sound: Any sound lacking acoustical reverberation and echo

  Velocity =frequency x wavelength……Equation (1)

- Sound Impedance: The acoustical impedance, which is a measure of the resistance to motion at a given point, is one of the most important properties of a material. A substance such as air has low characteristic impedance; a concrete slab has high impedance. Although there are several slightly different definitions of impedance, the specific acoustic impedance, which is the most frequently encountered in architectural acoustics, is defined as the ratio of the sound pressure to the associated particle velocity at a point.

$$z = \frac{p}{u}$$ …… Equation (2)

where z = specific acoustic impedance (N s /m³)

p = sound pressure (Pa)

u = acoustic particle velocity (m /s)

Material	Density (kg/m^3)	Speed of Sound (m/s)
Air @ 0° C	1.293	331
Air @ 20° C	1.21	344
Hydrogen @ 0° C	0.09	1286
Oxygen @ 0° C	1.43	317
Steam @ 100° C	0.6	405
Water @ 15° C	998	1450
Lead	11300	1230
Aluminum	2700	5100
Copper	8900	3560
Iron (Bar)	7700	5130
Steel (Bar)	7700	5050
Glass (Rod)	2500	5200
Oak (Bulk)	720	4000
Pine (Bulk)	450	3500
Fir Timber	550	3800
Concrete (Dense)	2300	3400
Gypsum board (1/2" to 2")	650	6800
Cork	240	500
Granite	—	6000
Vulcanized rubber	1100	54

Table 1. Velocity in Various Materials (Beranek and Ver, 1992; Kinsler and Frey, 1962).

Table 1 shows the velocity of longitudinal waves for various materials. It turns out that the velocities in gasses are relatively close to the velocity of molecular motion due to thermal excitation. This is a reasonable result since the sound pressure changes are transmitted by the movement of molecules (Okeke, 2003).

Because velocity is constant in air, low-frequency sound has long wavelengths, and high-frequency sound has short wavelengths. This is important to remember in acoustical design.

- Sound Intensity: Another important acoustical parameter is the measure of the energy propagating through a given area during a given time. This quantity is the intensity. shown in Fig.2. For a plane wave it is defined as the acoustic power

passing through an area in the direction of the surface normal(Kinsler and Frey, 2010).

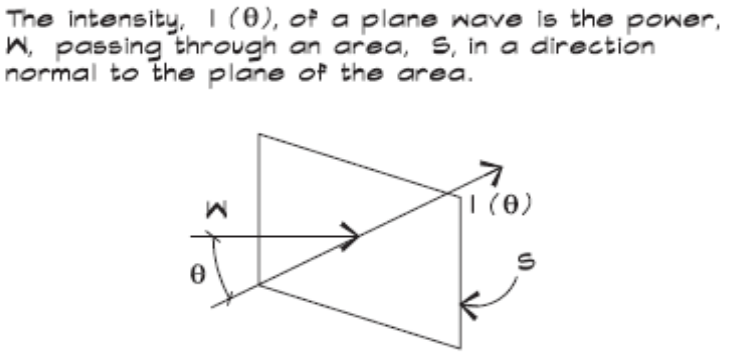


Figure 2: Sound Intensity

Where E = energy contained in the sound wave (N m/ s)

W = sound power (W)

I (θ) = intensity (W /m2) passing through an area in the direction of its normal

S = measurement area (m2)

T = period of the wave (s)

θ = angle between the direction of propagation and the area normal

The maximum intensity, I, is obtained when the direction of propagation coincides with the normal to the planar surface, when the angle θ = 0.

$$I = \frac{W}{S}$$ .....Equation (3)

- Sound power: The sound power is the sound energy being emitted by a source in each cycle. The energy, which is the mechanical work done by a wave, is the force moving through a distance as shown in equation (4).

$$E = p\,S\,dx$$ ……..…….Equation (4)

where p is the root-mean-square acoustic pressure, and S is the area. The power, W, is the rate of energy flow, see equation (5).

$$W = \frac{p\,S\,d\,x}{d\,t} = p\,S\,u$$ ……...Equation (5)

where u is the velocity of a small region of the fluid, and is called the particle velocity. It is not the thermal velocity of individual molecules but rather the velocity of a small volume of fluid caused by the passage of the sound wave.

A weighted sound level is the intensity of sound that can break through a facility in decibels as shown in Table 2.

AT A GIVEN DISTANCE	dBA re 20 μN/m²	ENVIRONMENTAL
	140	
50 HP Siren (100')	130	
Jet Takeoff (200')	120	
Riveting Machine	110	Casting Shake-Out Area
Cut Off Saw	100	Disco Electric Furnace Area
Textile Weaving Plant Subway Train (20')	90	Boiler Room Printing Press Plant
Jack Hammer (50') Heavey Truck (50')	80	Cultural Centre
Freight Train (100') Vacuum Cleaner (10')	70	Near Freeway (Auto Traffic)
Speech (3')	60	Inside Car (50 MPH) Large Store
Large Transformer (200')	50	Light Traffic (100') Quiet Residence Exterior
	40	Min Levels Residential Areas in Chicago at Night Private Business Office
Soft Whisper (5')	30	
	20	Studio (Voice Over)
	10	
Threshold of Hearing	0	

Table 2. Representative A-Weighted Sound Levels *(Peterson and Gross, 1974)*

POWER (Watts)	POWER LEVEL (dB re 10^{-12} Watts)	SOURCE
25 to 40 Million	195	Saturn Rocket
100,000	170	Ram Jet
		Turbo Jet Engine with Afterburner
10,000	160	Turbo Jet Engine, 7000-lb Thrust
1,000	150	4-Propellor Aircraft
100	140	
10	130	75-Piece Orchestra Pipe Organ Small Aircraft Engine } Peak RMS Levels in 1/8 Second Intervals
1	120	Large Chipping Hammer
0	110	Blaring Radio Centrifugal Ventillating Fan (13,000 CFM)
0.1	100	Auto on Highway
0.01	90	Vane Axial Ventillating Fan (1500 CFM)
0.001	80	Voice - Shouting (Average Long-Time RMS)
0.000,01	70	Voice - Conversational Level (Average Long-Time RMS)
0.000,001	60	
0.000,000,1	50	Cultural Centre
0.000,000,01	40	
0.000,000,001	30	Voice - Very Soft Whisper

Table 3. Sound Power Levels of Various Sources *(Peterson and Gross, 1974)*

- Energy Density: In certain instances, the energy density contained within a region of space is of interest. For a plane wave if a certain power passes through an area in a given time, the volume enclosing the energy is the area times the distance the

sound has travelled, or c t. The energy density is the total energy contained within the volume divided by the volume.

$$D = \frac{E}{S\,c\,t} = \frac{W}{S\,c} = \frac{p^2}{\rho\,c^2}$$

……..Equation (6)

- Reverberation: is the persistence of sound in a particular space after the original sound is produced. A reverberation, or reverb, is created when a sound is produced in an enclosed space causing a large number of echoes to build up and then slowly decay as the sound is absorbed by the walls and air. This is most noticeable when the sound source stops but the reflections continue, decreasing in amplitude, until they can no longer be heard. Usually, reverberation is one of the major causes of poor intelligibility of speech within a room; but, within limits, it may actually enhance the sound of music within a space. Reverberation control is a necessary and important aspect of good acoustic design, but it is often greatly overemphasized. Good room proportions and configuration, control of echoes, and absorption of noise usually assure an acceptable reverberation time within a space.
- Reflection: is the change in direction of a sound wave at an interface between two different media so that the sound wave returns into the medium from which it originated. The law of reflection says that for specular reflection the angle at which the wave is incident on the surface equals the angle at which it is reflected. Reflections from strategically located and properly shaped room surfaces may be highly desirable, because such reflections may strongly enhance the source signal. But excessively delayed or highly persistent reflections are usually undesirable.

(For most purposes, and within the normal frequency range of importance to human hearing, it may be assumed that the angle at which sound waves, like light waves, reflect from a surface equals the angle of incidence. Because of the enormously longer wavelength of sound compared with light, however, this assumption is inexact but nevertheless it is acceptable for most acoustic design.)

In most rooms, absorption of most of the acoustical energy impinging on many of the surfaces (the floor, distant walls, etc.) is desirable to prevent buildup or increase of unintelligible or useless sound. For this purpose, sound absorbents may be placed on some or all of the surfaces. The difference in sound pressure level (or noise level) caused within a space by the introduction of absorbents can be calculated, and from such a calculation, it is possible to determine how effective such treatment will be.

2.2.4 SOUND AND VIBRATION CONTROL IN BUILDINGS

Sound and vibration sources are usually speech and sounds of normal human activity - music, mechanical equipment sound and vibration and traffic. Characteristics of these sound sources are well known or easily determined. Therefore, the builder or designer is usually most interested in the transmission paths for sound and vibration (Wilson, 2010). These are gases (usually air); denser fluids (water, steam, oil, etc.); and solids (building materials themselves). During sound transmission in a building, some of the sound energy is absorbed or dissipated, some is reflected from various surfaces, and some is transmitted through the building materials and furnishings (Shaw, 2014).

2.3.4 DAMPING OF VIBRATIONS

This refers to an effect that reduces the amplitude of oscillation in an oscillating body, as a panel or object vibrates, it radiates acoustical energy to the air surrounding it and to solid surfaces touching it or attached to it (Elsevier, 2000). If the energy of vibration could be dissipated, the radiation would be reduced and the sound and vibration levels lowered. One way to do this is to attach firmly to a vibrating panels a fibrous substance(those with high internal friction or poor connections between particles) or viscous-elastic materials (neither elastic nor completely viscous, such as certain asphaltic compounds). These dampen the vibrations by absorbing the energy and converting it to heat.

In the assembly of barriers, damping can be accomplished with proper connections and attachments, use of visco-elastic adhesives, proper attachment of insulating materials, and similar means. Special visco-elastic materials for adhesive attachment or brush or spray application to panels are available (Bagley, 1994).

Isolation against vibration or impact produced by machinery or other vibrating equipment is usually provided by use of special resilient or mounting systems. Springs, elastomeric pads, and other devices are used in such work. Noise and vibration transmitted via plumbing and heating pipes, ducts, and conduits can be objectionable unless proper precautions are taken.

2.2.5 SOUND ABSORPTION

Sound absorption is that property of any material that changes the acoustic energy of sound waves into another form, often heat, which it to some extent retains, as opposed to that sound energy that material reflects or conducts. Acoustic absorption is represented by the symbol A in calculations. Absorption is not a single mechanism of sound attenuation: propagation through a heterogeneous system is affected by scattering as well.

The absorptive of a given material is frequency-dependent and is affected by size, shape, location and the mounting method used. Porous insulative materials such as mineral wool or glass wool are effective sound absorbers compared with good conductors such as metals. Micro perforated plates, however, supply "hard" absorptive surfaces.

The best-known acoustical materials are acoustical absorbents (although actually all materials are acoustical). Generally, these absorbents are lightweight, porous, ‘‘fuzzy’’ types of boards, blankets, and panels.

Acoustical absorbents act as energy transducers, converting the mechanical energy of sound into heat. The conversion mechanism involves either pumping of air contained within the porous structure of the material, or the flexing of thin panels or sheets. Most materials employ the first principle.

The internal construction of most absorbents consists of a random matrix of fibers or particles, with interconnected pores and capillaries. It is necessary that the air contained within the matrix be able to move sufficiently to create friction against the fibers or capillaries. Non connected-cell or closed-cell porous materials are not effective absorbents.

Tuned chambers, with small openings and a restricted neck into the chambers, also are used for sound absorption; but they are somewhat specialized in design and function, and their use requires expert design in most instances.

The surface of absorbents must be sufficiently porous to permit the pressures of impinging sound waves to be transferred to the air within the absorbent. Very thin, flexible facings (plastic or elastomeric sheets) stretched over panels and blankets do not interfere significantly with this pressure transfer, but thick, rigid, heavy coatings (even heavy coatings of paint) may seriously restrict the absorption process. Perforated facings, if sufficiently thin and with sufficient closely spaced openings, do not appreciably degrade the performance of most absorbents.

The visible surface of absorbent panels and tiles may be smooth or textured, fissured or perforated, or decorated or ‘‘etched’’ in many ways. Absorbents are normally produced from vegetable or mineral fibers, porous or granular aggregates, foamed elastomers, and other products, employing either added binders or their own structure to provide the structural integrity required. Because of their lightweight, porous structure, they are relatively fragile and must be installed where they are not subject to abuse; or they may be covered with sturdy perforated or porous facings to protect them.

The absorptivity of a material varies with its thickness, density, porosity, flow resistance, and other characteristics. Further, absorptivity varies significantly with the frequency of the impinging sound. Usually, very thick layers of absorptive material are required for good absorption of low-frequency sound, while relatively thin layers are effective at higher frequencies. Little or no absorption, however, can be obtained with thin

layers or flocked surfaces, textured but nonporous surfaces, or other products often mistakenly thought to be absorptive or claimed to break up the sound. Generally, there is an optimum density and flow resistance for any particular family of materials (particularly fibrous materials). Usually, absorptivity increases with thickness of the material. Performance data for absorbent materials are usually readily available from manufacturers and trade associations.

Sound control is accomplished by means of barriers and enclosures, acoustically absorbent materials, and other materials and systems properly shaped and assembled. Vibration control is accomplished by means of various resilient materials and assemblies, and by damping materials (visco-elastic materials of various types).

2.3 HISTORY OF ACOUSTICS

Acoustics is the science of sound which deals with the production of sound, and also the propagation of sound from the source to the receiver, and the perfection of sound. acoustics has become a broad topic encompassing disciplines like audiology, architecture neuroscience and others too and we have branches of acoustics as musical acoustics electro acoustics architecture acoustics etc. (Thomas 2007).It is theorized that African music and dance evolved a highly complex rhythmic character rather than the melodic line of early European music, in part, to its being performed outdoors. Wallace Clement Sabine (1868–1919), an early pioneer in architectural acoustics, felt that the development of a tonal scale in Europe rather than in Africa could be ascribed to the differences in living environment. In Europe, prehistoric tribes sought shelter in caves and later constructed increasingly large and reverberant temples and churches. Gregorian chant grew out of the acoustical characteristics of the Gothic cathedrals, and subsequently baroque music was written to

accommodate the churches of the time. In the latter half of the twentieth century both theater design and performing arts became technology-driven, particularly with the invention of the electronic systems that made the film and television industries possible. With the development of computer programs capable of creating the look and sound of any environment, a work of art can now not only influence, but also define the space it occupies. The more routine aspects of room acoustics, including noise and vibration control and development of effective acoustical treatment, in the late nineteenth and early twentieth century's, the theoretical beginnings of architectural Acoustics in relation to building forms started by a young physics professor at Harvard College, W. C. Sabine. Sabine's work began inauspiciously enough following a request by President Elliot to "do something" about the acoustical difficulties in the then new Fogg Art Museum auditorium, which had been completed in 1895 (Sabine, 1922). Sabine took a rather broad view of the scope of this mandate and commenced a series of experiments in three Harvard auditoria with the goal of discovering the reasons behind the difficulties in understanding speech. Bythe time he had completed his work, he had developed the first theory of sound absorption of materials, its relationship to sound decay in rooms, and a formula for the decay (reverberation) time in rooms. His key discovery was that the product of the total absorption and the reverberation time was a constant.

Soon after this discovery in 1898 he helped with the planning of the Boston Music Hall, now called Symphony Hall. He followed the earlier European examples, using a shoebox shape and heavy plaster construction with a modest ceiling height to maintain a reverberation time of 1.8 seconds. Narrow side and rear balconies were used to avoid shadow zones and a shallow stage enclosure, with angled walls and ceiling, directed the

orchestra sound out to the audience. The deeply coffered ceiling and wall niches containing classical statuary helped provide excellent diffusion (Hunt, 1964). The auditorium opened in 1900 and is still one of the three or four best concert halls in the world.

While the designers of Boston Symphony Hall followed one European design tradition, the designers of New York's Metropolitan Opera House followed another, that of the Italian opera houses. Opening in 1883 the Met, seating over 3600, is one of the largest opera houses in the world. Despite its size it has reasonably good acoustics in the middle balconies; however, the orchestra seats and the upper balcony seats are less satisfactory (Beranek, 1979).

With a volume nearly twice that of La Scalla, it is difficult for singers to sound as loud as in Milan. The hall, with some ceiling and balcony front additions by treating the acoustical problems.

2.3.1 AIRBORNE SOUND TRANSMISSION

A sound source in a room sets the air into vibration. The vibrating air causes any in turn, sets into vibration the air on the opposite side of the barrier (Fig. 3). The barrier, like any other body, resists motion because of its inherent inertia.

Because it takes more force, and therefore more energy, to move a heavier (more massive) barrier, sound loss through the barrier depends directly on the mass of the barrier. The loss in energy level between the original signal striking the barrier and the level of the energy transmitted to the opposite side is called the sound transmission loss of the barrier.

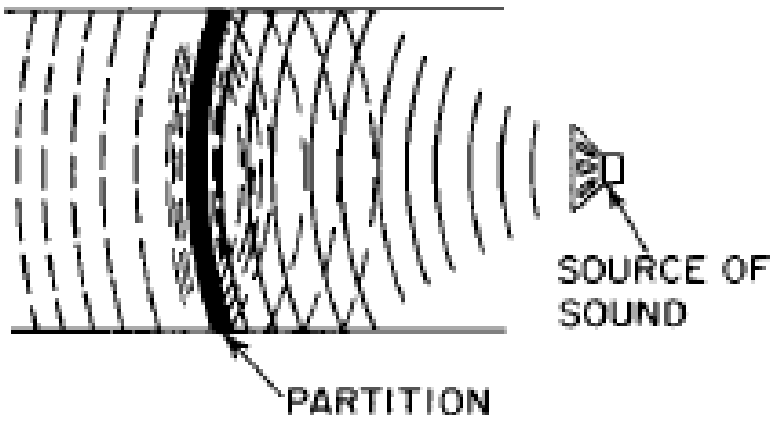


Figure 3: Sound transmission through a barrier.

Figure 3 shows graphically how a truly limp barrier of infinite width and height responds to sound energy of varying frequency (the mass law, straight-line vibration). In practice, however, no barrier is truly limp; a wall, floor, or ceiling always has a finite stiffness. Therefore, at low frequencies, barriers tend to have higher sound transmission losses than the mass law predicts. In some region of the spectrum, however, barriers tend to have lower sound transmission losses (pass sound more readily) than the mass law indicates (see curve for solid panel in Fig. 3).

2.3.2 BYPASSING OF SOUND BARRIERS

A sound barrier is an exterior structure designed to protect sensitive land uses from noise pollution. Noise barriers are the most effective method of mitigating roadway, railway, and industrial noise sources – other than cessation of the source activity or use of source controls. Rarely is a sound barrier the sole transmission path for the acoustic energy reaching it. Some energy invariably travels via the connecting structures (floors, ceilings, etc.), or through openings in or around the barrier. Structural flanking via edge attachments

and junctions of walls, partitions, floors, and ceilings can seriously degrade the performance of a barrier. Figure 12 shows some typical flanking paths and how to avoid such flanking. Even trivial openings through a sound barrier seriously degrade its performance. An opening with an area of only about 1 in2 transmits as much acoustical energy as a 6-in-thick concrete block wall of 100-ft2 area. Figure 13 shows the effect of openings of various sizes on walls of various effectiveness, the better the wall, the more serious the effect of openings or leaks. The more common points of leakage through or around barriers include perimeter of pipes, ducts, or conduits penetrating the barriers; relief grilles for return air; perimeter of doors or glazing; shrinkage or settlement cracks at partition heads or sills; joints between partitions and exterior curtain-wall mullions; joints around or openings through back-to-back electrical outlet boxes, medicine cabinets, etc.; common supply or return ducts with short, unlined runs between rooms; and operable windows opening to a common court. Such openings should be avoided, when possible, and all cracks, joints, and perimeters should be calked and sealed.

In some spaces (an open-plan school, ‘‘landscaped’’ office, etc.), screens, or partial-height barriers are used. Their effectiveness is much less than that of full height partitions or walls.

Construction	STC
¼-in plate glass	26
¾-in plywood	28
½-in gypsum board, both sides of 2 × 4 studs	33
¼-in steel plate	36
6-in concrete block wall	42
8-in reinforced-concrete wall	51
12-in concrete block wall	53
Cavity wall, 6-in concrete block, 2-in air space, 6-in concrete block	56

Table 4: Standard Test Condition (STC) of Various Constructions

Structural isolation therefore becomes an important consideration in the acoustic design of buildings. Highly sensitive areas of buildings, for example recording studios, may be almost entirely isolated from the rest of a structure by constructing the studios as effective boxes supported by springs. Air tightness also becomes an important control technique. A tightly sealed door might have reasonable sound reduction properties, but if it is left open only a few millimeters its effectiveness is reduced to practically nothing. The most important acoustic control method is adding mass into the structure, such as a heavy dividing wall, which will usually reduce airborne sound transmission better than a light one.

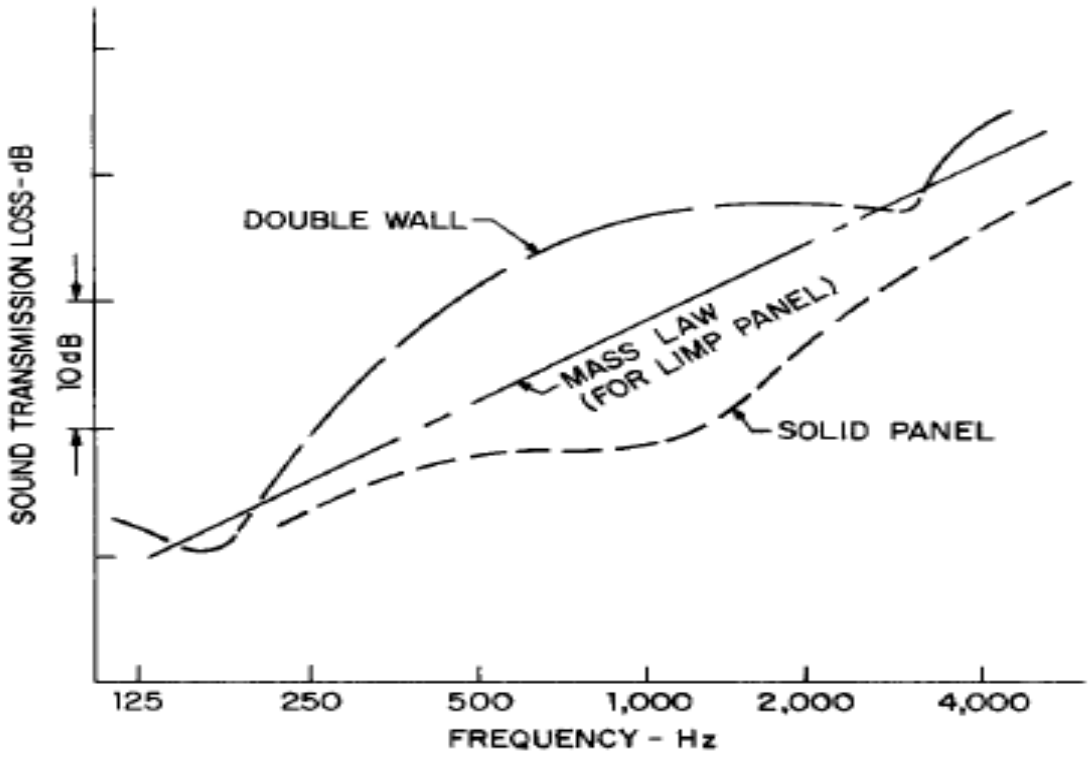


Figure 4: Sound Transmission Loss of Barriers.

There are few practical limp materials e.g. vinyl useful for ordinary building panels. Soft sheet lead is occasionally used for specialized barriers, or is applied to other panel material to increase the mass of the composite without increasing its stiffness. In addition, damping materials such as vinyl can be applied to the panels to damp out their vibrations quickly and to increase the energy loss as the panels vibrate (Malcom, 2000). While single, solid panels have somewhat smaller transmission losses than the mass law predicts, a double wall, a barrier comprising separated withes or leaves, of the same total weight produces greater transmission losses than the mass law predicts. (Rossing, 1990).

If the mass of a single, solid panel is divided into two separate, unconnected layers, the only energy transfer between them occurs via the air between the layers.

Air is not stiff; it can sustain little of the shear wave, and it is not an efficient transmitter of the back-and-forth motion of one layer to the other (except at certain resonant frequencies). As a result, particularly in the mid-frequencies, the sound transmission loss actually exceeds the distance, often considerably. The greater the distance between layers, the better the performance. Theoretically, the sound transmission loss should increase about 6 dB for each doubling of the width of the airspace. In practice, however, the increase in decibels is somewhat less than this.

If a porous, sound-absorbent blanket is inserted in the void between layers, the standing waves in the air layers are minimized. Furthermore, such a blanket has the effect of reducing the stiffness of the air, as well as absorbing some of the energy of the air as it pumps back and forth through the blanket. The result is an additional increase in sound transmission loss.

2.3.3 STRUCTURE-BORNE SOUND TRANSMISSION

Acoustical energy transmission from sound sources to distant parts of the structure via the structure itself is often a major annoyance in building acoustics. One reason is that structural flanking can seriously degrade the performance of sound barriers. Additional transmission paths include pipes, ducts, conduits, and almost any solid, continuous, rigid member in the building. Impact and vibrations can be transmitted through the floor-ceiling assemblies quite readily, if proper precautions are not taken. Normally, in ordinary construction, a good carpet over a good pad will provide sufficient impact isolation against the sounds of footfalls, heel clicks, and dropped objects. Where carpet is not feasible or in critical spaces, special floor-ceiling assemblies can be used.

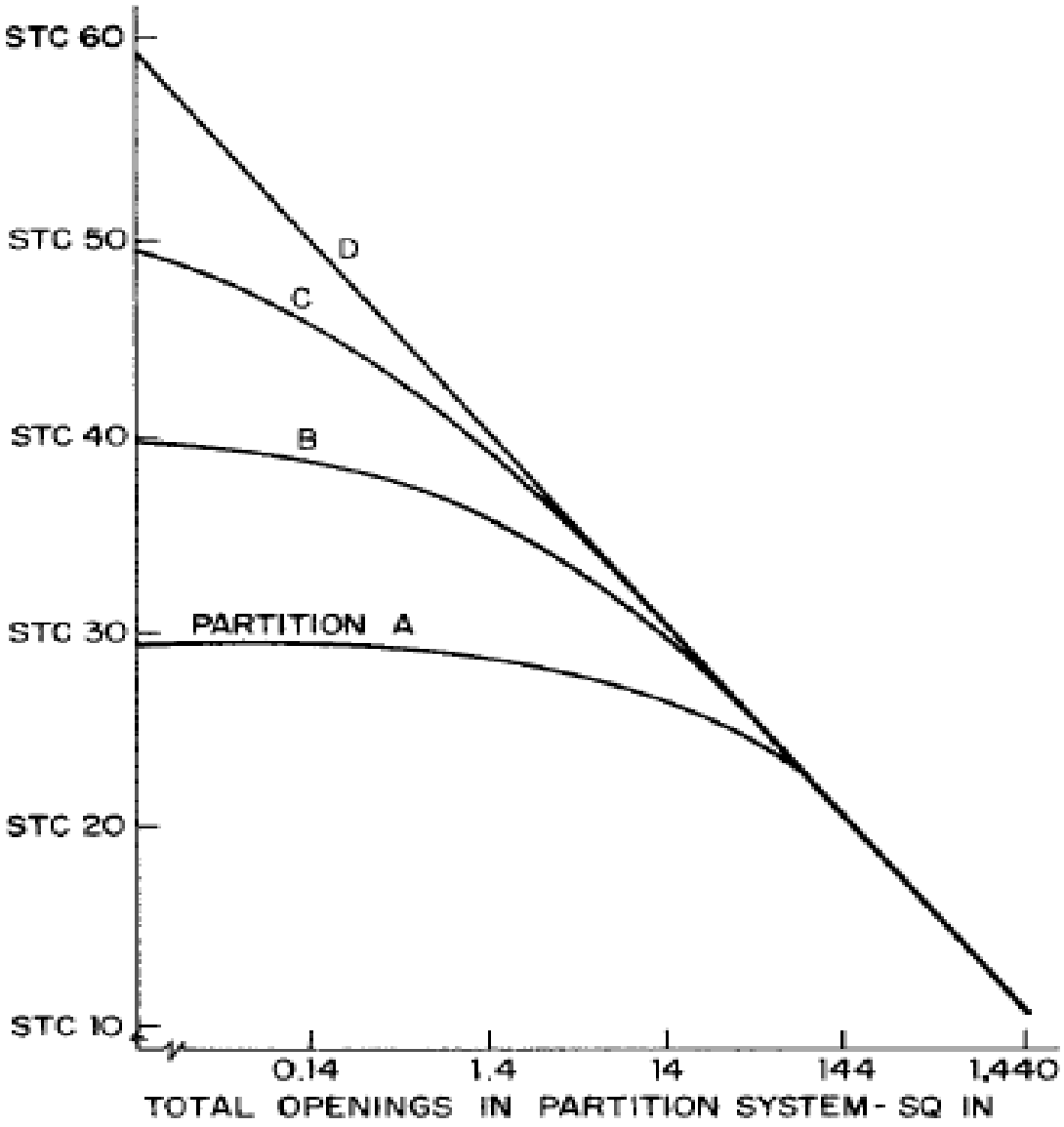


Figure 5: Effects of Leaks on STC of Partitions (For a 100 Ft2 Test Wall).

2.2.3 HUMAN RESPONSE TO CHARACTERISTICS OF SOUND

The ear is made up of three distinct part, hearing is controlled by the inner ear which contains the sensory organs. Slender resistant elastic membrane: it vibrates when sounds

are received from the auditory canal, then transmit the waves to the ossicle (Rinehart, 2006)

2.2.3.1 Pitch

Pitch is the human perception of how high or low a tone sounds, based on its relative position on a scale; it is a physical response to frequency. Musical pitch is defined in terms of notes however; there are psycho acoustical experiments to measure human perception of relative pitch as well. Absolute pitch discrimination is rather rare occurring in only 0.01 percent of the population (Rossing, 1990).

2.2.3.2 Loudness

Loudness is the human perception of the magnitude of a sound; it is the physical response to sound pressure and intensity, influenced by the frequency of the sound. Early efforts to quantify loudness were undertaken in the field of music. The terms "very loud," "loud," "moderately loud," "soft," and "very soft" were given symbols in musical notation—ff, f, mf, p, and pp in music. However, the terms are not sufficiently precise for scientific use and depends on the hearing acuity and custom of the person using them. Measured intensity of a sound is a more reliable method to determine its loudness. Loudness is ultimately dependent on the number of nerve impulses reaching the brain in a given time, but since those impulses come from different regions of the cochlea there is also a variation with the frequency content of the sound (Beranek and Ver, 1992).

	Type of Area	Recommended NC or RC Criteria Range
1	Private Residences	25 to 30
2	Apartments	25 to 30
3	Hotels/motels	
	a Individual rooms or suites	30 to 35
	b Meeting/banquet rooms	25 to 30
	c Halls, corridors, lobbies	35 to 40
	d Service/support areas	40 to 45
4	Offices	
	a Executive	25 to 30
	b Conference room	25 to 30
	c Private	30 to 35
	d Open plan areas	35 to 40
	e Computer equipment rooms	40 to 45
	f Public circulation	40 to 45
5	Hospitals and clinics	
	a Private rooms	25 to 30
	b Wards	30 to 35
	c Operating rooms	35 to 40
	d Corridors	35 to 40
	e Public areas	35 to 40
6	Churches	25 to 30
7	Schools	
	a Lecture and classrooms	25 to 30
	b Open plan classrooms	30 to 35
8	Libraries	35 to 40
9	Concert halls	5 to 15*
10	Legitimate theaters	20 to 30
11	Recording studios	10 to 20*
12	Movie theaters	30 to 35

Table 5. Interior Noise Design Goals *(Interior Noise Design Goals (ASHRAE, 1997).*

2.2.3.3 INTELLIGIBILITY

Speech intelligibility is a direct measure of the fraction of words or sentences understood by a listener; is a measure of how comprehendible speech is, or the degree to which speech can be understood. Intelligibility is affected by spoken clarity, explicitness, lucidity, comprehensibility, perspicuity, and precision. A signal-to-noise ratio is a commonly used concept in acoustics, audio, and electrical engineering, for satiable communication, the average speech level should exceed that of an interfering noise by 6dB;

lower sound-noise ratios are rarely acceptable (Moore, 1997). Manifesting in a wide frequency range, speech is quite resistant to many types of masking frequency cut-off - Moore reports, for example, that a band of frequencies from 1000 Hz to 2000 Hz is sufficient (sentence articulation score of about 90%). It is called a ratio since it represents the energy of the signal divided by the energy of the noise, expressed in decibels.

2.2.3.4 ANNOYANCE

The annoyance due to a sound can be highly personal. Any sound that is audible is potentially annoying to a given individual; is a feeling of displeasure associated with any agent or condition (related to sound) that is believed to affect adversely an individual or a group. A sound is said to be annoying if an exposed individual or a group of individuals would reduce the noise, avoid, or leave the noisy area if possible. And as Miller (1979a) points out, annoyance "is distinct from judgments of loudness and perceived noisiness, It is a response to noise rather than a dimension of auditory experience.

Annoyance due to noise depends on many factors, including several parameters of the noise itself. For example, louder noises are generally more annoying than quieter noises (van Dijk, Verbeek, & de Fries, 1987), though two sounds with equal intensity (i.e. loudness) may still result in different levels of annoyance. Patterned sounds appear to be less annoying than sounds that are randomly produced (Bragdon, 1972). Also, noises that are higher in pitch are generally rated as more annoying than lower-frequency noise. And finally, annoyance depends on the regularity of the noise. That is, noises that remain constant in pitch (Bragdon, 1972) and intensity (Molino, 1979) are generally rated as less annoying than noises that change in pitch or intensity.

2.4 COMPARISON OF THE ACOUSTICAL PERFORMANCE OF CASE STUDIES USING SIMULATION IN ECOTEC THEATER

Acoustic modeling and simulation are beneficial and effective computer-based tools. Room-acoustics programs have typically been used for the prediction and assessment of room acoustic indicators in the early design stage of various spaces. For example, the prediction of echograms and impulse responses by the use of ECOTEC.

ECOTEC-Emissions control optimization technology. Usually the made form in Revit is been uploaded into ECOTEC, although it recommends making the forms without importing, it works fairly well because of the simplicity of the form. Here you can see rays spreading out spherically and randomly from the source, The ECOTEC demonstrates the concave curves of the theatre focusing the sound inwards to back the source .The theatre will generate a picket fence echo which must not make evenly space reflections surface that what ECOTEC works.

2.4.1 ACOUSTICS INDICATORS

The acoustics of theaters are commonly judged by their reverberance evaluated from the sound level decay curves. The first, conventional Reverberation Time (RT) is defined as the time it takes for sound to decay by 60 dB after the sound source has stopped. It is usually determined by extrapolating the slope of a straight line fitted to the first part of reverberant decay curves as a function of frequency between -5 and -25 (RT20), or -35dB (RT30). The second indicator is the Early Decay Time (EDT), which is found to be a subjectively more relevant indicator than RT and is defined as the sound decay slope of a straight line fitted to the decay observed during the first -10 dB. EDT values are more

influenced by the Interior materials and finishes of theaters vary from one country to another. However, theaters walls are commonly finished with painted plaster. Wall wainscots are sometimes covered with marble tiles or wooden boards or panels tongued and grooved to compose a vertical pattern. The floor area is always carpeted. Plastered and painted concrete ceilings with simple to elaborate decorations and /or inscriptions are commonly used. Depending on the climatic conditions, the Theatre may be equipped with an air-conditioning system, in concert with some ceiling fans. Electro-acoustic sound reinforcement systems have also been installed in theaters of all sizes to improve the hearing conditions in the space, particularly when air-conditioning systems are installed.

2.5 REFLECTION OF SOUND ON DIFFERENTBUILDING FORMS.

2.5.1 REFLECTION ON FLAT SURFACES

If a sound is activated in a room, sound travels radially in all directions. As the sound waves encounter obstacles or surfaces, such as walls, their direction of travel is changed, i.e., they are reflected. Reflections from Flat Surfaces plate1.0 illustrate the reflection of waves from a sound source from a rigid, plane wall surface. The spherical wave fronts (solid lines) strike the wall and the reflected wave fronts (broken lines) are returned toward the source. Like the light/mirror analogy, the reflected wave fronts act although they originated from a sound image. This image source is located the same distance behind the wall as the real source is in front of the wall. This is the simple case - a single reflecting surface. In a rectangular room, there are six surfaces and the source has an image in all six sending energy back to the receiver. In addition to this, images of the

images exist, and so on, resulting in a more complex situation. However, in computing the total sound intensity at a given receiving point, the contributions of all these images must be taken into consideration. Sound is reflected from objects that are large compared to the wavelength of the impinging sound. This paper would be a good reflector for 10 kHz sound

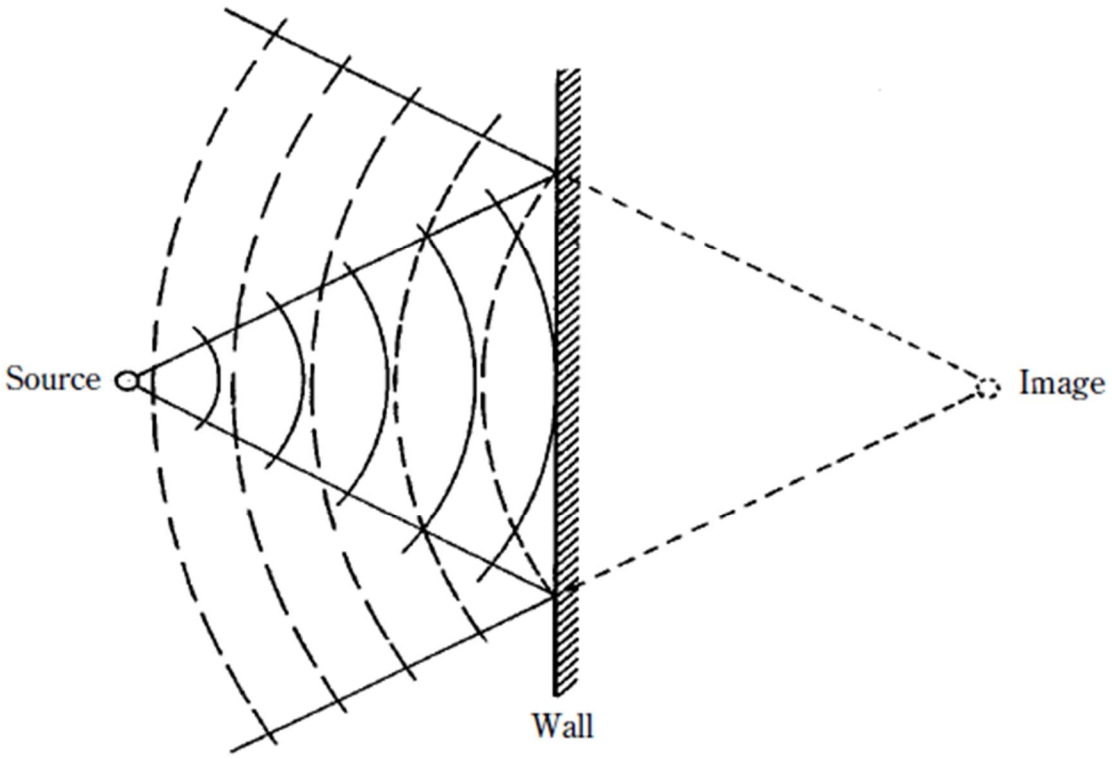


Figure 6: Reflection of sound on flat surfaces.

(wavelength about an inch). At the low end of the audible spectrum, 20 Hz sound (wavelength about 56 ft) would sweep past the book and the person holding it as though they did not exist, and without appreciable shadows. Below 300–400 Hz, sound is best considered as waves.

2.5.2 DOUBLING OF PRESSURE AT REFLECTION

The sound pressure on a surface normal to the incident waves is equal to the energy density of the radiation in front of the surface. If the surface is a perfect absorber, the pressure

equals the energy-density of the incident radiation. If the surface is a perfect reflector, the pressure equals the energy-density of both the incident and the reflected radiation. Thus the pressure at the face of a perfectly reflecting surface is twice that of a perfectly absorbing surface. At this point, this is only an interesting sidelight. In the study of standing waves, however, this pressure doubling takes on greater significance

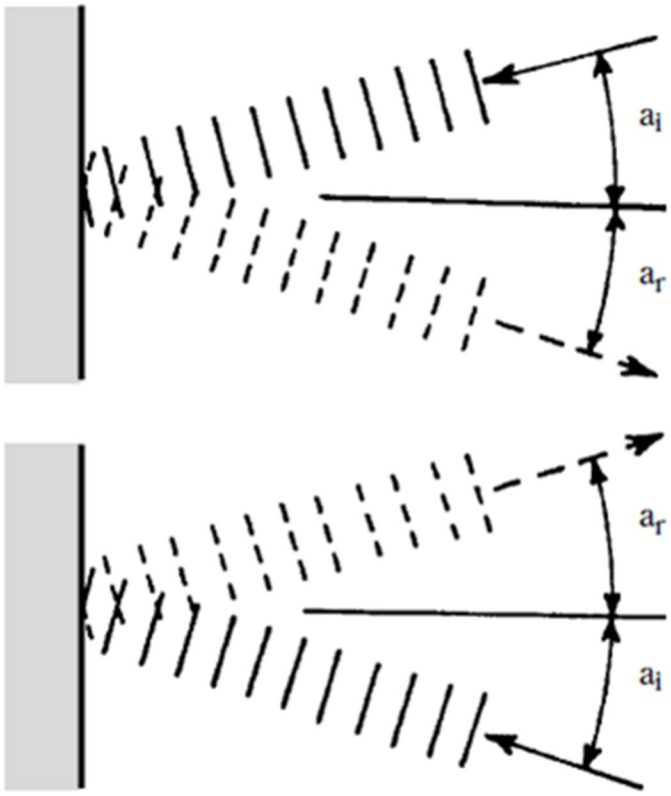


Plate II:Angle of incidence is equal to the angle of reflection.

2.5.3 REFLECTIONS FROM CONVEX FORMS/SURFACES

Spherical wave fronts from a point source tend to become plane waves at greater distance from the source. For this reason impinging sound on the various surfaces to be

considered will be thought of as plane wavefronts. Reflection of plane wavefronts of sound from a solid convex surface tends to scatter the sound energy in many directions as shown. This IS to a diffusion of the impinging sound.

The poly cylindrical sound-absorbing system described in the previous chapter both absorbs sound and contributes to much-needed diffusion in the room by reflection from the cylindrically shaped surface.

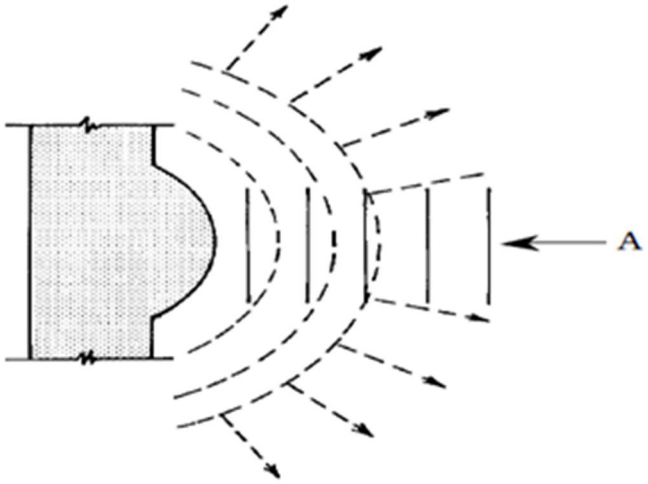


Figure 7: plane sound waves impinging on a convex irregularity tend to be dispersed through a wide angle if the size of the irregularity is large compared to the wave-length of the sound.

2.5.3 REFLECTIONS FROM CONCAVE FORMS/SURFACES

Plane wave fronts of sound striking a concave surface tend to be focused to a point as illustrated. The precision with which sound is focused to a point is determined by the shape of concave surfaces.

The angle of incidence, *a*i, is equal to the angle of concave surface. Spherical concave surfaces are common because they are readily formed. They are often used to make a microphone highly directional by placing It at the focal point. Such microphones are frequently pick up field sounds at sporting events or in recording song birds or other

animal sounds in nature. In the early days of broadcasting sporting events in Hong Kong, a resourceful technician saved the day by using an ordinary Chinese wok, or cooking pan, as a reflector. Aiming the microphone into the reflector at the focal point provided an emergency directional pickup. Concave surfaces in churches or auditoriums can be the source of serious problems as they produce concentrations of sound in direct opposition to the goal of uniform distribution of sound. The effectiveness of reflectors for microphones depends on the size of the reflector with respect to the wavelength of sound. A 600mm diameter spherical reflector will give good directivity at 1 kHz (wavelength about 200mm), but it is practically on-directional at 200 Hz (wavelength about1200mm).

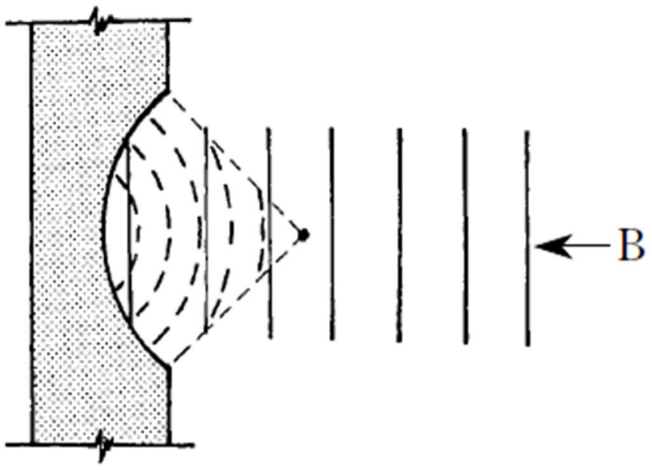


Figure 8: plane waves impinging on a concave irregularity tend to be focused if the size of the irregularity is large compared to the wavelength of the sound.

2.5.4 REFLECTIONS FROM PARABOLIC SURFACES

It is generated by the simple equation y= *x*2. A very “deep” parabolic surface, such as that of plate v exhibits far better directional properties than a shallow one. Again, the directional properties depend on the size of the opening in terms of wavelengths. the

parabola used as a directional sound source with a small, ultrasonic Galton Whistle pointed inward at the focal point. Plane waves striking such a reflector would be brought to a focus at the focal point. Conversely, sound emitted at the focal point of the parabolic reflector generates plane wave fronts. This is demonstrated in the photographs of plate V in which standing waves are produced by reflections from a heavy glass plate. The force exerted by the vibration of the air particles on either side of a node is sufficient to hold slivers of cork in levitation.

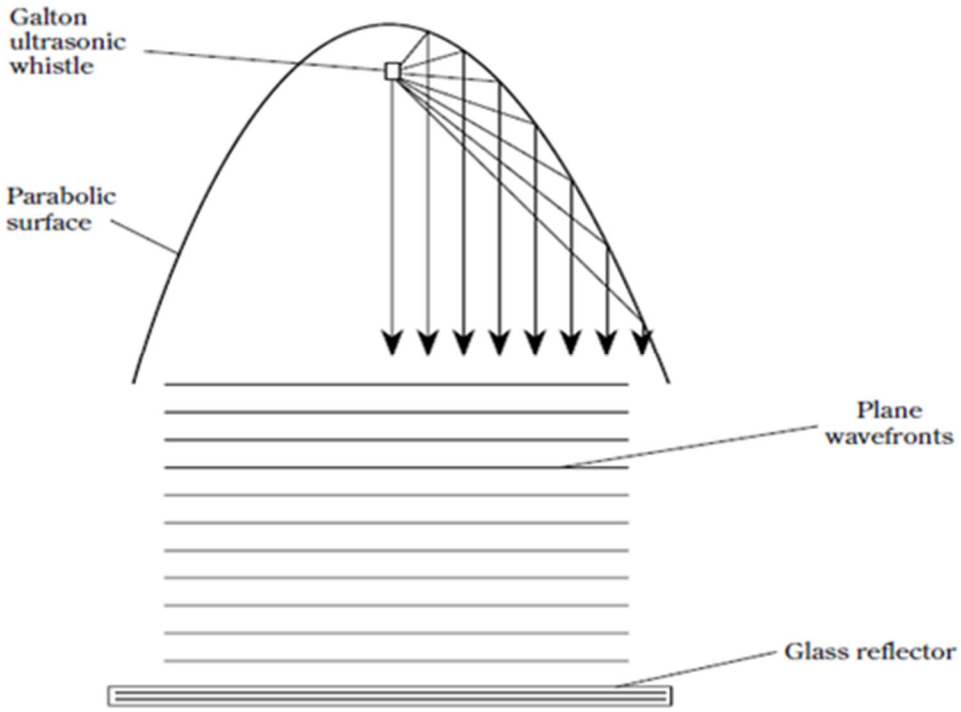


Figure 9: A parabolic surface can focus sound precisely at a focal point.

Reflections inside a CylinderSt. Paul's Cathedral in London boasts a *whispering gallery*. The way this whispering gallery works is explained in figure 10and Reflections from the exterior surfaces of cylindrical shapes have been mentioned in the treatment of "polys." In this case the source and receiver are both inside a mammoth, hard-surfaced cylindrical room. At the source, a whisper directed tangentially to the surface is clearly

heard on the receiver side. The phenomenon is assisted by the fact that the walls are dome-shaped. This means that upward-directed components of the whispered sounds tend to be reflected downward and conserved rather than lost above.

Standing Waves the concept of standing waves is directly dependent on the reflection of sound as emphasized. Assume two flat, solid parallel walls separated a given distance. A sound source between them radiates\sound of a specific frequency. The wave front striking the right wall is reflected back toward the source, striking the left wall where It is again reflected back toward the right wall, and so on. One wave travels to the right, the other toward the left. The two traveling waves interact to form a standing wave. Only the standing wave, the interaction of the two, is stationary. The frequency of the radiated sound is such as to establish this resonant condition between the wavelength of the sound and the distance between the two surfaces. The pertinent point at the moment is that this phenomenon is entirely dependent on the reflection of sound at the two parallel surfaces. Reflection of Sound from Impedance Irregularities. The television repairman is concerned about matching the electrical impedance of the television receiver to that of the transmission line, and matching the transmission line to the impedance of the antenna(or cable). Mismatches of impedance give rise to reflections, which causes numerous undesirable effects.

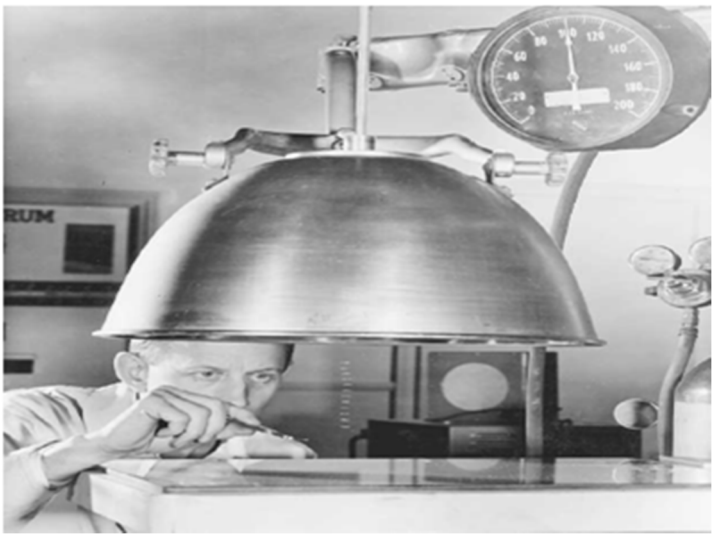


Plate I: A Parabolic reflectorfollowing the equation y=x2 reflects sound from an ultrasonicGalton.



Plate II: close-up of the levited cork chips are spaced about ½ inch, the frequency of the sounds emitted by the Galton Whistle is about 30 kHz.

A similar situation prevails in an air-conditioning duct. A soundwave (noise) traveling in the duct suddenly encounters the large open space of the room. This discontinuity (impedance mismatch) reflects a significant portion of the sound (fan noise, etc.) back toward the source. This is an example of a benevolent miss match as the air-conditioner noise is reduced in the room. The Corner Reflector In an art museum with large

Dutch paintingson display, the eyes of certain subjects seem to follow as one walks by. Corner reflectors are like that. There seems to be no way of escaping their pernicious effect. The corner reflector receiving sound from the source *S*, sends a reflection directly back toward the source. If the angles of incidence and reflection are carefully noted, a source at *B* will also send a direct, double-surface reflection returning to the source. A source at *C*, on the opposite of *B*, is subject to the same effect. You might be instinctively aware of perpendicular (normal) reflections from surrounding walls, but now consider reflections from the four corners of the room that follow the source around the room. Corner reflections suffer losses at two surfaces, tending to make them somewhat less intense than normal reflections at the same distance. The corner reflector of Fig. 10-9 involves only two surfaces. How about the four upper tri-corners of the room formed by ceiling and walls and another four formed by floor and wall surfaces? The same follow-the-source principle applies. In fact, sonar and radar people have long employed targets made of three circular plates of reflecting material assembled so that each is perpendicular to the others.

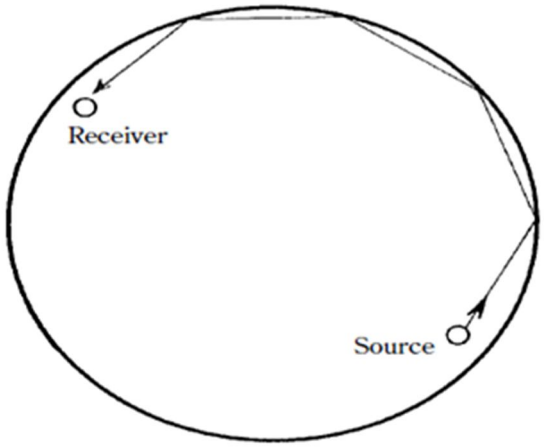


Figure 10: A whisper directed tangentially to the cylindrical surface is readily heard by the receiver on the far side of the moon.

2.5.5 ARCHITECTURE AND CULTURE.

Throughout history, works of architecture can be viewed as products of various culture, Products of Power religious and political power structures. Thus, as part of a social behaviours, (Amos, 1999). buildings tell us not only about aesthetic and design issues; buildings can also tell stories of social relations, as well as human attitude towards the environment for example, the construction of cities and infrastructures by monarchs was accomplished through the exercise of power at the expense of the less powerful.

At various point in history, different culture classes and gender have been in effect, disenfranchised from the making of the built environment. As a result, the architecture of the disenfranchised has been isolated, marginalized and undervalued. However, such marginalized works need to be respected for their individual contributions to the making of individual places, and for the value of their parallel For these purposes, then culture may be said to be about a group of people who have a set of values and beliefs which embody ideals, and are transmitted to members of the group through enculturation. These lead to a world view-the characteristic way of looking at the world and, in the case of design, of shaping the world. The world is shaped by applying rules which lead to systematic and consistent choices whether in creating a life-style, a building style, a landscape, or a settlement(Rapoport,2002).. One can also ask what cultures do, as opposed to what they are. One view implicit in the above is that cultures or their constituents may be seen as properties of populations, i.e. the distinctive means by which such populations maintain their identity and relate to their environment. Another view is of culture as a control mechanism for everything humans do. culture can also be looked as that structure which

gives meaning to particulars(Bruner, 2012). By considering the views of culture discussed here, and asking how they relate to built form, some insights might be gained too.

CHAPTER THREE

METHODOLOGY

3.1 METHOD OF STUDY

The approach of this study is based on a combination of primarily quantitative and qualitative methods. The research methodology includes literature reviews oriented towards optimizing building forms for acoustical control. Application, zoning, spatial organization of facilities, making up a cultural centre and other principles targeted towards enhancing acoustical quality of in cultural centre's. The review covers literature from textbooks, published/unpublished texts, journals, magazines, internet and any available reading materials

A study of the existing planning and design strategy in cultural centres within and outside the country to review the extent to which building forms as acoustical treatment are considered and the methods employed in solving acoustical problems.

The cultural centres are studied and analyzed individually based on their building forms. This study analyzes each cultural centre and how each has applied the use of forms as a means to solving acoustical problems.

Based on the selected cultural centres, an assessment table on building form is used to conduct a comparative analysis of all the cultural centres studied in order to find out the extent to which these elements have been applied to cultural centres designs.

The Criteria for the selection of case studies include the following stated points.

i. The case study were selected based on the building forms of the theatres to minimizing or solving acoustical problems on cultural centre's.

ii. They are selected based on their architecture, prominence and time of construction.

iii. They are selected based on their location and historical background like local, international, capital cities and so on.

iv. They are with respect to the source of sponsorship (private or public)

The case study research method is basically qualitative and a reflection of its extent will be seen from the examination and responses obtained. The following will be used

A. **Independent variables**: This research discusses building forms in relation to acoustical performance, These are the variables examined:

i. Building forms used.

ii. Plan shape and geometry of the Auditorium.

iii. Size.

iv. Scope of facilities and materials.

B. **Dependent variables**: Acoustic performance architectural and cultural features

3.2CASE STUDIES ON CULTURAL CENTRES IN RELATION TO ACOUSTICS

The adopted case studies to be carried out on this research will be based on purposive sampling of selected cultural centres located around the middle belt either having a close relationship to the types of acoustical treatment given them.

Dependent Variables	Independent Variables
Architectural Features	Facilities + Spatial Planning 1. Spatial planning 2. Building construction + Structure

Cultural Features	Cultural Features 1.Motifs, 2.sculpturesetc. broken into building components
Acoustical Performance	Acoustic Performer 1. Building form 2. Acoustic controls e.g.barriers, isolation and absorbers

Table 6: Variables assessed

Case Studied :

i. U.K. Bello Arts Theater Minna Niger State. Because of it rich cultural qualities and the standards used in its construction methods it will be a perfect reflection of the proposed one in Benue state.

ii. Cyprian Ekwensi Arts and culture was selected due to its sponsorship and Location, its position in the south west part of the country has a good touch to the rich art and culture of that area.

iii. University of Jos Multi-Purpose Theater; This was selected due to its location and the type of building form used in order to show how such building form affects the control of sound.

3.3DATA COLLECTION INSTRUMENTS

The collection of data is done through various ways which includes visual surveys, field forms, indepth interviews.

3.3.1 VISUAL SURVEY

A visual survey is conducted by watching and identifying what has been achieved by the already existing cultural centres with reference to elements of acoustical treatment on such cultural centres, characteristics of place and architectural features. This was enhanced by the use of photographs.

3.3.2 FIELD FORMS

Field forms with variables of acoustics and cultural characteristics of place. Acoustic variables include reverberation, echo and dead sound. While cultural characteristics of place includes motifs, sculptures.

3.3.3 IN-DEPTH INTERVIEW WITH USER / OPERATORS

The selected cultural centre designer/architects, operators / managers will be interviewed to get more information on each of the existing design.

3.4 DATA ANALYSIS

The data on selected cultural centers are analyzed to show the extent to which each cultural centre applies the elements of acoustical treatment (building form) on its cultural centres characteristics of place, using descriptive analytical methods.

By getting valid source information about the relevant selection of key variables, simulation is used to simplify approximations and assumptions in optimizing building forms for acoustical controls in cultural.

3.4.1 SIMULATION

This is an attempt to model a real life or hypothetical situation on a computer so that it can be studied to see how the system works. by changing variables in the simulation.

Acoustic modeling and simulation are beneficial and effective computer-based tools. Room-acoustics programs have typically been used for the prediction and assessment of room acoustic indicators in the early design stage of various spaces. For example, the prediction of echograms and impulse responses by the use of ECOTEC.

ECOTEC-Emissions control optimization technology. Usually the made form in Revit is been uploaded into ECOTEC, although it recommends making the forms without importing, it works fairly well because of the simplicity of the form. Here you can see rays spreading out spherically and randomly from the source, The ECOTEC demonstrates the concave curves of the theatre focusing the sound inwards to back the source .The theatre will generate a picket fence echo which must not make evenly space reflections surface that what ECOTEC works.

The indicators used are as follows;

1. Reveberation Time (RT)
2. Early Decay Time (EDT)
3. Echo.

3.5 DATA PRESENTATION

Data collected on each case study is analyzed and represented in different forms which include: photographs, tables, figures.

3.5.1 PHOTOGRAPHS OF EXISTING CULTURAL CENTRES

Pictures of the existing cultural centres studied are taken, and documented showing the cultural centre building forms, its facilities and how acoustical elements are applied, and to what extent.

3.5.2 TABLES

Data collected on this research will be documented and tabulated on cultural characteristics case study assessment tables. Refer to tables under case studies (chapter four).

3.5.3 FIGURES

Data collected on the case studies are also be documented in form of drawings, such as the site plans.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

Three case studies are selected based on the outlined criteria in the methodology in Chapter Three. The aim of gathering sufficient data for analysis is in order to extract, with the aid of the listed variables in the methodology, the concept behind their forms in relation to acoustic, design trends of cultural centers, challenges and ways of improving and avoiding these challenges

4.2 UK BELLO ARTS THEATER MINNA, NIGER STATE

The Theater which is owned by the Niger State government was commissioned in 1991 as an arts centre in the state capital by General Ibrahim Badamasi Babangida. The complex consists of an administrative unit, a theater, gallery and a recreational centre. The materials used for the construction are as follows; concrete, sandcretes blocks are the major materials used for the construction of the super structure. Aluminum roofing over steel were used for the roofing of the building. No locally sourced materials within site were employed. It was finished using cement and painted with emulsion paint. The complex consists of the following facilities

1. A Theatre
2. Shopping complex and
3. Offices.

The materials used for the construction are as follows

1. Roof: Long span aluminium roof
2. Wall: sandcretes hollow blocks
3. Floor: Terrazzo floor finish for both exterior and interior floor



Plate III: U.K. Bello Arts Theatre,Minna Niger State

The building form for its theater is oval in shape, it plan as shown in fig 12 was designed in that form so that acoustical treatment can be considered, and in so doing the effect of acoustics as a problem was been minimized drastically by the nature of the building forms used which is oval in shape thereby making the vibrations and echo minimal. Below is the floor plan of the U.K.Bello Theater.

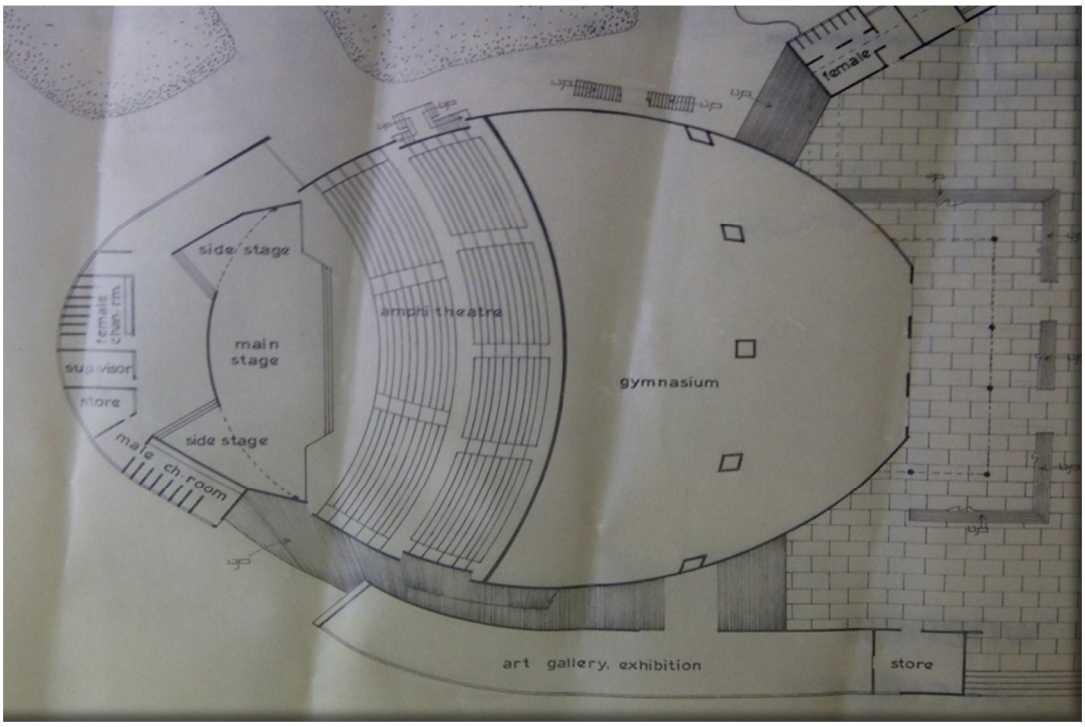


Figure 11: U.K Bello Plan Theatre showing its entrance, gymnasium, Theater stage and the back stage**.**

The floor plan for the facility shows the spatial planning of the facilities including the gymnasium, auditorium, backstage, stage, conveniences and offices.

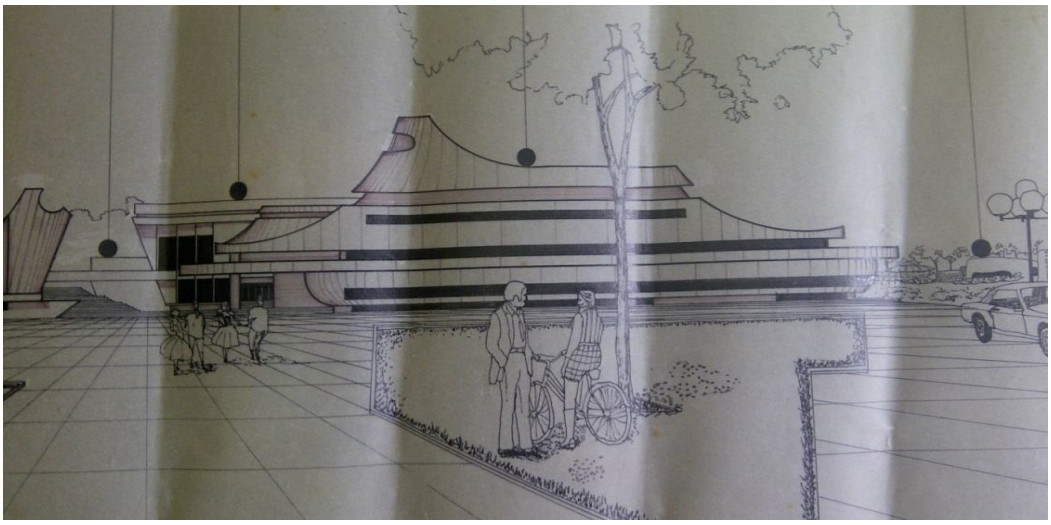


Figure 12: The general approach for the U.K. Bello arts and culture Minna Niger state.

The front elevation of the U.K. Bello Arts and Culture Minna showing all its facilities that creates the union to making it function as an entity as shown in Fig 13. The facility is presently in a good state, making it habitable and fit to carry out its primary functions. which are basically state lectures taken by expatriate of various works of life brought in by the state Government in advancement of her people and parties by the students of Federal University of Technology which is not less than one kilometer from the facility. lectures for General studies(GST) and other pre-planned lectures by lecturers, even Jos at large uses the Theater for governmental activities and also social gatherings for her people and the students too and cultural displays.

4.2.1 BUILDING/STRUCTURAL FORM

Basically, the integrity of the structure is a column /beam connection system. The sitting area is racked and the racked slab rests on columns/beam spaced at equal distances around the racked area to form its support system. And also Beam and column system was

employed on the construction of the walls of the building. The roof rests on the intermediate columns. And the following components were studied

- Spatial Planning.
- Building Construction and the
- Structure



Plate IV: U.K. Bello Gymnasium area leading to the Theater

Entrance leading to the facility with several columns showing how it entrance takes the oval-shape to aiding it acoustical treatment for good sound see plate xii.

4.2.2 PRESENT STATE

The facility is presently in a good state, making it habitable and fit to carry out its primary functions. Though it's under construction, the application of building form to solving acoustical problem was considered,

Its internal building form which is the main theatre enhances the acoustical performance by reducing reverberation of sound in the theater and also provider its users with dead sound.



Plate V: U.K. Bello Theatre, Minna.



Plate VI: Oval shaped U.K. Bello Theater.



Plate VII: Interior of the UK Bello Arts Theater.

Sound control is accomplished by means of barriers and enclosures, acoustically absorbent materials, and other materials and systems were averagely shaped and assembled.

Vibration control is accomplished by means of various resilient materials and assemblies, and by damping materials (visco-elastic materials of various types).

Airborne and structure-borne energy are controlled by somewhat different techniques by the use of gypsum ceiling and particle boards to absorb scattered sound as shown in plate xii and xiii.



Plate VIII: Gypsum and particle ceiling at displace

4.2.3 CONCLUSIONS

To conclude, the art centre has provided for facilities which makes it use very efficient as an art centre. It's layout is adequate and has the proper arrangement of it's functional spaces for instance; it has adequate space for outdoor activities

4.3 CASE STUDY TWO: CYPRIAN EKWENSI CENTRE FOR ARTS AND CULTURE

This theatre for art and culture is owned by the Federal Government but is been named after Cyprian Ekwensi the head of features at the Nigerian broadcasting cooperation (N. B. C) and also a writer, which is located in the federal capital territory of Nigeria commissioned in 1991 by Gen.Ibrahim Badamassi Babangida who was the then head of state.The following facilities comprise the cultural centre; an administrative unit, theater, gallery, recreational area, museum, ceramic and studio, community hall and a graphic and painting studio.

This case study is been analysed using the following parameters in the table below

Dependent Variables	Independent Variables
Architectural Features	Facilities + Spatial Planning 1. Spatial planning 2. Building construction + Structure
Cultural Features	Cultural Features 1. Motifs, sculptures etc. broken into building components
Acoustical Performance	Acoustic Performance 1. building form 2. acoustic controls e.g. barriers, isolation and absorbers

Table 7: Variables assessed

4.3.1 FLOOR PLAN

The Cyprian Ekwensi centre for art and culture plan is rectangular in shape which do not favor acoustical treatment to it usage or application. And only consist the following functions, auditorium, stage and it back-stage and conveniences.

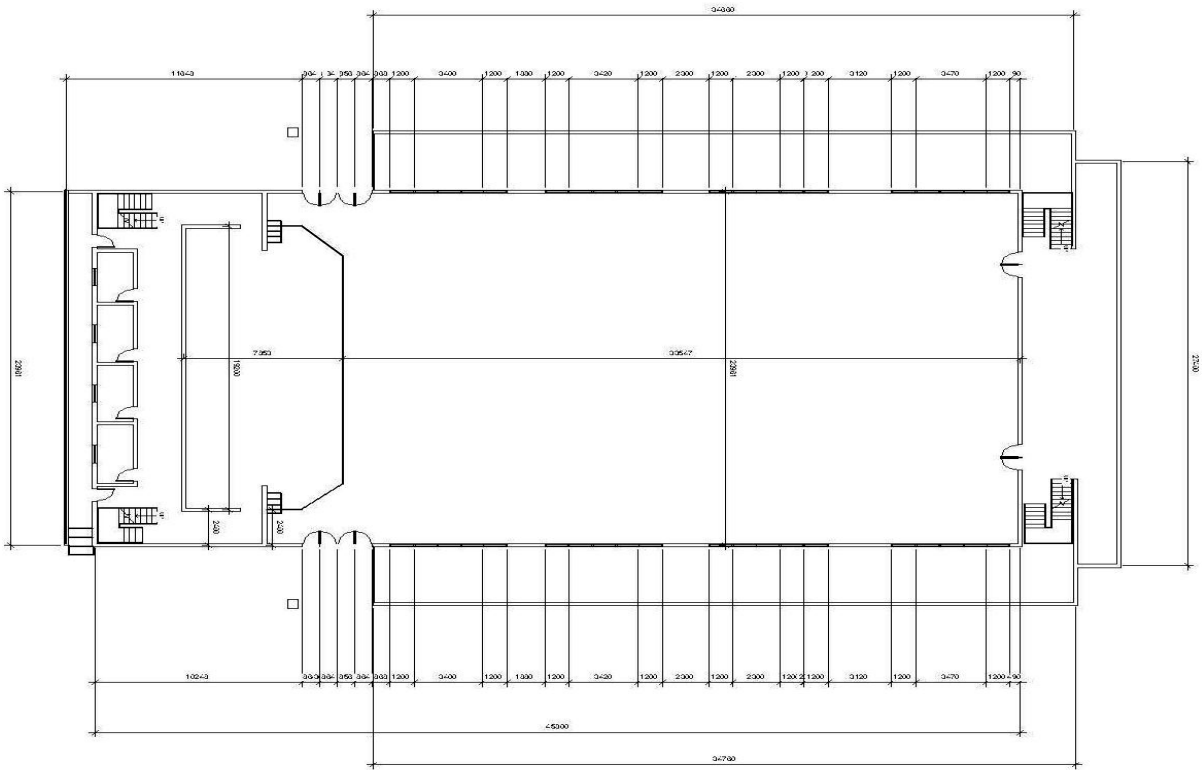


Figure 13: Rectangular Theater for Cyprian Ekwensi Art and culture centre Abuja.

4.3.2 BUILDING CONSTRUCTION MATERIALS

Concrete, sand screed blocks are the major materials used for the construction of the super structure. Aluminum roofing over steel were used for the roofing of the building. No locally sourced materials within site were employed. It was finished using cement and painted with emulsion paint, which does not enhance the treatment of acoustic. The floor was tiled all through which does not also aid accurate sound it does not help in absorbing sound so as to focus sound to her users or listeners therein. Seats used are averagely used as absorbent in the control of sound but not to a large extend



Plate IX: Entrance to the Facility.

The use of cement and concrete was employed in the process of construction



Plate X: Exhibition hall for their cultural

This picture shows the entrance to the theatre where functions like wedding receptions, drama cultural arts are been carried out, and on its walls we have cultural displays of arts works and painting.



Plate XI: The building form of Cyprian Ekwensi Theatre centre for arts and culture

The Cyprian Ekwensi arts and culture theater is rectangular in form, which is not a solution to the treatment of acoustics in it during performance of whatsoever form that requires sound.

4.3.3 BUILDING/STRUCTURAL FORM

The beam and column system was employed on the construction of the walls of the building. The roof rests on the intermediate columns



Plate XII: Back Stage for rehearsals.

4.3.4.1 Variables

ARCHITECTURAL FORM**:** The walls in the front façade have motives which were taken from the culture of various regions within Nigeria; even on the columns mosaic designs were used.



Plate XIII: East view of Cyprian Art and Culture.

BUILDING MATERIALS**:** Reinforced concrete, and mosaic designs depicting cultural plays.

Construction Technology**:** use of sustainable design elements like wood for the struts and framework as well as glass for the interior skin and concrete depicts an art center are not completely present.

ACOUSTICs: Used as the major variable to checkmating whether all others were provided or used properly to seeing to a design that is effective and serves it purpose as a Theatre.

4.3.4 BUILDING FORMS IN RELATION TO ACOUSTICS

The building form employed in the design of the Cyprian Ekwensi theater do not favour the acoustical properties of its users, that sound is not been heard in its dead form, instead it's

been heard after so many reflections before it gets to its users, herby needs correction in my proposed theater for the Idoma people in Otukpo.

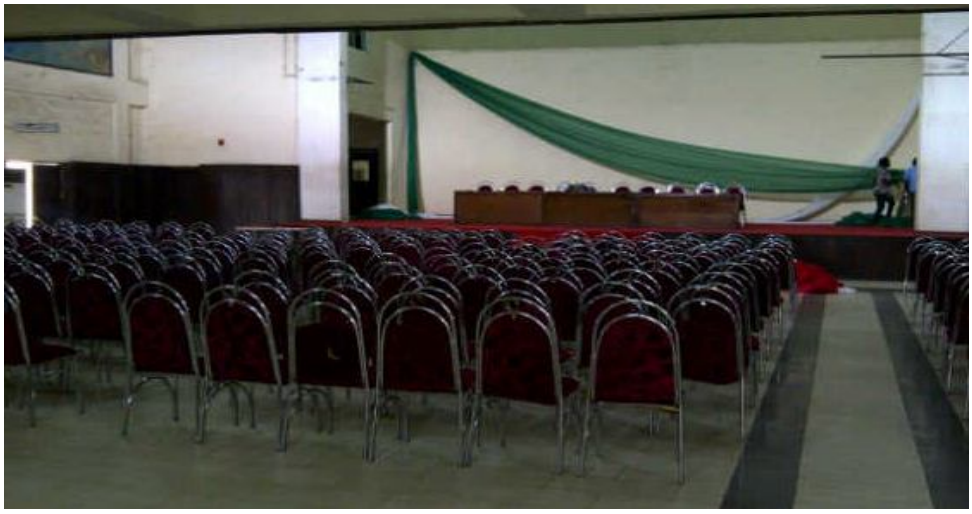


Plate XIV: Interior for Cyprian Ekwensi Theatre.

The rectangular building form of the arts and culture centre, which causes reverberation during musical performance



Plate XV: Theatre's Gallery and also for Exhibitions

The gallery of its theater and the use of materials do not favors acoustics, due to the nature of its building form and the use of hard wall surfaces and ceiling materials



Plate XVI: Materials used in the Theatre.

Material used as acoustical treatment on the wall, but not covered all around the wall. At the Cyprian Ekwensi Art and Culture, Sound and vibration sources are usually speech and sounds of normal human activity—music, mechanical equipment sound and vibration, traffic, and the like. Characteristics of these sound sources are well known or easily determined by the building form of the Theater. Therefore, the builder or designer was not interested in the transmission paths for sound and vibration. These are gases (usually air); denser fluids (water, steam, oil, etc.); and solids (building materials themselves)were not considered, .instead, a space to just carry people for functions which, During sound transmission in the theater, building, some of the sound energy dissipated, virtually all is been reflected from various surfaces, and is not been transmitted through the building materials and furnishings.

4.3.5 CONCLUSIONS

To conclude, the facility falls shorts of the kind of cultural centre that's been proposed for Otukpo, Benue state due to the building form used for it theater

4.4 CASE STUDY THREE: UNIVERSITY OF JOS MULTI-PURPOSE THEATER

4.4.1 INTRODUCTION

The University of Jos, Bauchi road campus is located at Jos North. Jos North has the total land mass of 112 square meters and said to have the population of about 429,300 people.

University of Jos was first established in November 1971 as a satellite campus of the University of Ibadan. The first students were admitted in January 1972 as pre-degree students with the first Bachelor of Arts degree program begun in October 1973.In October 1975 then military government under Gen. Murtala Mohammed established the Uni-Jos as a separate institution. The first Vice-chancellor of the University of Jos was professor Gilbert Onuaguluchi .classes began at the newly reorganized University of Jos in October 1976 with 575 students spread over the existing four faculties of Arts and Social sciences, Education, Natural sciences and Medical sciences. Post-graduate programme was added in 1977.by 1978 faculties of Law and Environmental sciences were established and the faculty of Arts and social sciences were separated.



Plate XVII: The Front elevation of the Uni-Jos Multi-purpose Theater and adjoining Departments.

4.4.2 UNIVERSITY OF JOS MULTI-PURPOSE THEATER LOCATION

The multi-purpose Theater is located in Bauchi road campus Jos central. it is very close to the main entrance of the campus and could be agreed to be in close proximity to most of the faculties in the university and also serves the peaceful people of Jos, plateau state. It has the total area of 1485.99metersquare. Theater is facing the East side while zoology and botany department is at the south side, zoology and botany lab is located behind the multi-purpose hall which is the West side. While A1 hall is at the North side. The multi-purpose hall can accommodate up to 1500 seaters



Plate XVIII: Entrance into University of Jos and its side view.

4.4.3 FLOOR PLAN

The university of Jos Multi-purpose Theater floor plan is rectangular in shape which do not favor acoustical treatment to it usage or application. And only consist the following functional spaces auditorium, back-stage, stage, exhibition room offices and conveniences.

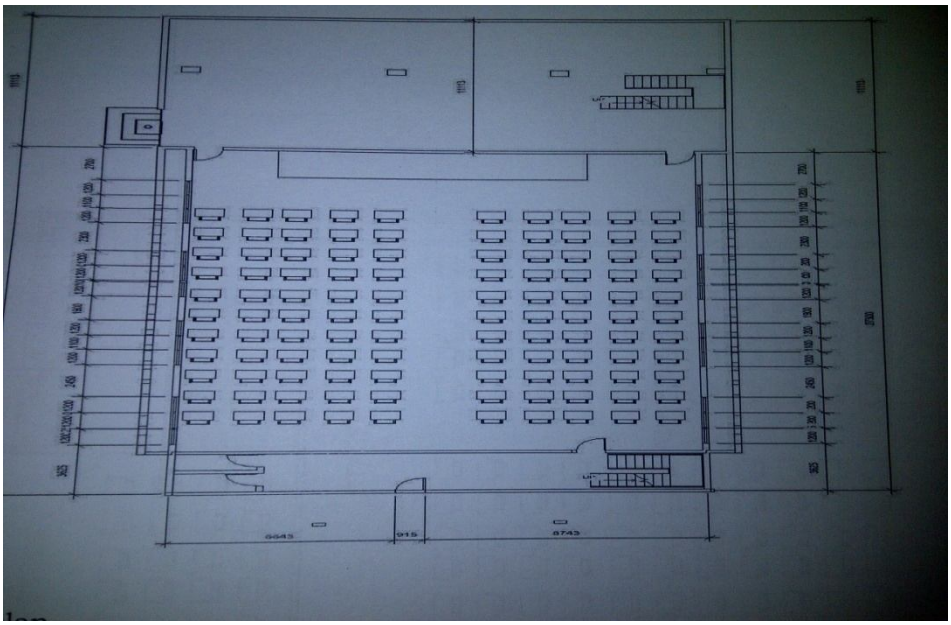


Plate XIX: Rectangular floor plan for Uni-Jos multi-purpose Theater.

4.4.4 PRESENT STATE

The facility is presently in a good state, making it habitable and fit to carry out its primary functions, which are basically lectures taken by students of various department which is been referred to as General studies(GST) and other pre-planned lectures by lectures, even Jos at large uses the Theater for governmental activities and also social gatherings for her people and the students too and cultural displays, seminars and a host of other activities that requires the gathering of a large no of people. Though its present state

does not favor Acoustics because the application of building form to solving acoustical problem was considered, its building form does not go in pattern to subduing acoustical problems averagely or reverberation of sound.

4.4.5 BUILDING FORM OF UNI-JOS MULTI-PURPOSE THEATER

Though its present state does not favor Acoustics because the application of building form to solving acoustical problem was considered, its building form does not go in pattern to subduing acoustical problems averagely or reverberation of sound.



Plate XX: Hard surfaced materials in the Theater in Uni-Jos.

Building Materials**:** Reinforced concrete, hollow sandscreed blocks, concrete as roof, Aluminum roofing sheet as parapet covering hollow blocks as fenestration and it was painted using Emulsion both externally and internally seats were made of Obeche timber. In summary, the materials used do not aid acoustics in any form e.g. by the kind of building form used or by the use of building materials.



Plate XXI: Rectangular shape Theater with students in it.

4.4.6 ACOUSTICS IN RELATION TO ITS FORM

The builder or designer was not interested in the transmission paths for sound and vibration. These are gases (usually air); denser fluids (water, steam, oil, etc.); and solids (building materials themselves) were not considered, instead, a space to just carry people for functions which, During sound transmission in the theater, building, some of the sound energy dissipated, virtually all is been reflected from various surfaces, and is not been transmitted through the building materials and furnishings.

4.4.7 CONCLUSIONS

To conclude, the University of Jos Multi-purpose Theater does not provided for adequate facilities which will make it efficient as a Theater for both its students and the people of Jos, Plateau State which will definitely serve as an imperfect guide to the

proposed one in Otukpo for the Idomas. Therefore the loopholes have been taken note of, for effective implementation of what is supposed to be on the proposed one in Otukpo, Benue State.

The following Theatres were simulated

1. Cyprian Ekwensi Art and Culture Theatre Abuja.
2. University of Jos Multi-Purpose Theatre Jos
3. UK Bello Art and Culture,Minna.

4.6 SIMULATIONS FOR THE VARIOUS THEATRES VISITED

4.6.1 CYPRIAN EKWENSI THEATRE.

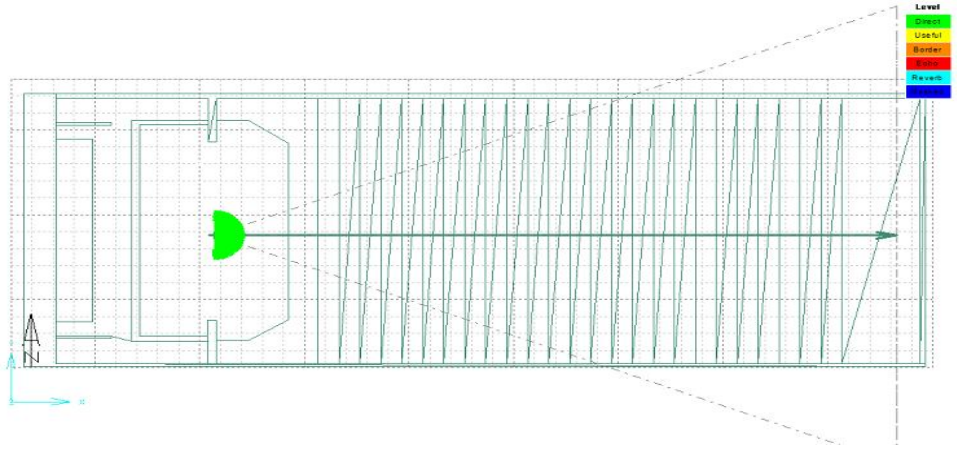


Figure 14: Floor plan for Cyprian Ekwensi showing sound source.

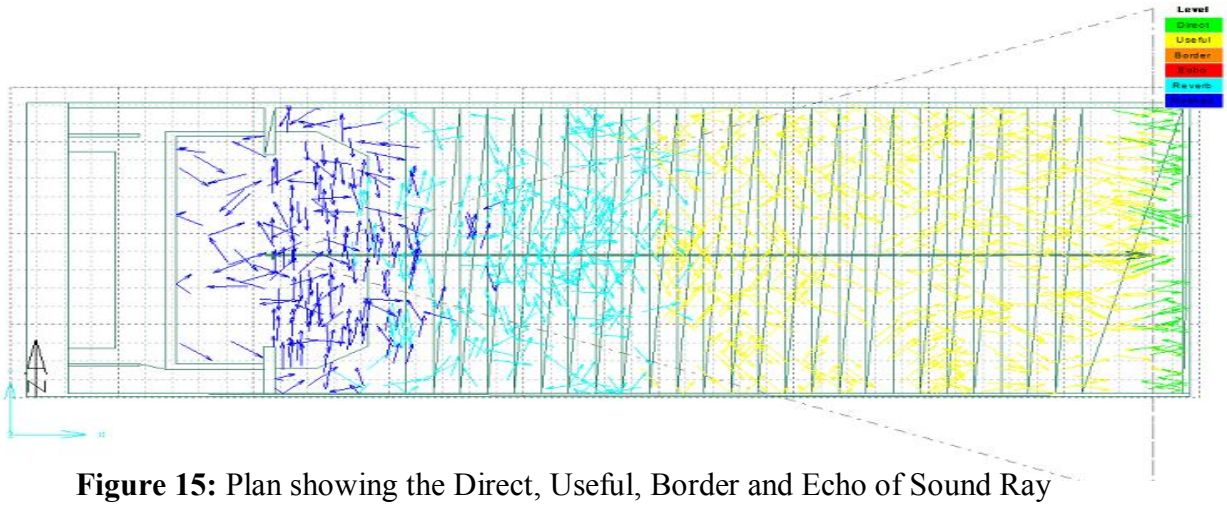


Figure 15: Plan showing the Direct, Useful, Border and Echo of Sound Ray

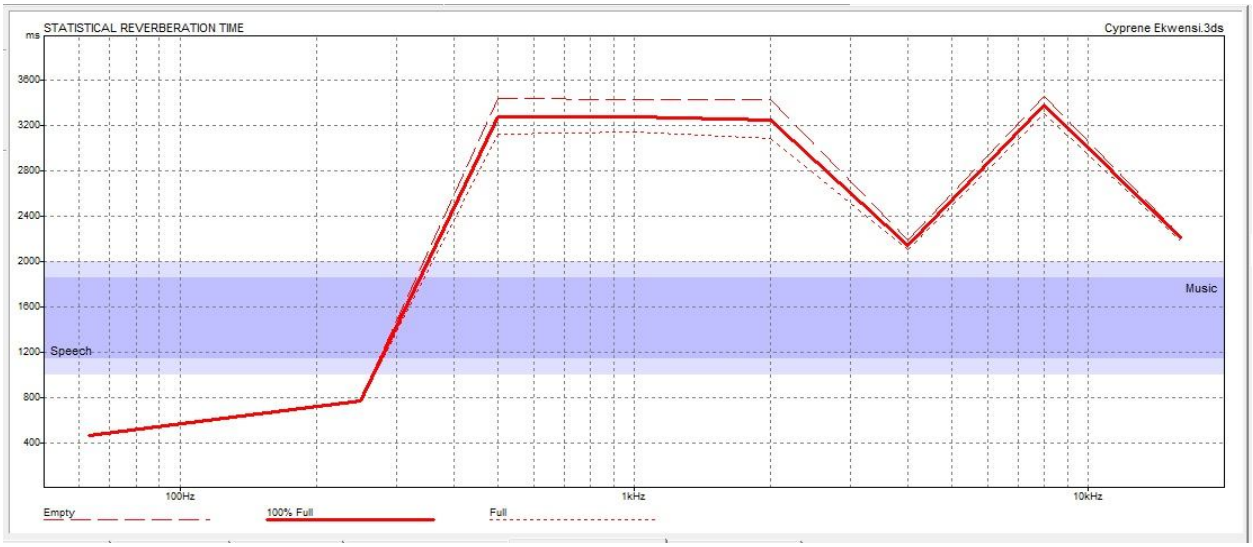


Figure 16: Graph showing the statistical Reverberation Time for the Theatre, when it's empty, 100% and full.

4.6.2 UNIVERSITY OF JOS MULTI-PURPOSE THEATRE

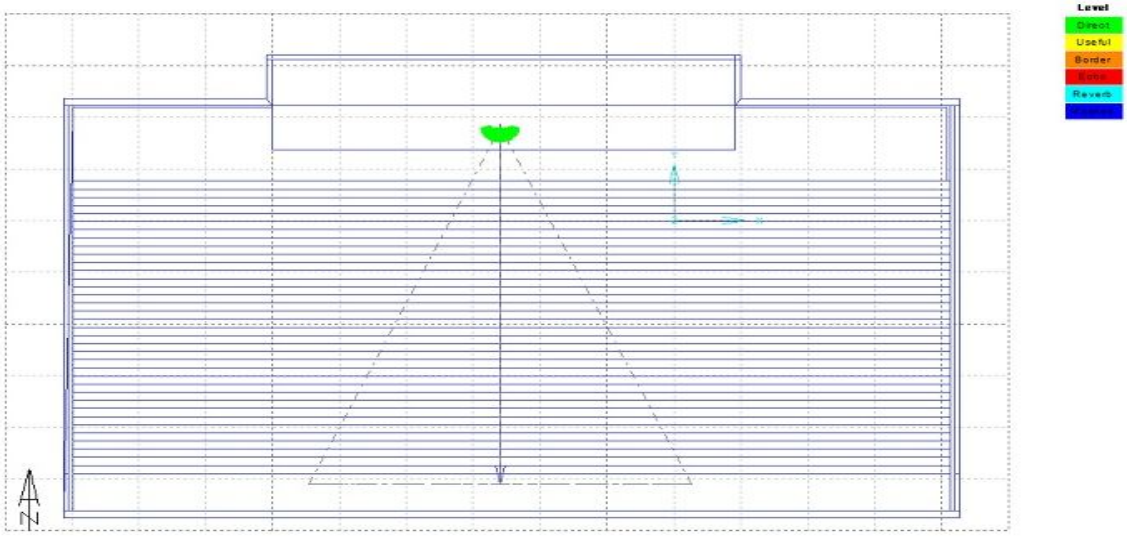


Figure 17: UJ Theatre showing a direct ray from it's sound source.

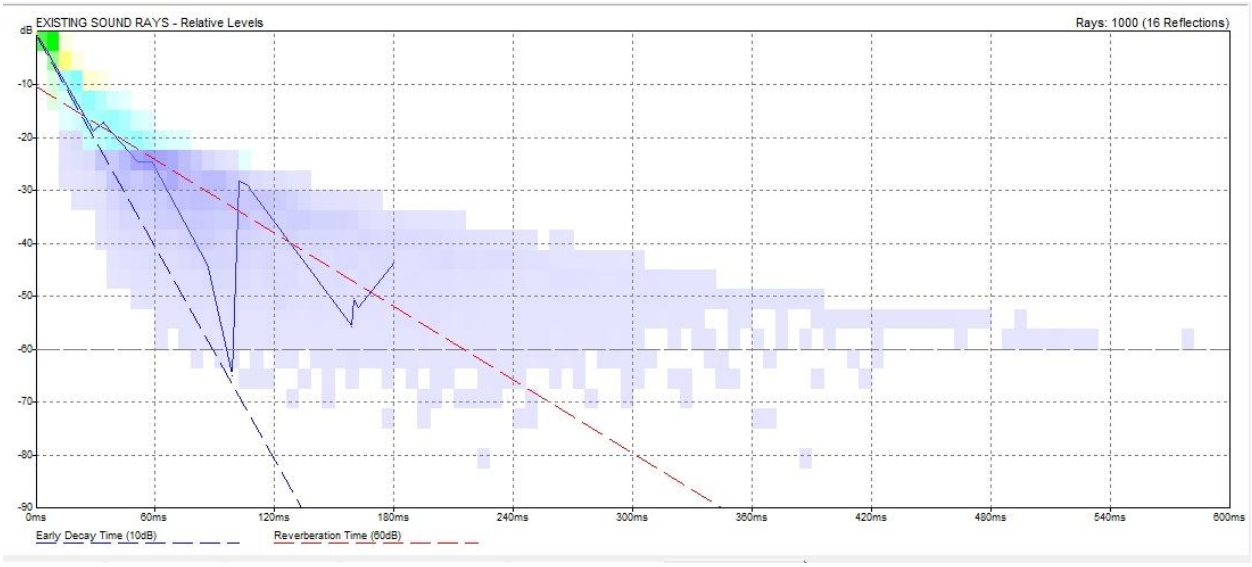


Figure 18: Acoustical Response Graph indicating relative levels of sound ray in university of jos multi-purpose hall having a high reverbretion time of 340m/s.

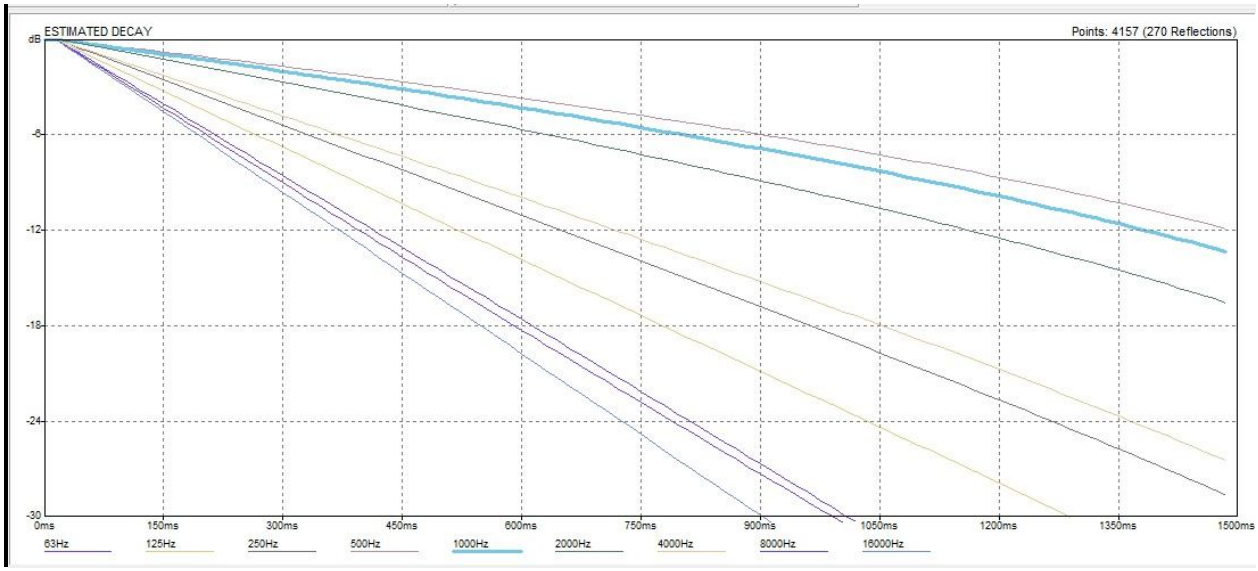


Figure 19: Acoustical Response graph for UJ Multi-purpose Theatre having a high estimated decay with 4157(270reflections) which is unsuitable to achieving a dead sound required.

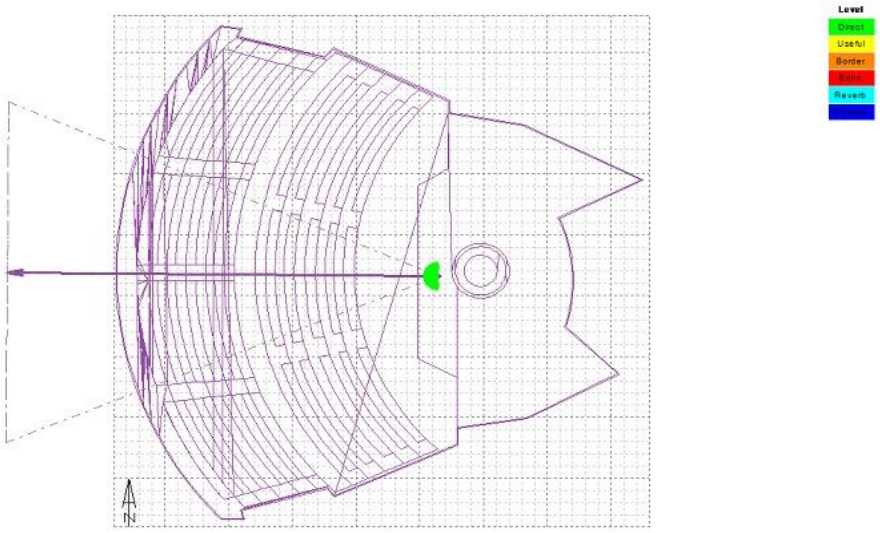


Figure 20: Plan for UK Bello theatre showing some direct rays from it's sound source when empty.

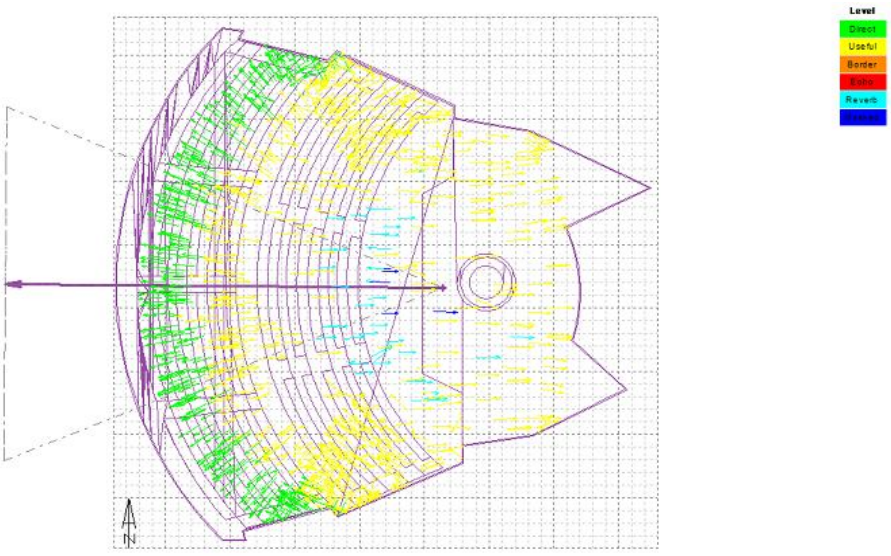


Figure 21: Plan showing the levels of Direct, useful, border and echoes with more of direct and useful rays in UK Bello

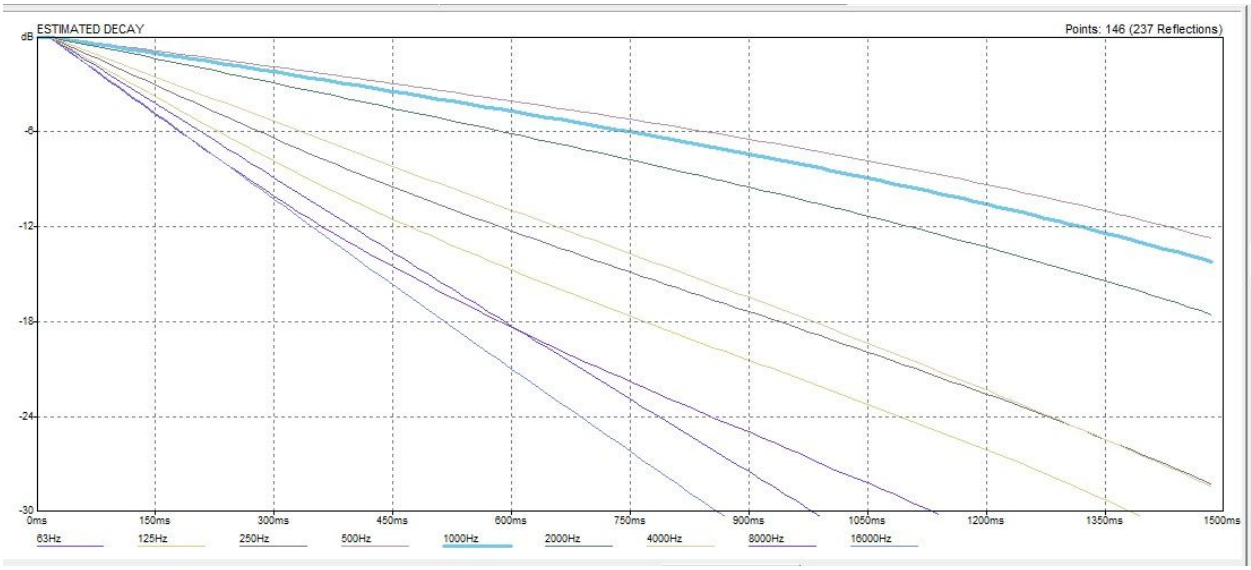


Figure 22:Graphical representation of UK Bello indicating it's estimated decay to it's Acoustical Response having it's points as 146(237 reflections)

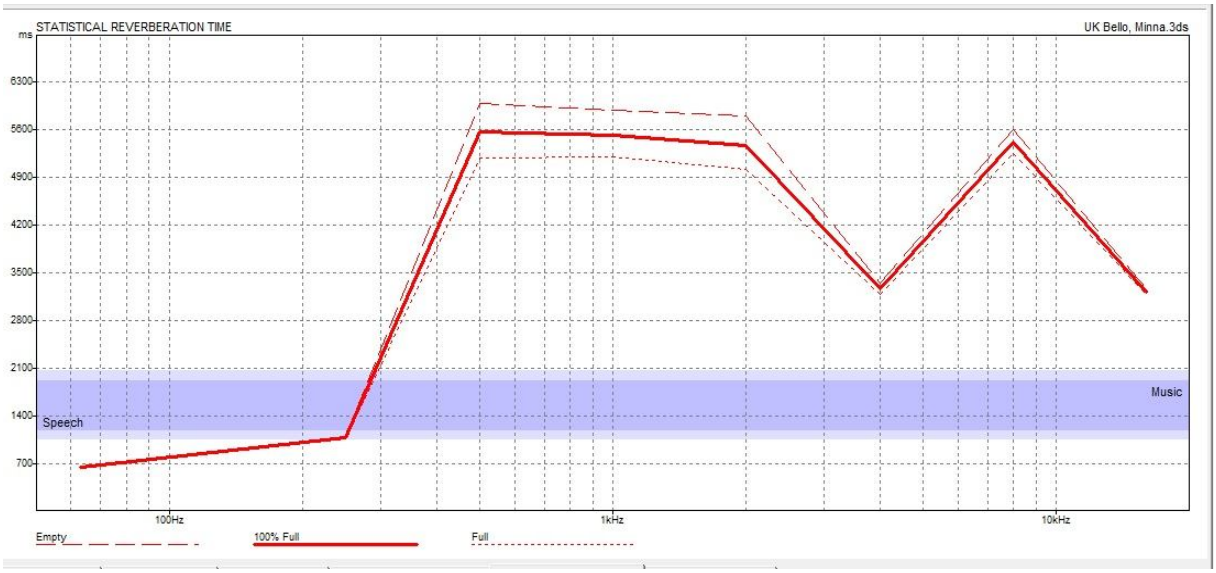


Figure 23: Graph of statistical Reverberation time when theatre is empty,100%full and full in relation to it's reverberation time

4.7 GRAPHICAL COMPARISM OF THE ACOUSTICAL RESPONSE OF THE THREE THEATRES

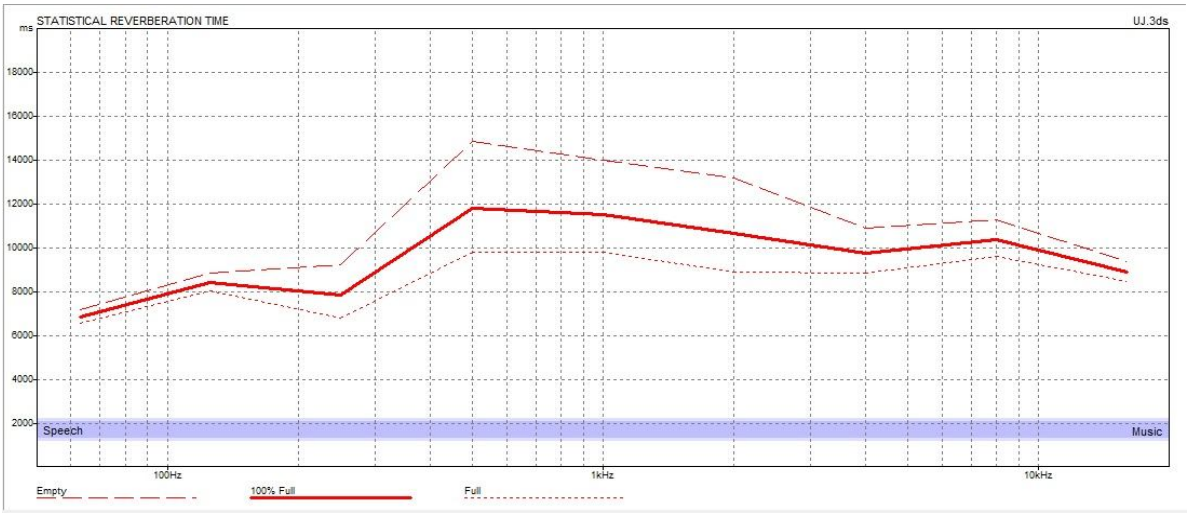


Figure 24: Graph showing the acoustical response of university of Jos multi-purpose Theatre when empty,100% full and full which affect it's reverberation time.

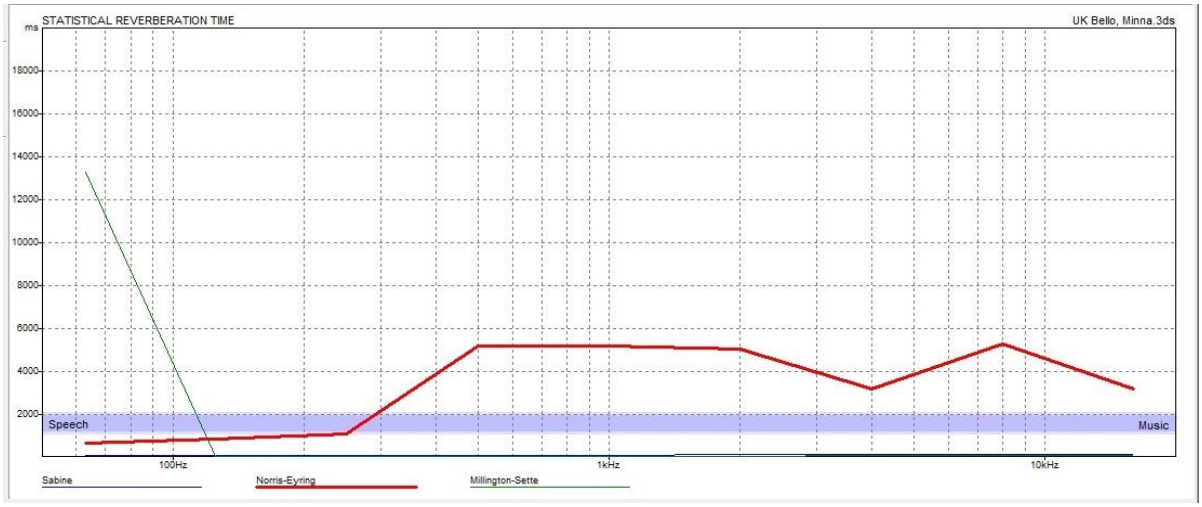


Figure 25: Graph showing the acoustical response of university of U.K Bello Theatre when empty,100% full and full which affect it's reverberation time.

4.8 CONCLUSIONS FOR RESULT FINDINGS

From the simulation analysis carried out on the Theatres namely cyprain Ekwensi Theatre, University of Jos Multi-Purpose Theatre and U.K Bello Theatre, it was discovered that the three building forms does not serve as Acoustical treatments for sound. except for UK Bello that was a bit fair, Thereby in choosing a perfect building form for the proposed Idoma cultural centre (theatre),and from results and literatures, Theatres with shorter walls that converges serves as perfect building form for Theatres and also with the results shown below which also informed and determined the Hexagonal building form for the proposed Theatre.

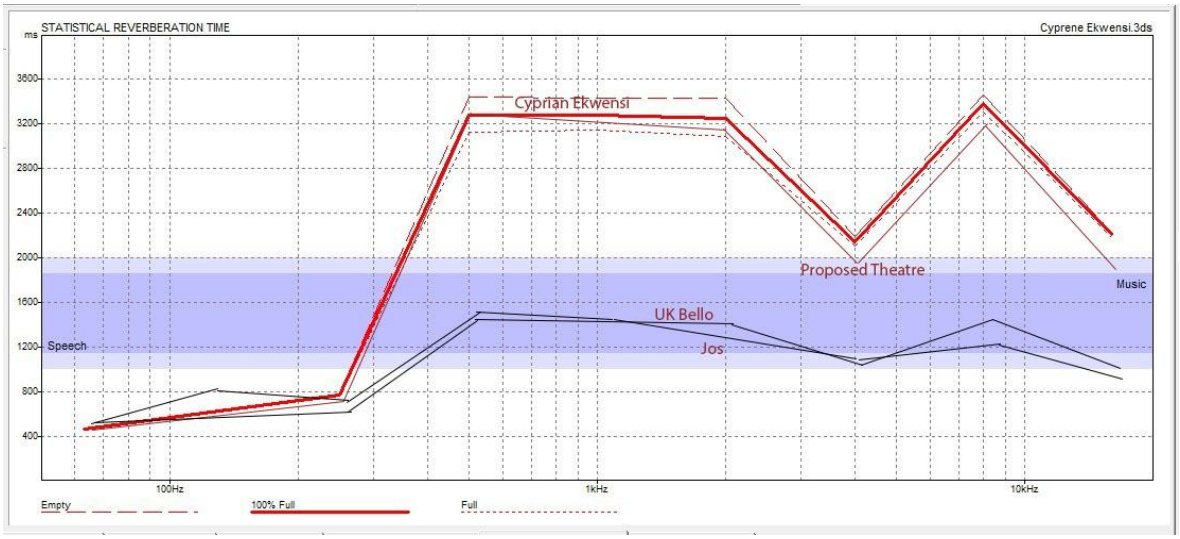


Figure 26: Showing the points scored and averages of the three Theatres simulated.

THEATRES	REFLECTIONS	POINTS	AVERAGE
U.K. Bello Theatre	**Had 237 Reflections**	**146 points**	**191**
CyprainEkwensi	**Had 1131 .**	**380 points**	**255.5**
University of Jos	**Had 270**	**4157 points**	**2213.5**

CHAPTER FIVE

5.0 AREA OF STUDY

The Idoma cultural centreis located in Otukpo which is the traditional headquarter of the Idomas, and the seat of the Ochiidoma. Otukpo is also the most populous town of the Idoma speaking people and it's also located on the latitude and longitude of 6, 49 0 north 8 40 also,the climate of otukpo is usually dry season from November to march and the rainy seasons are determined by the tropical maritime air mass moving south west and the continental air mass moving North-East humidity is very high, often exceeding 75% daily.and also it surface wind speed varies between 8.9 to 9.6km/h

(www.tutiempo.net/en/weather/makurdi/DNMK2013).

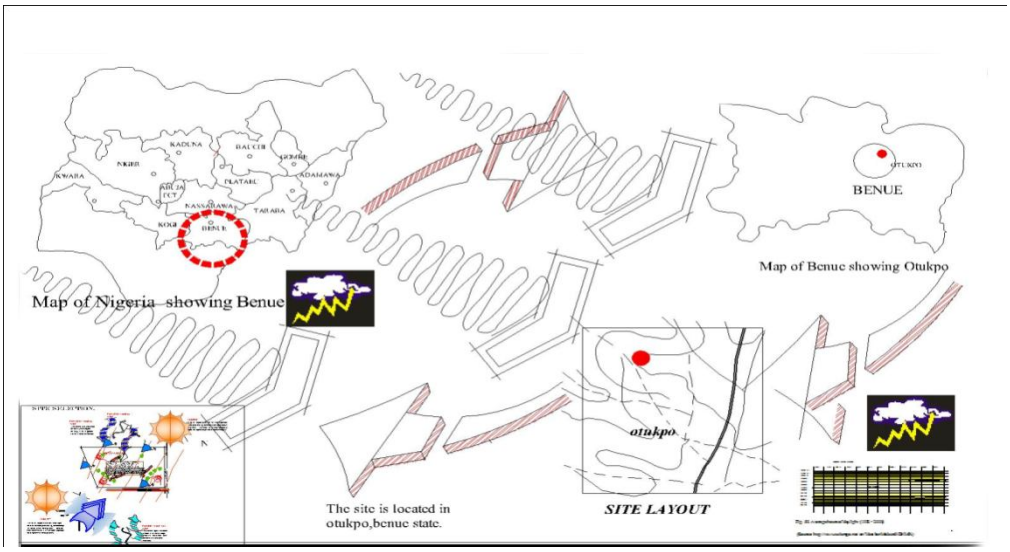


Figure 27: Site location

The site is located close to the Ochi Idoma's Palace and also having the River Benue the second longest river in Nigeria which originates from the Adamawa Plateau ofNorthern Cameroon meandering 43km away from it which has also influenced the

selection of my site which will also serve as a great boost to their cultural activities of the Idoma's too.



Figure 28: Otukpo Town, on the banks of the River Benue

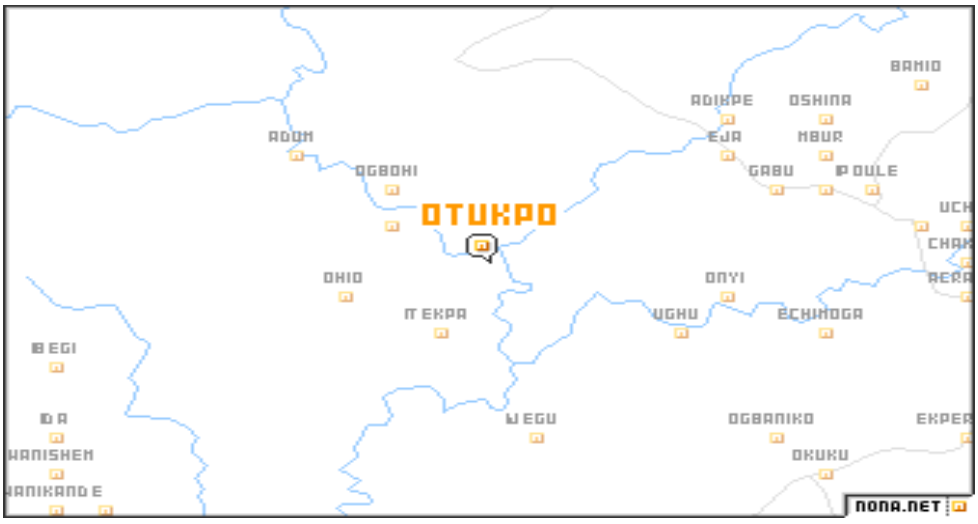


Figure 29: Showing Otukpo.

The river is approximately 1,400 km long, rising in the Adamawa Plateau of northern Cameroon, from where it flows west, through the town of Garoua, into Nigeria south of the Mandara mountains, and through Jimeta, Ibi and Makurdi before meeting the

Niger at Lokoja. The river creates an appropriate environment, that would provide the right atmosphere for site seeing and cultural activities, where residents as well as visitors, young and old alike can take time to learn about the arts of the people. (http://www.benuestate.gov.ng/OBOF.pdf)

5.1SITE SELECTION CRITERIA

The site was selected based on the following criteria;

i. Size

ii Proximity to Ochiidoma's palace

iii Proximity to Nearby houses, schools and Field

iv Proximity to lodges

v Traffic Control

vi Numbers of Roads linking to site

vii Site Features

The site has the maximum advantage of natural geological features which also gives the room to be accessed from existing transportation corridors and also the availability of services (nearness to existing power lines and water supply) which gives the site a serene beauty in and out, and finally its proximity to other recreational facilities and other related services cannot be over-emphasized..

5.2ALTERNATIVE SITES

Three alternative sites were chosen for this research, based on the purposive sampling technique.

5.2.1 SITE SELECTION

5.3.1.1 Site A

This site lies along the North Bank of the River Benue, close to the New Bridge.The site is relatively flat and the site topography does not place much beauty to the site which is readily accessible from the Otukpo main route and there are no existing services, but electricity, telephone lines and be readily tapped from surrounding developments and the site offers a pleasant views. The site lies next to a vocational centre.

Comments;

The site covers a small area, as much of the neighboring area has been taken up by the vocational centre. It is thus, not suitable for design of this scale.



Plate XXII: View of site. Source: Author's Field work

5.2.1.2 Site B

The site is located along Otukpo road, off the ochiidoma's palace in Otukpo local government area.The site is gently sloping with a sharp depression and it again slopes gently to the river Benue. The sloping terrain of the site presents a good opportunity for scenic landscaping and also the site is accessible from a road passing along the southern part of the site in front of it coming from Markurdi, there are existing services, and some can be tapped from the road running in front of it. finally, The site is conspicuous as one approaches the Otukpo Township via Edumoga road, thus attracts the attention of visitors. Views into and out of the site are very pleasant which is to the palace too.

Adjacent to the site is an existing park which attracts people to the area.

Comments;

The site is suitable for a design of this scale.



Plate XXIII: Pictures of the site

Best score	Criteria	SITE A	SITE B	SITE C
	SIZE	3	1	2
	PROXMITY TO EMIR'S PALACE	2	3	1
	PROXIMITY TO NEARBY HOUSES, SCHOOLS AND FIELD	1	3	2
	PRXIMITY TO THE HOTELS AND LODGES.	3	1	2
	TRAFFIC CONTROL	3	1	2
	NO. OF ROADS LINKING TO SITE	3	1	2
	SITE FEATURES	3	1	2
	AVERAGE SCORE	2.57	1.57	1.85

Table 8: Site Selection. Source: Author's Field work

5.2.1.3 Site C

The site lies along the high-level area of Otukpo. The site is relatively flat, and with no existing building with a road passing in front of the site which enhances accessibility and will also lack the advantage of scenic landscaping because its relatively flat and its father away from the ochi-idoma's palace.

Comments;

The site is difficult to access, and is thus not suitable.

After careful comparative study of features and affordances of three selected sites, site B is found to be more suited for the purpose of Recreation Center. This site is therefore selected for the development of the project

5.2.2 EVALUATION OF THE SITES

The criteria listed above will be used to evaluate the sites and the sites will be rated as they satisfy the criteria. a score line of numbers 1 – 3 will be used for the evaluation of the sites, since there are 3 of them, 1 will represent the most favourable option between 3 sites, followed by 2 then 3 will represent the least favourable option of the 3 sites. On event of equal representation of two or the three sites, it will imply that the three sites are rated equally, with the criteria considered.

Site B merits a lot of the criteria needed for the location of an idoma cultural centre,otukpo. It is therefore selected.

5.3SITE ANALYSIS

The natural site characteristics have been studied. These characteristics determine restrictions and opportunities, potential use areas, as well as development suitability, and the analysis was based on the following factors.

5.3.1 PHYSICAL AND GEOGRAPHIC CHARACTERISTICS

5.3.1.1 Vegetation

The site is located in the guinea savannah vegetation belt. Typical plants include Neem, Locust bean, Shea butter trees, as well as several species of shrubs. The Otukpo riverfront is characterized by denser vegetation than most other parts of the town, and certain plants such as Palm trees dominate the along the river.

The vegetation on the sites comprise sparse trees, mainly locust been and palm trees, dense shrubs and elephant grass. As far as possible, trees will be maintained in the design, serving as landscape elements, and providing shade in certain outdoor spaces.

5.3.1.2 Topography

The site lies approximately 70m above sea level, sloping towards the river, with a gradient of about 5.2^{o}. The topography of the site will be maintained in the design. Consequently, depressed levels will be incorporated, thereby facilitating the harmony between architecture and the waterfront environment.

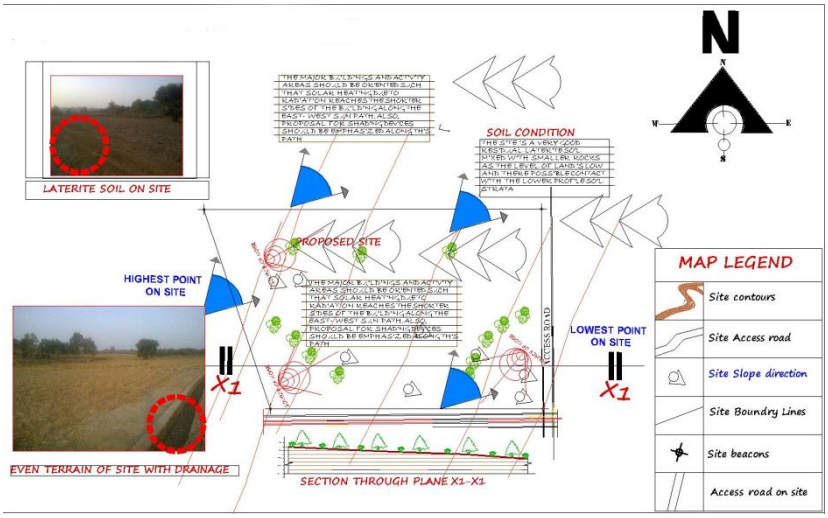


Figure 30: Site Analysis: topography

5.3.1.3 Views

Stimulating views from the site include the River, as well as the scenic landscape at the south bank of the river see fig.31 above. Access to these views will be incorporated in the design through visual corridors. There would be a lot of outdoor spaces, and the use of transparent materials like glass to enhance this. The orientation of facilities will follow the linear course of the river, thus exposing more spaces to these views.

5.3.1.4 ACCESSIBILITY



Figure 31: Map Showing the Site and Major Access Roads

The site is accessible from Apa local government area, a busy trunk 'A' Road, used by vehicles coming into Otukpo from the Northeast, or exiting the town. Also known as New Bridge Road, the Road is one of two roads linking the North and East, and is thus very busy see figure 32. The road is thus not a good choice for ingress and egress, especially for a recreation facility, where visitors seek retreat from the hustle and bustle of town life.

The site is also accessible from Apa which is to be the New State for the Idoma's if been passed to law by the Nigerian government eventually and also harbours the river Benue which meanders through Otukpo like most inland Waters, the river is navigable for only about 5 months of the year, between May and October, which is the rainy season. The river is navigable by any barge with a draught of 1.2m or less. Very often though, this depth is not available, because there is no river dredging.

Common routes include Obi Ado local government, to and from Okpokwu, and to and from a neighboring island about 500m from the site. A luxury restaurant accessed by boat will be located on this neighboring island. A route will be proposed to and from the adjacent golf course at the south bank. A slalom course will be established in the natural setting of the river following its course since the minimum required gradient of 1:100 for slalom courses is available.

5.3.2 GEOLOGICAL DATA

The site falls within the lower South Benue Valley. The underlying base soil in this region comprises a thick mass of cement bedded coarse-grained deposits described as Markurdi sandstone. The topsoil is mainly ferratic comb soil and sandy loam of weak structure, which is slightly acidic. (Wright et.al)

5.3.3 CLIMATIC DATA

The climate of Otukpo is characterized by two distinct seasons, which are the dry season from November to March, and the rainy seasons from April to October. These seasons are determined by the tropical maritime air mass moving South-West, and the continental air mass moving North-East. Normally, humidity is very high, often exceeding 75% daily. The hottest periods of the year are recorded during the months of March to May. Winds are generally low-variable speed and become the most important factor mitigating the oppressive heat and humidity. Generally, mean surface wind speed varies between 8.9 to 9.6 Km/h.(www.tutiempo.net/en/Weather/Makurdi/DNMK2008)

Climatic factors will determine the nature of building orientation, fenestrations, roof pitches, use of building materials and landscaping. Large massing of volumes will be avoided because of high temperatures and humidity. Moisture resistant building materials and large fenestrations will be employed.

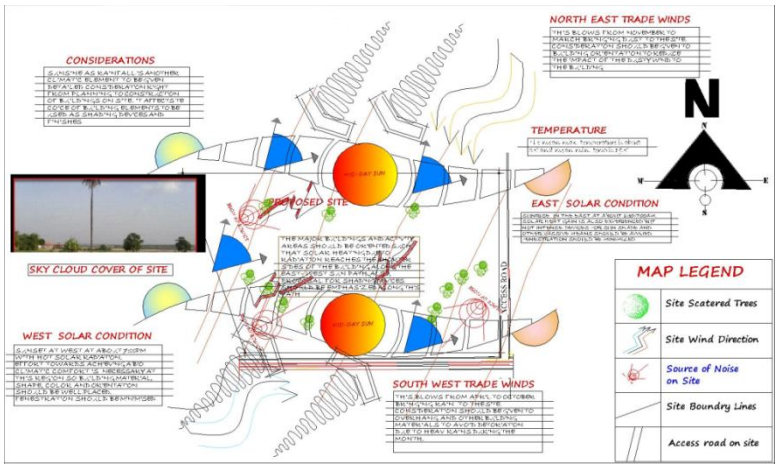


Figure 32: Site Analysis: Climate showing all weather conditionals on site

5.3.4 TEMPERATURE

Otukpo is characterized by high temperature and humidity which is same with the one obtainable in Makurdi too,where the air temperatures range from 32°C during the day to 22°C during night times.

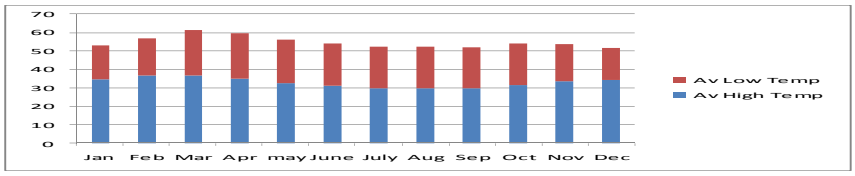


Figure 33: Average maximum and minimum daily temperatures (1998 - 2008)(source: http://www.tutiempo.net/en/Weather/Makurdi/DNMK)

5.3.5 RAINFALL

Conventional rainfall is the norm, occurring between March and October. The highest mean monthly rainfall occurs of about 260mm occurs in September. Rainfall occurs about 94 days a year, with a total yearly average of about 1311mm.

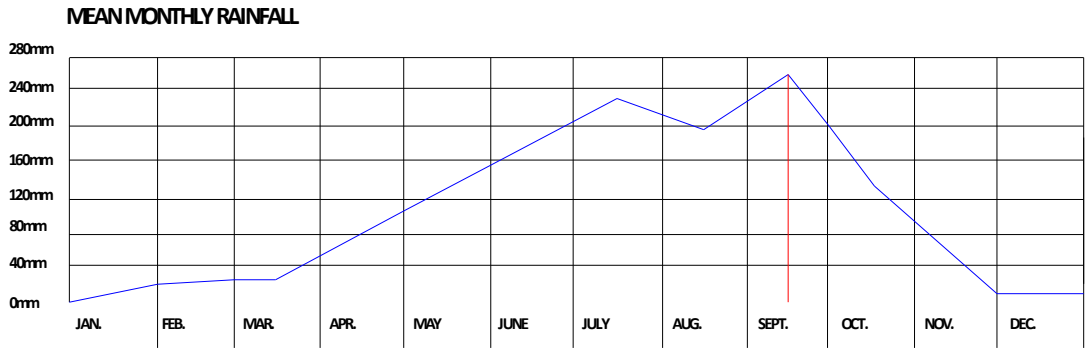


Figure 34: Average mean monthly rainfall *(1998 - 2008)*(Source: http://www.tutiempo.net/en/Weather/Makurdi/DNMK)

5.3.6 DAYLIGHT

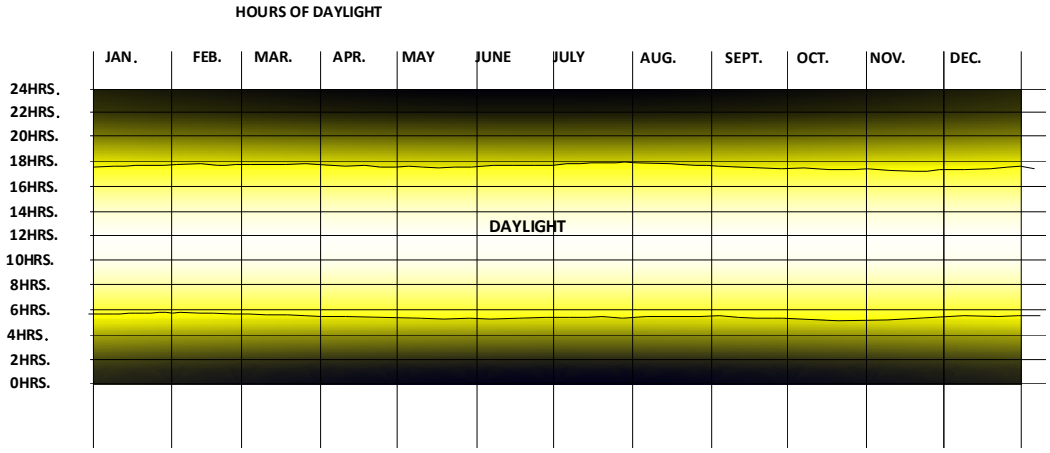


Figure 35: Average hours of daylight (1998 - 2008) (Source: http://www.tutiempo.net/en/Weather/Makurdi/DNMK*)*

CHAPTER SIX

DESIGN REPORT

6.1 DESIGN BRIEF

Otukpo, the major town of the Idoma's desires to have an architectural landmark that will symbolize the cultural richness of the state true arts.

There is the need to provide a building that would connote the artistic strength of the people and provide the suitable platform for the people to showcase their creative ideas to the world.

The main purpose of the project is to establish a Theatre, scaled to the needs of a growing, and increasingly discerning market for artworks, the building will also play a strong role in Otukpo and educational life of her people to learning their culture.

The second principal objective of the project is to help to establish a new, lively, attractive and warmly regarded cultural centre, a new focal point for urban life. The design of the building and related spaces must therefore have those qualities which will give expression to these objectives and encourage them by the serene environment with its broader surroundings. The building will be open and welcoming in character. The design of the public spaces will establish a sense of permeability and encourage a high level of activity within its environs.

6.2DESCRIPTION OF SPACES

The project shall incorporate, the main Theatre building, restaurant and Amphitheatre, open air exhibition research areas(mini-zoo), Amphitheatre, art and vocational center and shopping facilities which would be shopping souvenir shops.

6.2.1MAIN THEATRE BUILDING

The main building in the facility is the Theatre building which is hexagonal in shape thereby serving as the best building form for acoustical performance proven by simulation result and analysis. Which also diffuses reverberation and echoes of sound to a perfect dead, and it will also house facilities consisting of the various offices spaces for both temporary and permanent staffer, office spaces, main hall, library and storage and conveniences. see figure 37.

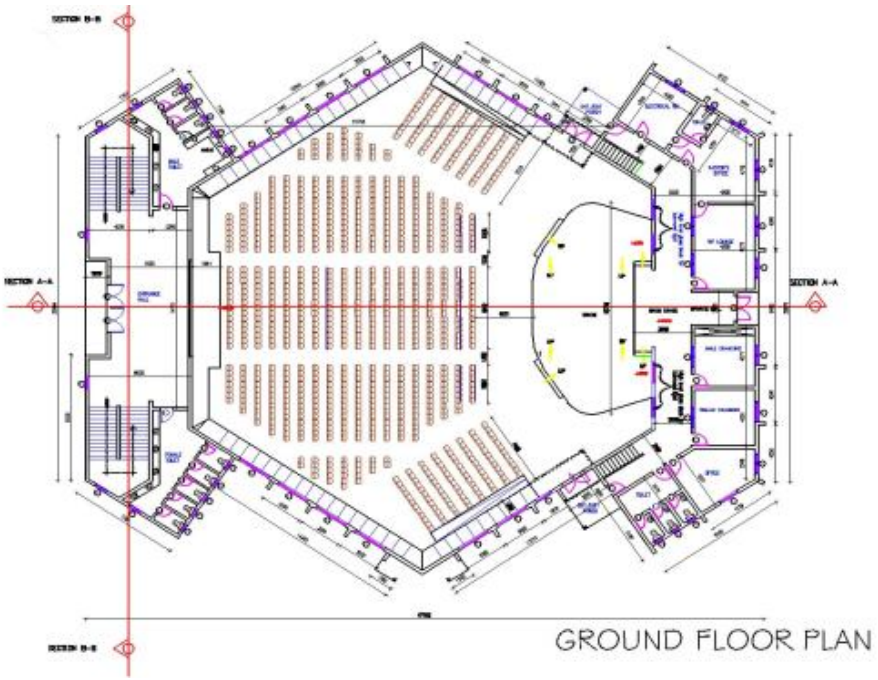


Figure 36: Proposed Ground Floor Plan

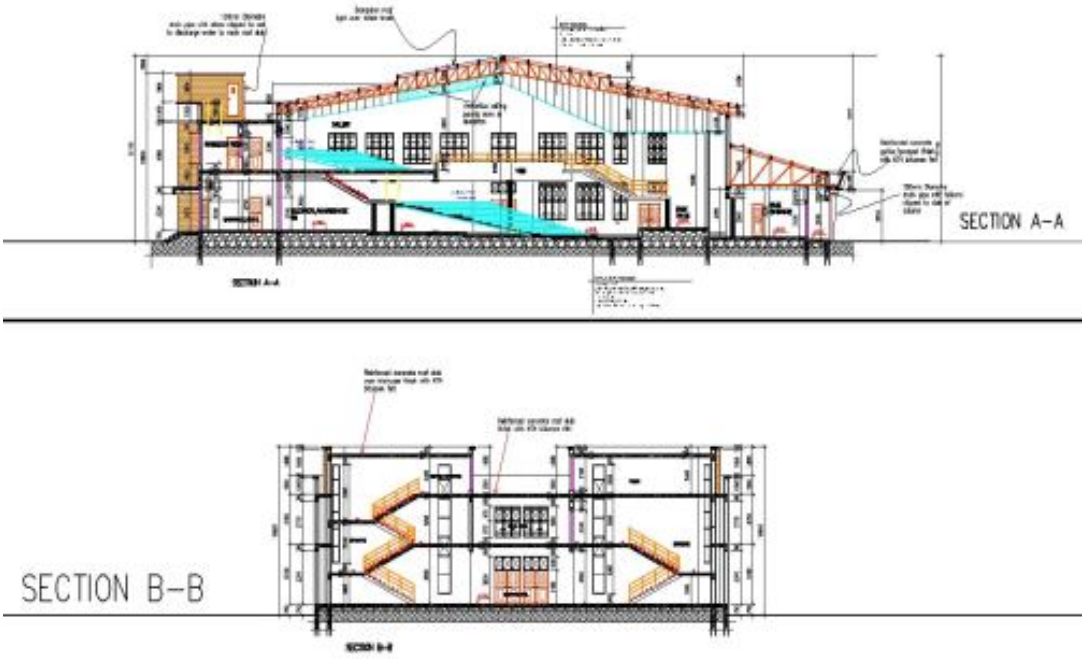


Figure 37: Sections



Figure 38: Figure 19; showing the elevations of the Theatre that depicts the culture of the Idomas.

6.2.2RESTAURANT

This have been provide to cater for food on the premises, it consist of both the eatery where they would be the main section and the children section and a bar behind along with an outdoor space overlooking the river, This shall include the main dining hall and an outdoor dining area; a kitchen and two stores. The restaurant will be part of the admin to the entire facility.

6.2.3ARTS AND CRAFTS WORKSHOPS

These will be a separate unit from the main museum complex, which will provide spaces for the production of arts and crafts works that will be displayed in the exhibition room as well as souvenirs for the museum visitors.

This area consist of the studio/workshops along with an office for the director of the section and his assistant there is also a classroom here where lectures could be delivered

6.2.4SHOPPING FACILITIES

These will provide outlets for the sale of souvenirs, and other items to visitors. The shops will not be part of the main museum complex, but would rather be placed in close proximity with the art and craft workshop, the facility will consist of rows of shops.

6.2.5AMPHITHEATRE

This will be used for performance on a larger scale, for a large audience such as on traditional festivals, marriages and other important functions it's its circular form is

informed by the Ate of the idoma people which serves as a centre of meeting for visitors. see plate L.

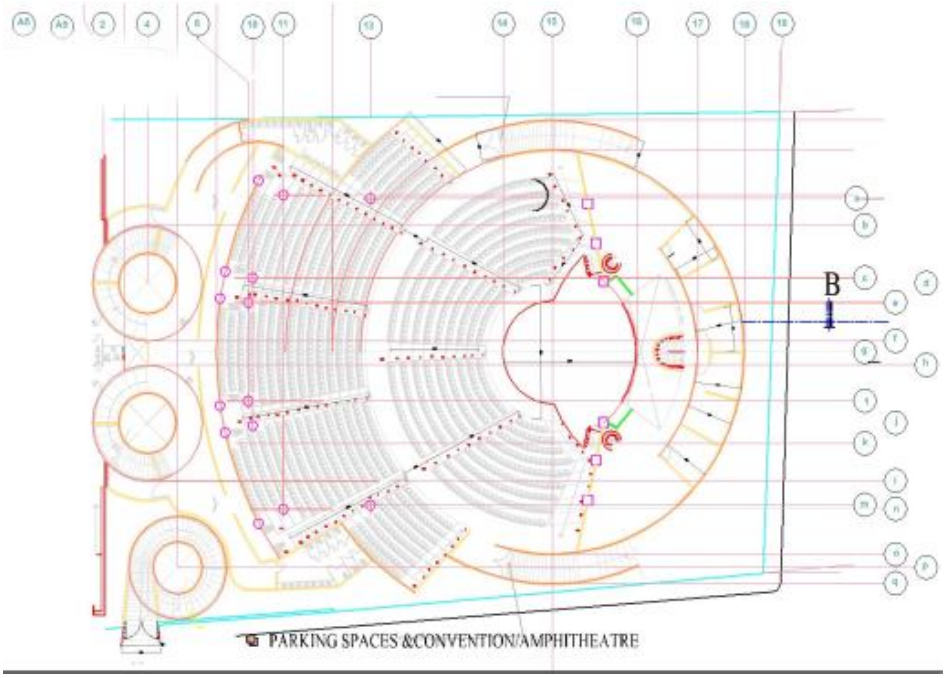


Figure 39: plan of the Amphi-Theatre

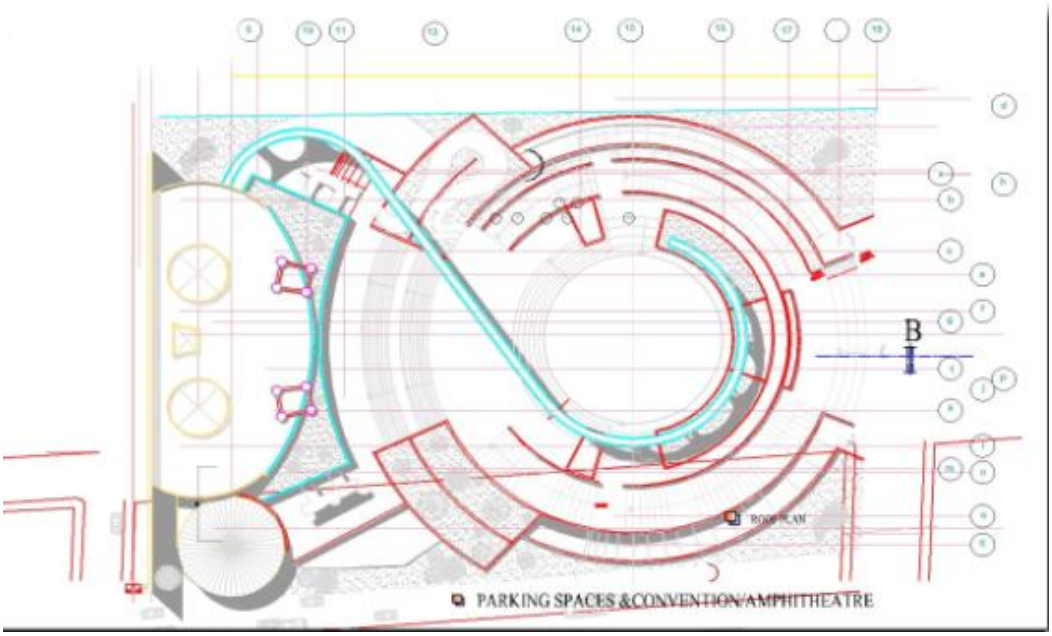


Figure 40: circular building form of it's Amphitheatre.



Figure 41: approach and rear elevation of the Amphi-Theatre.

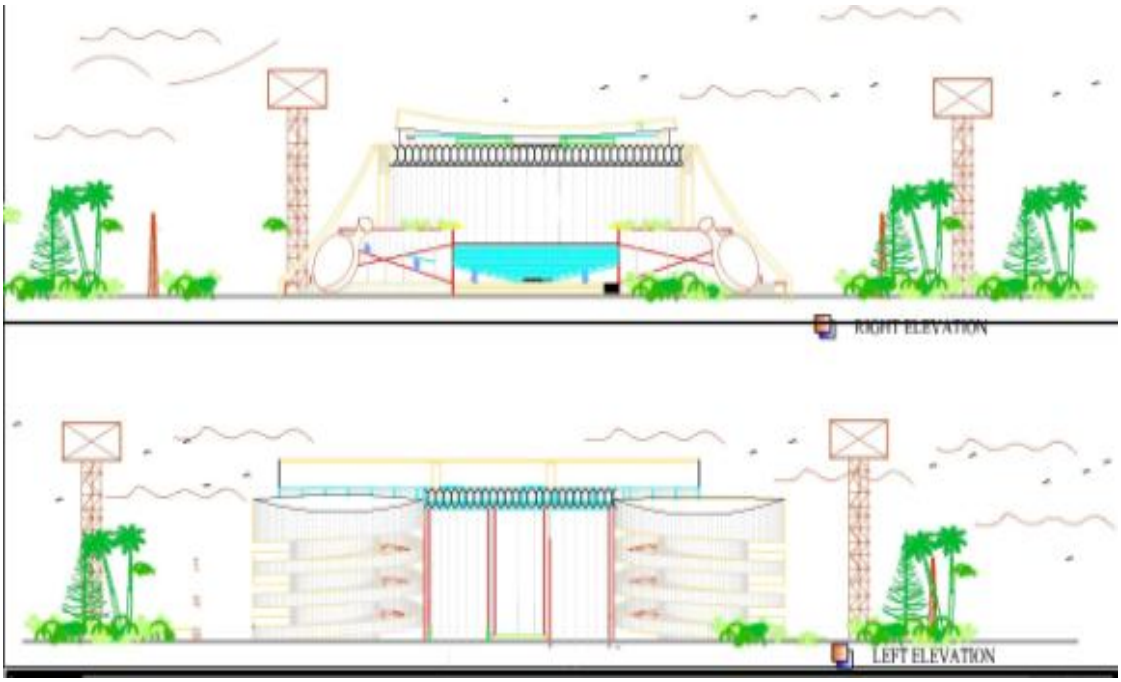


Figure 42: the right and left elevation of the Amphi-Theatre.

6.2.6ADMINISTRATIVE OFFICES

These will provide office accommodation for the staff that will run the museum. The capacities of the office have been determined based on the organogram of a cultural centre; which was further tailored to suite the purpose of the proposed cultural centre of contemporary art it also consists of office spaces for the staffers the will run the affairs of the facility. see plate LII.

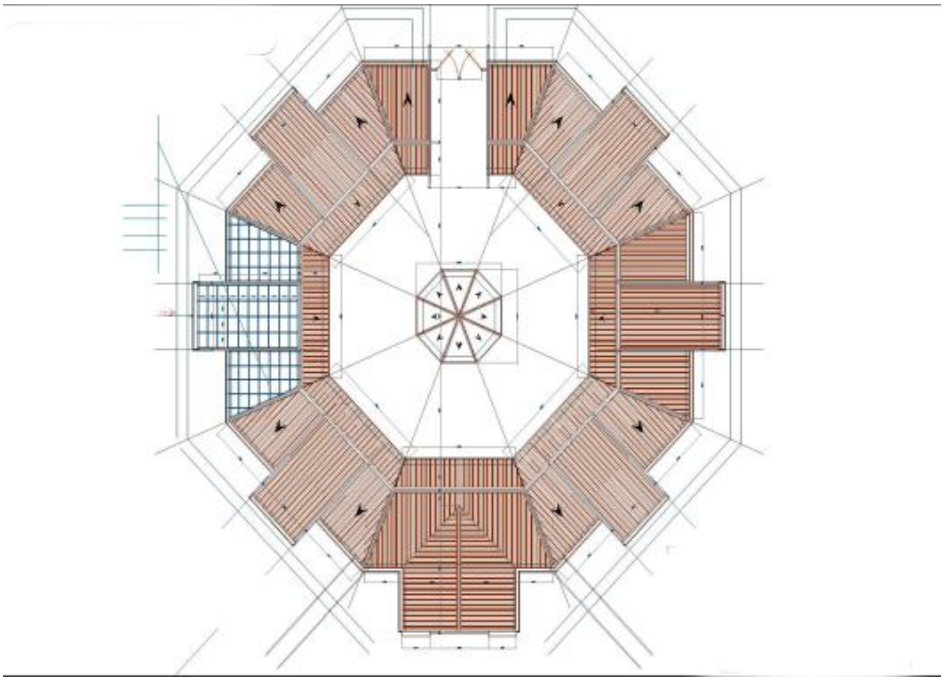


Figure 43: the roof plan of the Admin.

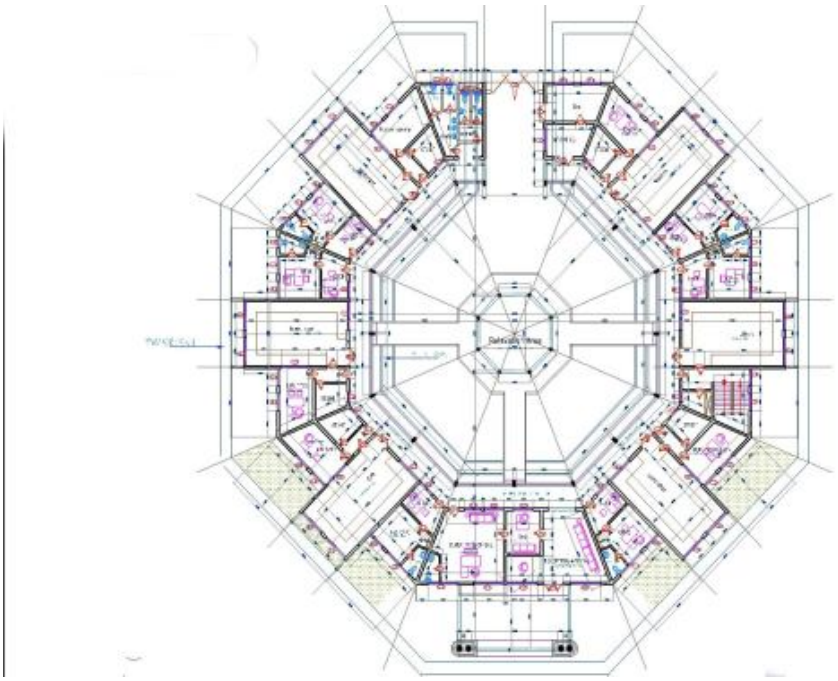


Figure 44: floor plan of the admin.floor plan and it's roof plan

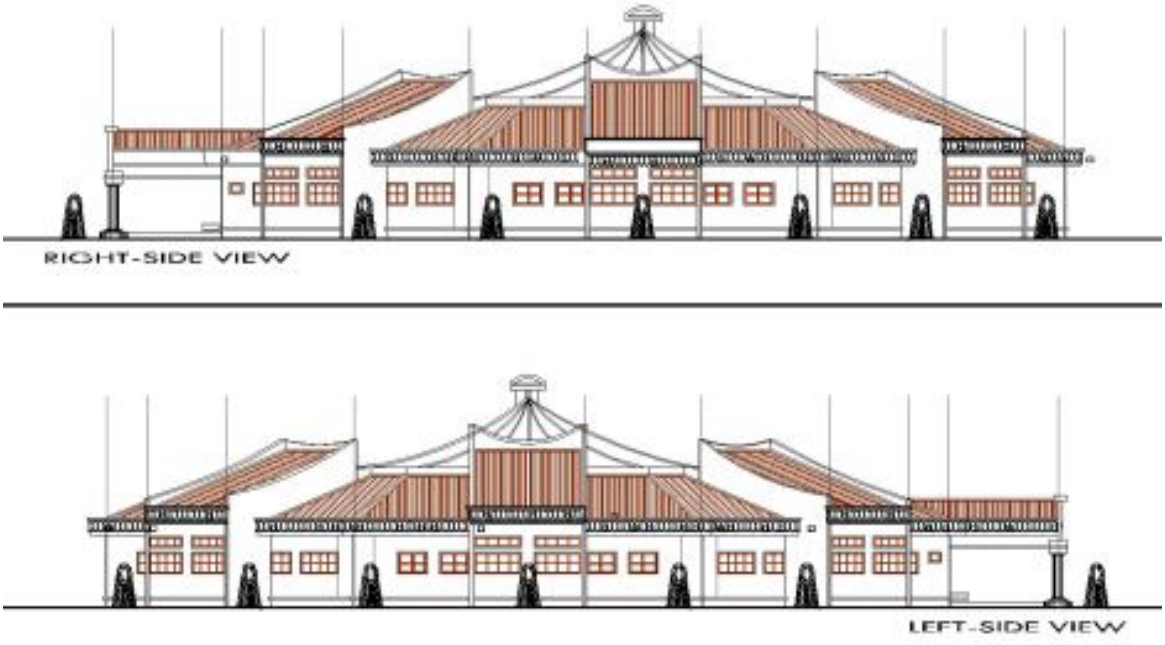


Figure 45: right and left elevations of the Admin.

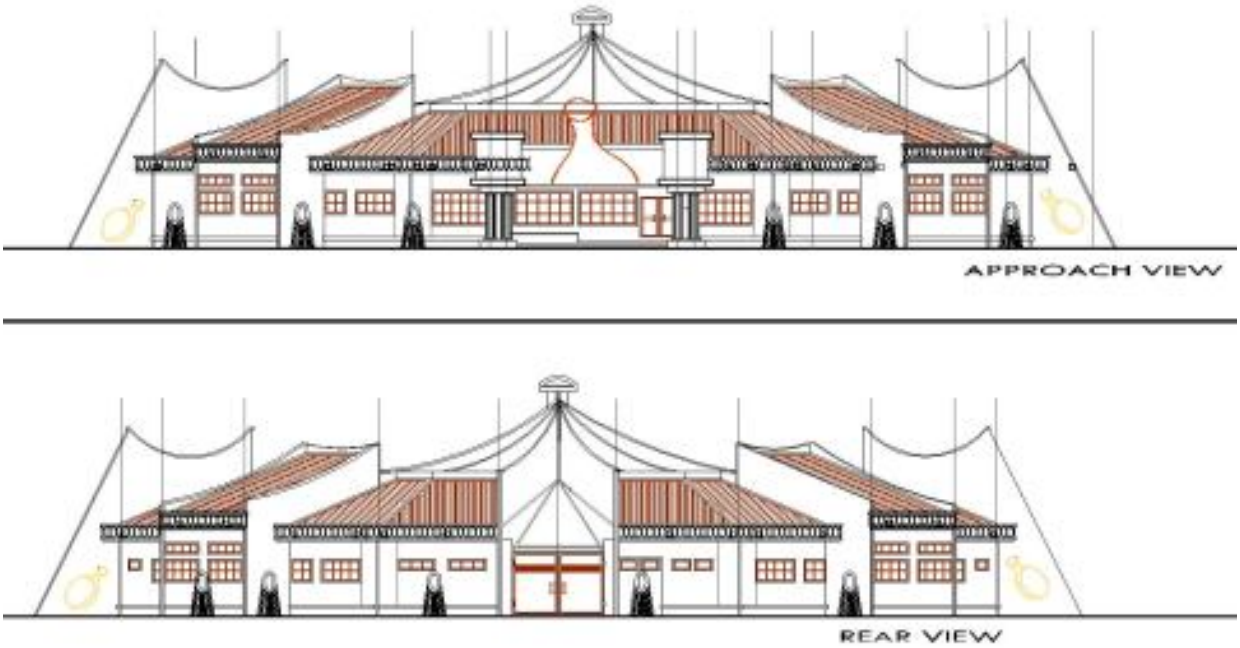


Figure 46: the Approach and Rear elevations.

6.2.7 LIBRARY

This will provide reading and research facility for visitors. The library will be within the main museum complex.

6.2.8 LECTURE HALL

This will be a multi-purpose hall that will be used for showing films, holding conferences, meetings, lectures and seminars, this will be integrated into the main build which will form part of the main complex.

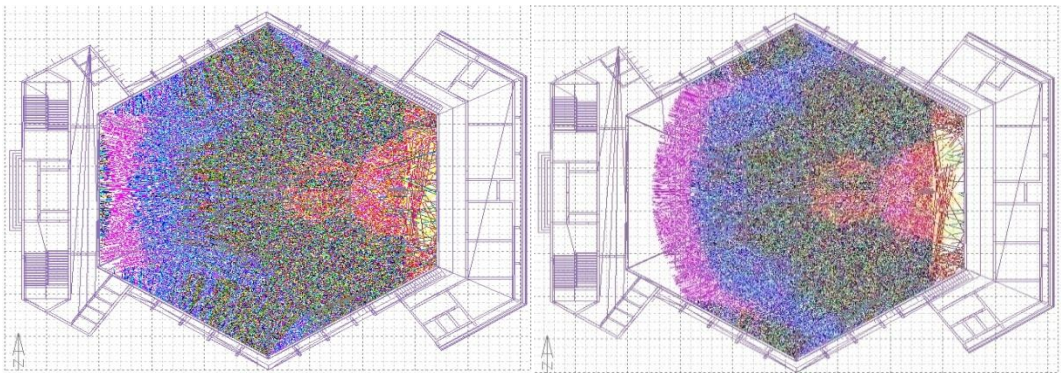


Figure 47: the direct, useful, border/echo and marked ray in the proposed cultural centre Theatre.

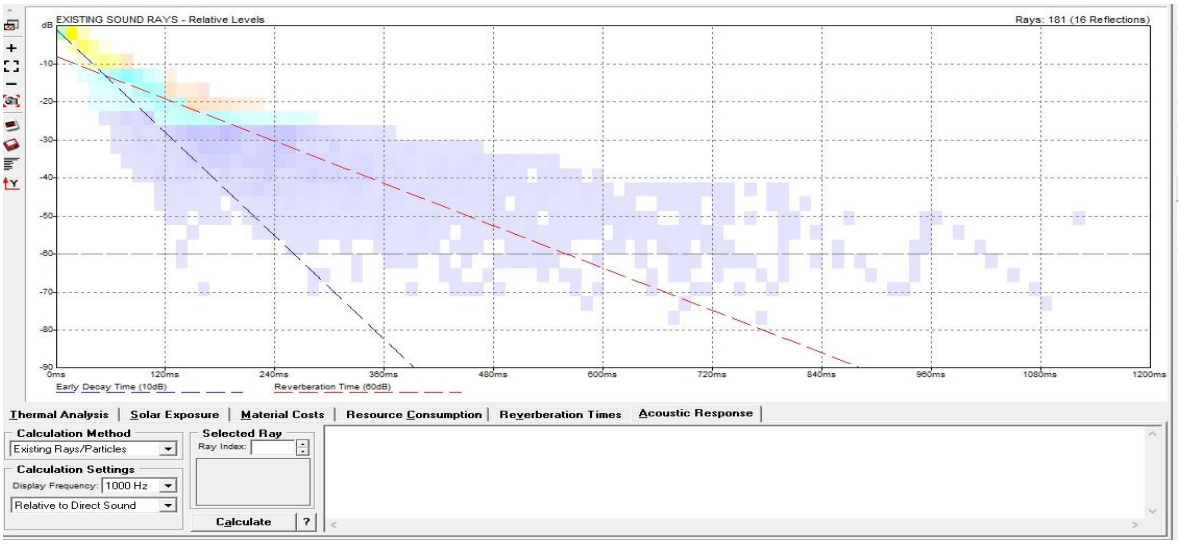


Figure 48: the relative levels for existing sound rays having a total numbers of rays to be 181 and 16 reflections serving as a perfect building form for acoustic.

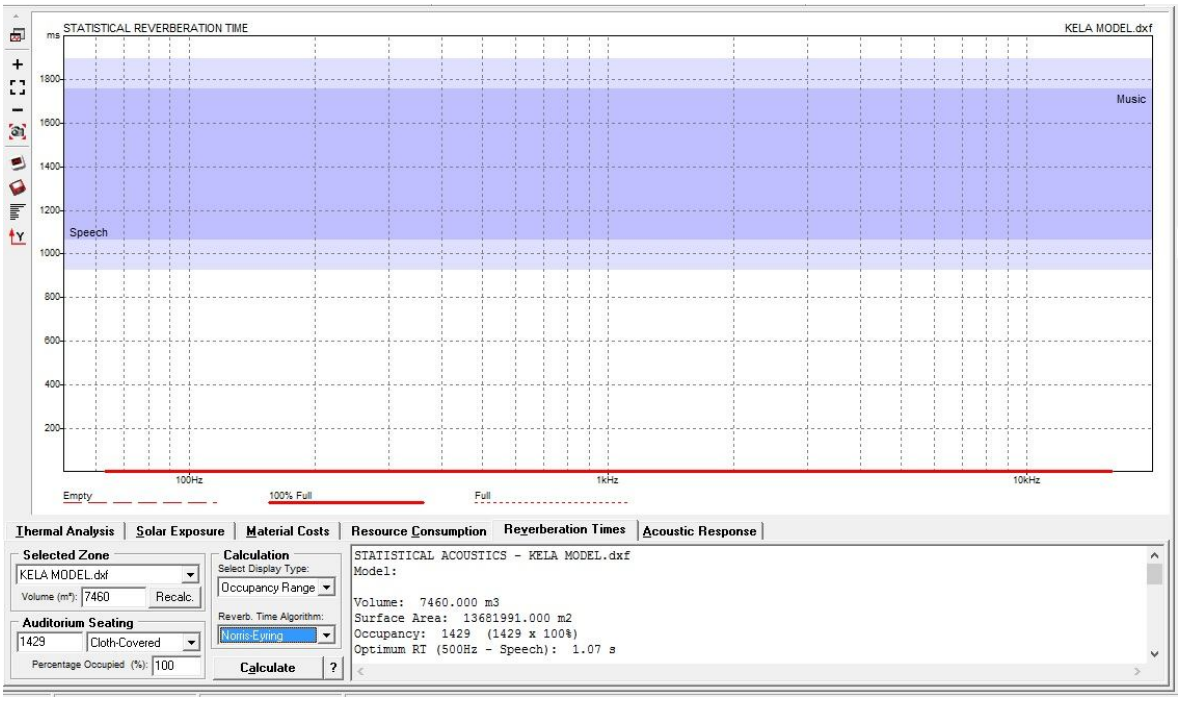


Figure 49: the statistical reverberation time for the proposed Theatre, Otupko.with the volume of 7460.000m3 and occupancy 0f 1500 and RT OF 1.07S.

6.3 SCHEDULE OF ACCOMMODATION

The total site area is 87,500 meter square. The site has four facilities occupying less than 60% of the total area. The parking area provides for 164 cars for public and staff.

6.3.1 OPEN AIR THEATER

Capacity	1000 Person seat
Area per person	0.425 m square
Total Area	1000 * 0.425=425m square

6.3.2 EXHIBITION HALLS

	Function	Area meter square
1	Pottery	350m square
2	Woodwork	350msquare
3	Metal work	350m square
4	Historical items pictures and publications	350m square
5	Fabrics and weaving	350m square
6	Leather works	350m square
	TOTAL AREA	3100m square

Table 9: Space requirement for exhibition halls Space requirement for exhibition halls: (Source: Nuefert, 2000).

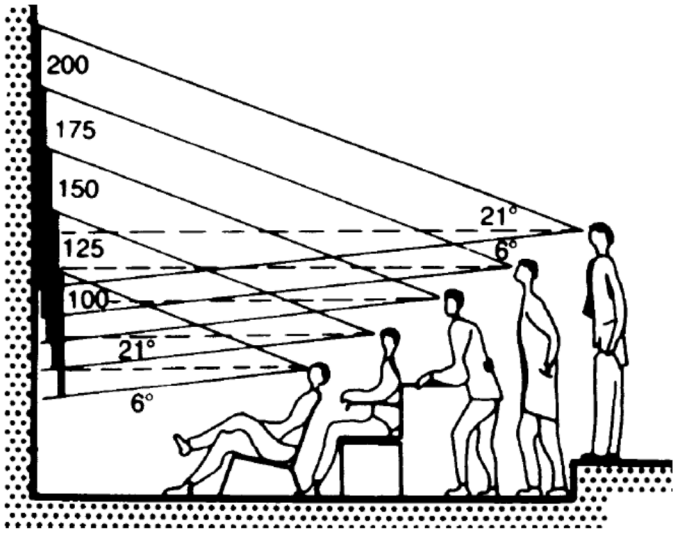


Figure 50: Range for field of vision *(Source: Nuefert 2000)*

The items to be displayed can be mounted on top of open display units, enclosed in secure display units, mounted on walls and so on. The exhibition halls have been provided with sufficient space to allow for the exhibition of various categories of items and circulation of human traffic.

6.3.3 ARTS AND CRAFTS WORKSHOPS

	Function	Area (square meter)
1	sculpture	80m square
2	Woodwork	80m square
3	metal work	80m square
5	Fabrics and weaving	50m square
6	leather works	50m square
7	Ceramics	60m square
	TOTAL AREA	400m square

Table 10: Space requirement for arts and crafts workshop(Source: Nuefert, 2000)

6.3.4 Library

	Function	Area (square meter)
1	Library 30 people Reading room	60m
2	Processing -New arrivals -Archiving	 12m 12m square
3	Librarian -Office	12m square
4	Store	15m square

	TOTALAREA	111m square

Table 11: Space requirement for the library (Source: Nuefert, 2000)

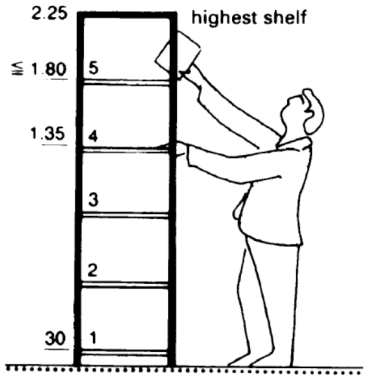


Figure 51: Spatial provisions for library book shelves. (Source: Nuefert, 2000)

6.3.5 RESTAURANT

	Space	Area (square meter)
1	Restaurant 17 tables 60 people	260m
2	Kitchen	65m
3 stores	2	24m
	TOTAL AREA	349m

Table 12: Space requirements for restaurant(Source: Nuefert, 2000)

6.3.6LECTURE HALL

Capacity 80 SEATS

Space per person 0.425m square

Total area 128m square (excluding circulation)

6.3.7SOUVENIR SHOPS

Capacity 18 shops

Space per store 30m square

Total Area 540m square

6.3.7MUSEUM BUILDING

	Function	Area (square meter)
1	Main entrance	80
2	Reception	60
3	Waiting area	100
4	Exhibition hall	1200
5	Children's museum	100
6	Security area	40
7	Store	500
8	Internet café	120
9	Research library	120
10	Administrative section	280
11	services	180
	TOTAL	2,780

Table 13: Space requirement for the main building (Source: Nuefert, 2000)

CHAPTER SEVEN

7.1 DESIGN CONCEPT

Otukpo plays a major role in the state, as the headquarters of the Idoma province and remains an important town in Idoma land.The area mainly populated by the Idoma speaking tribe, though with numerous local dialects spoken in the diverse reaches of Idoma land Idoma language is the umbrella lingua, it is the seat of the Royal Highness of the Och' Idoma, the paramount chief of the Idomas'.

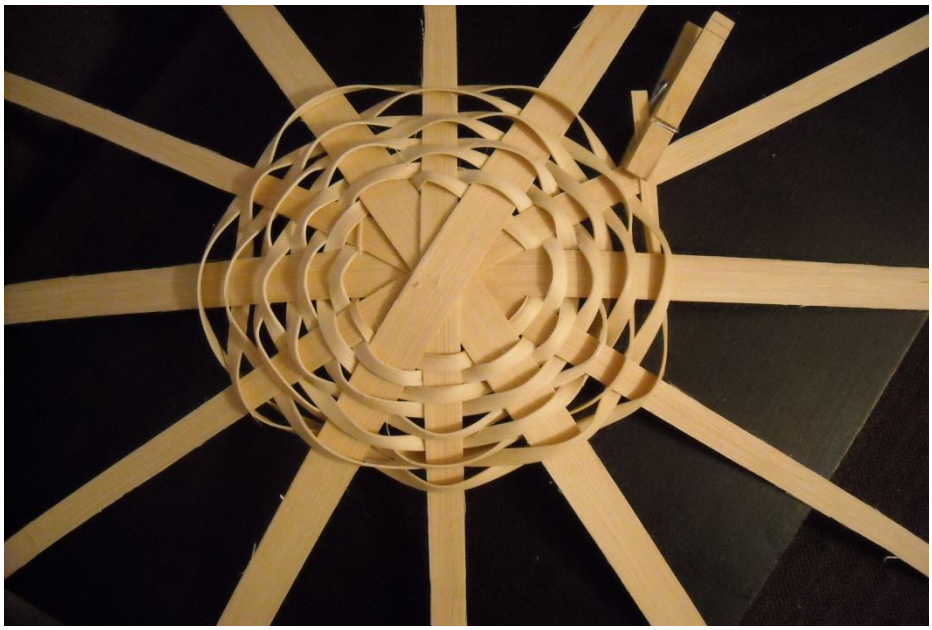


Plate XXIV: concept formulation (Source: Author's fieldwork)

Alight flexible stake inter twinned to form a basket liked enclosure signifying the unity of the Idomas in its makeup and connected to the base which has a cultural significance to the people and at the same time linked to their arts is deemed fit for a cultural centre, after carrying out some research, the stakes has been considered most suitable, owing to the fact that it originates from the water side, since becomes symbolical for the idoma's in the context of unity and could be displayed as an item in the cultural

centre it is considered suitable for the concept formulation and in so doing serves as the centre .telling a story of its content before an observer even enters the building. The concept proposed was developed after critical analysis of case studies; trends have been identified and established see plate xxiv.

In Africa the stakes have been most commonly used polished and pierced as roof sheets, stakes have come a long way in history throughout the continent. Stakes from the River Benue have been traded extensively throughout Africa from the 11th century A D.

The cowries have been combined in such a way that the museum would say from a distance what is inside, what it contains, its content shall be transferred to the outer casing, in such a way that the building and its content shall have the same value, complement each other and present a unified whole.

The other building units separate from the main complex will also carry similar considerations in their design form and character. The design concept harnesses the following aspects of the people:

Growth

The building expresses the non-static nature in its form, the form has been designed to express movement by using both small stakes and large volumes bamboo sticks arranged in such a way that the small ones are placed at the sides and the big one is at the middle showing that the building moves towards the middle and how growth can be represented on the plan of the building has been provided here a shape that can easily be adaptable to changes due to future expansion.

Figure 20AdoptedPrinciples



Plate XXV: concept Source: Author

Nature

This is the sole of, drawing up inspiration from nature and designing of buildings that evolve from nature and in this case the stakes and the bamboo sticks served as the intuitive concept see plate xxv. Stakes has been used as a source of inspiration for the design of the culture centre to having circular building form to represent unity in its design..

Context

This has been used to express the relationship of the stakes which is the concept of the design to the bamboo stakes site.

Vista

Views of the facility has been made pronounced by using a site that can easily be appreciated from a vantage point from the bridge away from the ochiidoma's palace, the form of the building as well as its height and the scenic environment has also been used to emphasize this unique quality.

Land topography

The work has been designed in such a way that the building and topography has been harmonized to complement each other, this has been achieved by stepping the building to suit the topography of the site.

7.2 SITE PLANNING CONCEPT

The site has been designed in such a way that the arrangement of facilities flows in tune with that of nature and the various element on site. This has been achieved by the use of spirals, curves which are none rectilinear lines as found in nature, employed to display the forces of nature as it acts with the facility on the site to suit its functions and to arouse interest to enhance visitors experience.

The planning is such that the main Theatre has been placed at the apex thus, striking an observer as the first thing on getting to the site, achieved by placing the building opposite the main entrance which is a dual roadway which branches to the Amphitheatre, admin. On one side and then the souvenir shops as wells as the arts and crafts workshops on the other side, all of which have been laced with sculpture gardens. The other entrance however, is used both as a service route, as well as workers entrance and can also be used as entrance for very important dignitaries visiting the cultural centre.

The cultural centre(Theatre) buildings being of both relaxation learning and preserving culture, it has been placed on the quiet part of the site as regards zoning where the pleasurable ambience of the serene environment of the natural settings provided by the terrain on the site can effectively be utilized.

7.3 BUILDING FORM

The building form has been abstracted from the combination of the cowry shells, it has been combined as it is usually done in the arts of cowries to produce something interesting and beautiful, that has been observed in the fashion of the people where the shells are used to adorn clothing, bags, shoes and are also used in creating items such as bracelets, necklaces, in the afore mentioned examples this shells are combined to form unique pattern to suit the taste and style required, in the same vein this idea of combining the shells has been translated into architecture, in which case the shells have been used both in generating the form and the shape of the plan for the main building.

7.4 DESIGN CONSIDERATIONS

7.4.1 SPATIAL ARRANGEMENT/ORIENTATION

The facility has been designed such that there is the main accessed point for museum visitors which is a tarred road with pavements by the sides for both vehicular and pedestrians and this road leads straight to the main museum building, the road branches to the right where there is the souvenir shops and craft workshop and to the left where there is the amphitheater, parking for each of these units have been provided and there have been designed in such a way that there all radiate from the front of the building,. An evenly distributed sculpture garden emphasizes the integration of ‘leisure’’ and ’recreation’ on the site. Service route have also been provided which is separate from the normal access point to the site, which is also used as the staff entrance.

The Buildings on the site have been orientated in such a way that the longer side is on the north-south axis while the shorter side is on the west-east axis, this has been done to reduce the effect of sun on the building envelope.

7.4.2 CIRCULATION

Efforts were made to delineate pedestrian and vehicular routes on the site, and the vehicular routes have been design in such a way that there is no long stretch of straight roads to encourage over speeding and possible accident, both rather the roads are curvilinear which goes with the flow required in organic architecture.

7.4.3 DAY LIGHTING

Calculations for museum lighting are very theoretical; the quality of light is decisive. Hence effort where made to control the lights entering the building, adjustable shading devices where provided in all the windows to control the light entering the gallery spaces and skylights with tinted translucent plastic or synthetic membrane have also been provide to provide light for the spaces within the main building.

7.4.4 VENTILATION

The ventilation of museum spaces is always dependent on the behavior of the artifact been displayed in respond to light, temperature and humidity as such the windows could be used and there is a provision for HVAC to carter for the ventilation as is required for the various gallery spaces.

7.4.5 SITE PLANNING AND LANDSCAPING

Emphasis is placed on a well landscaped environment to aid relaxation and complement activities of the museum. Tree canopy shaded driveways, hedges are put in place to enhance the micro climate. The planning of the sculpture gardens follows from fractal principles of scaling, self similarity and infinity. Stone paving have been used for the walkways, to emphasis use of natural materials – a doctrine of organic and biomorphic architecture.

7.5 BUILDING MATERIALS AND TECHNOLOGY

Stone, reinforced concrete and glass shall be the dominant building materials for the construction of the edifice

7.5.1 REINFORCED CONCRETE

The fluidity of reinforced concrete makes it a good construction material for the swooping shells and curved columns.

7.5.2 STONE

Is the oldest sustainable material. It is also abundant around the state capital and particularly suites the adapted river metaphor.

7.5.3 TITANIUM

Is fast becoming a competitive building material. It is known for its corrosion immunity, strength, durability and low maintenance cost.

Physical attributes includes: Immunity to environmental attack: corrosion resistance results from its stable highly-adherent, protective surface oxide film.

Low thermal expansion: Titanium's coefficient of thermal expansion is half that of stainless steel and copper and one-third that of aluminum. It is virtually equal to that of glass and concrete, making titanium highly compatible with these materials. Consequently, thermal stress on titanium is very low.

Light weight: The specific gravity of titanium is 4.51 g/cm^3 - about 60% that of steel, half that of copper and 1.7 times that of aluminum. Being such a lightweight metal, titanium imposes fewer burdens on structure. It is easily fabricated and permits ease of installation.

Environmentally Safe: due to its relative inertness in most atmospheres, titanium is considered environmentally friendly. It is 100% recyclable and the product of a renewable resource.

Strength: In addition to having excellent mechanical strength (comparable to mild steel), titanium is durable and shock resistant. Its modulus of elasticity (a measure of strain rate) is half that of stainless steel. This means titanium is more flexible than other architectural metals during earthquakes and other periods of violent movement.

Energy Efficiency: For a metal, titanium is an excellent insulator. Its thermal conductivity of 10 Btu/hr.-F°/ft. is very low (one-tenth that of aluminum) increasing a building's energy efficiency

Aesthetic qualities: titanium is available in its natural finish silver grey color or it can be anodized to a spectacular range of colors.

7.6 SERVICES

7.6.1 WATERSUPPLY

Borehole Water supply is proposed for the facility and also water mains runs along the road where tap water could be accessed, in addition to these water could be gotten from the river for on-site construction.

7.6.2 POWER SUPPLY

Power shall be tapped from the PHCN national grid. There is provision for a power house, with two generator sets – one working and one standby, to cater for power failure.

7.6.3 HEATING VENTILATION AND AIR CONDITIONING SYSTEM

To complement natural ventilation, a central air conditioning system shall be installed.

CHAPTER EIGHT

SUMMARY OF FINDINGS ANDCONCLUSION

8.1 SUMMARY

The research work stems from creating a signatory building for a cultural centre in Otukpo, the problem being that in most previous works architects lay too much emphasis on cultural element(s) to express their creative ideas and in so doing neglect the Acoustical Treatment in the facilities.

The above question has been addressed using Acoustical Treatment which offers a better methodology towards giving a unique identity to a building conversely to the abstraction of its building form, since this approach to architecture places emphasis on building forms, environment, expression and culture of the users, it is considered to be all embracing and hence suitable.

Review of relevant literature in Nigeria and other countries shows the significance of contemporary cultural centres in transforming a city and further discussing the new trends and typologies that shapes cultural centre design.

Findings from writings, simulations and works of prominent sound architects and theorists aided in culminating a set of principles on which sound has been ordered, from these principles, theme peculiar to all of them such as nature, context, vista, interaction with site and growth have been extracted .

Case studies were analyzed using general variables and specific variables (directly related to the subject of sound), of which the degree of application of sound in terms of expressiveness, building form with site, composition, technology, and materials used were considered. Findings from the case studies and literature review were thus used in generating design and planning concepts for the propose facility,these findings demonstrated that emphasis is on the form of the building and that the form is also related to the site character.

Generalizations on the acoustical treatment on Theatres of culture centres buildings were then made and the site where the project will be located was also studied with its peculiarities brought out to the advantages of the design. The locations of the facility are strategically positioned to produce a vista of thought, recognition and appreciation. The proposed design would create an iconic art monument worthy of general appraisal.

It is anticipated that the creation of a landmark building will transform the city, foster economic activities in Otukpo and the facility will assist in the promulgation of the Nigerian/African arts both at home and abroad.

8.2 CONCLUSION

CONCLUSIONS FOR RESULT FINDINGS

1. From the simulation analysis carried out on the Theatres namely cyprain Ekwensi Theatre, University of Jos Multi-Purpose Theatre and U.K Bello Theatre, it was discovered that the three building forms does not serve as Acoustical treatments for sound. except for UK Bello that was a bit fair, Thereby in choosing a perfect building form for the proposed Idoma cultural centre (theatre),and from results and literatures, Theatres with shorter walls that converges serves as perfect building form for Theatres and also with the results shown below which also informed and determined the Hexagonal building form for the proposed Theatre.

THEATRES	REFLECTIONS	POINTS	AVERAGE
U.K Bello Theatre	**Had 237 Reflections**	**146 points**	**191**
CyprainEkwensi	**Had 1131 .**	**380 points**	**255.5**
University of Jos	**Had 270**	**4157 points**	**2213.5**

Table 14: the points scored and averages of the three Theatres simulated.

The intent of the thesis was to examine our effective building forms are been utilized in the designs of cultural centres, its level of applicability in present day architecture with particular reference to cultural centre, to produce an architecture which would be visually pleasing in terms of expression and satisfactory in terms of it's building form both of which are the current waves in architecture and are inherent in Acoustics, the resulting iconic building shall tell its own story from a distance of its rich content, which

would further help to increase the patronage level and provide an excellent platform to boost the arts of the people on a national and international scene.

2. This thesis has demonstrated through empirical evidence how Hexagonal building form can be used to produce dead sound for her listeners, which has been applied in Theatre design to create an architectural destination.

8.3 RECOMMENDATIONS

Upon seeing the potentials inherent in the use of Building forms as Acoustical treatment in Theatres in Cultural centres. The following recommendations are posited:

Theatres should be simulated and tested before they are constructed in order to get a perfect dead sound during performances. There are diverse and mercurial areas of Theatres that can serve as inspiration to the design of Cultural centres.

Conceptual design for buildings should go beyond abstracting artifact or artworks. There should be a sense of deeper meaning to Acoustics in designs. because cultural centres remains viable tool to fostering unity in any Nation.

The approach to cultural centre designs should integrate facilities for a much wider spectrum of users. These edifices should also serve as venues for plays, recreational purposes, conferencing, educational and commercial activities.

8.4 CONTRIBUTION TO KNOWLEDGE

The contribution of this work to the advancement of knowledge can be seen , in the use of an Hexagonal building form as a tool to achieving dead sound for listeners in Theatres from the simulation tests carried out. Secondly, using cultural centre as a tool to foster unity and togetherness by utilizing its wholesome nature.

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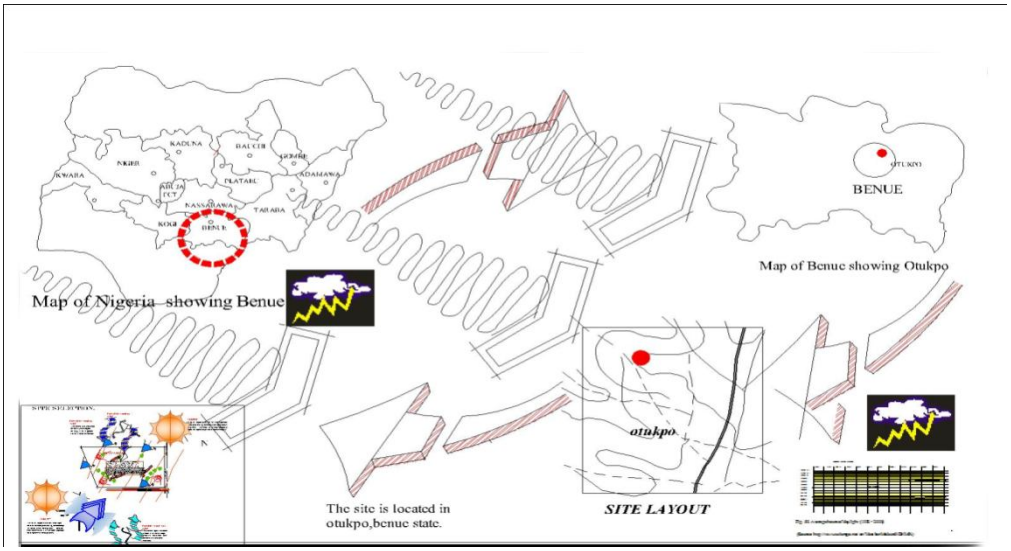
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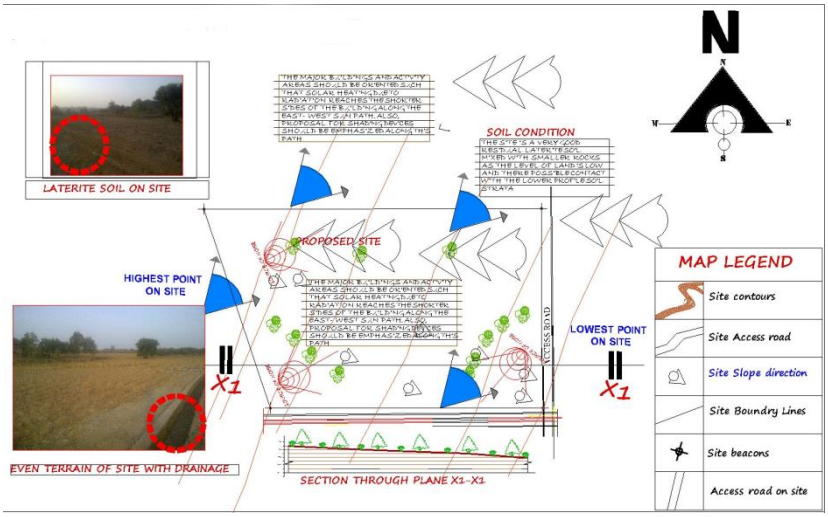
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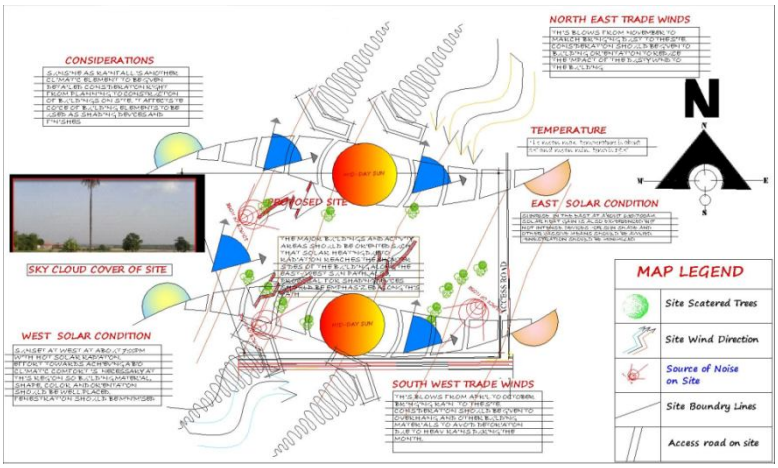
APPENDIX-LIST OF DRAWINGS



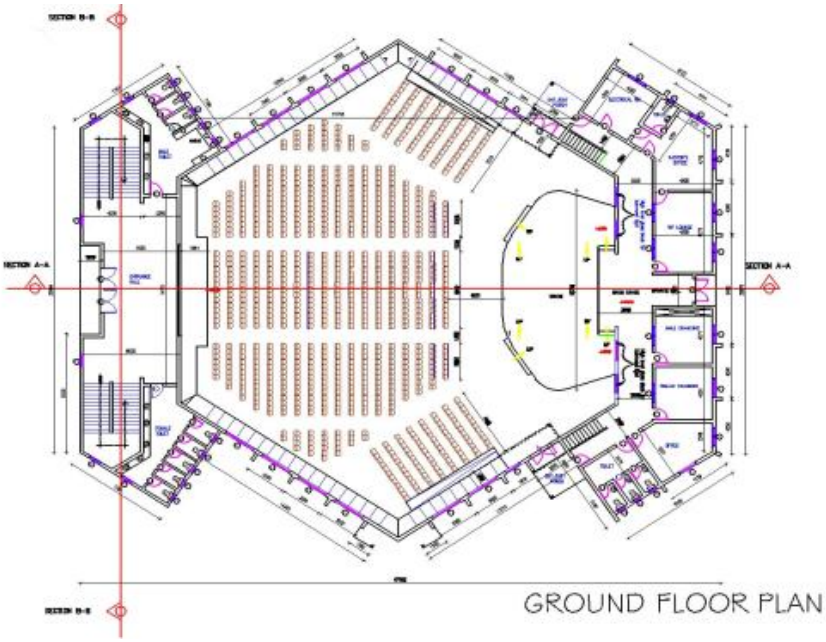
APPENDIX 1 Showing the site location map of proposed site



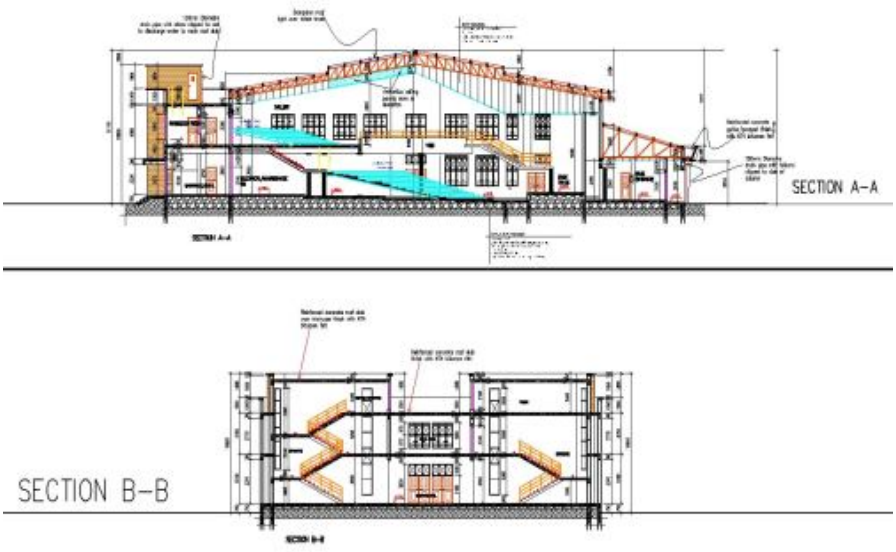
APPENDIX 2 Showing site selection criteria for site.



APPENDIX 3 site considerations for selected site.



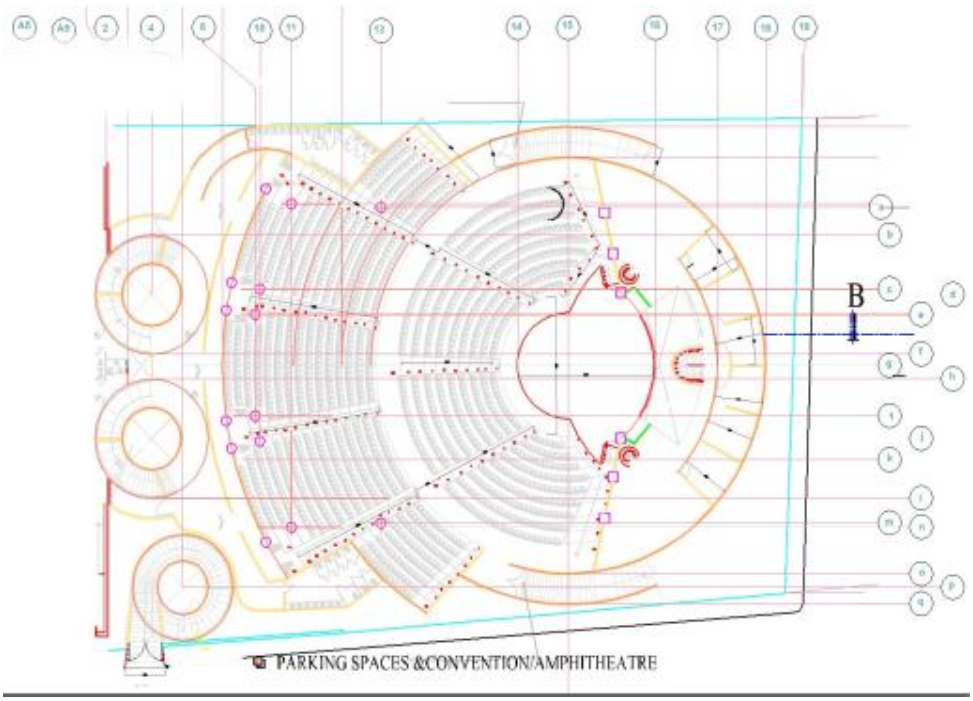
APPENDIX 4 Showing floor plan of proposed cultural Theatre.



APPENDIX 5 Showing the sections of the Theatre.

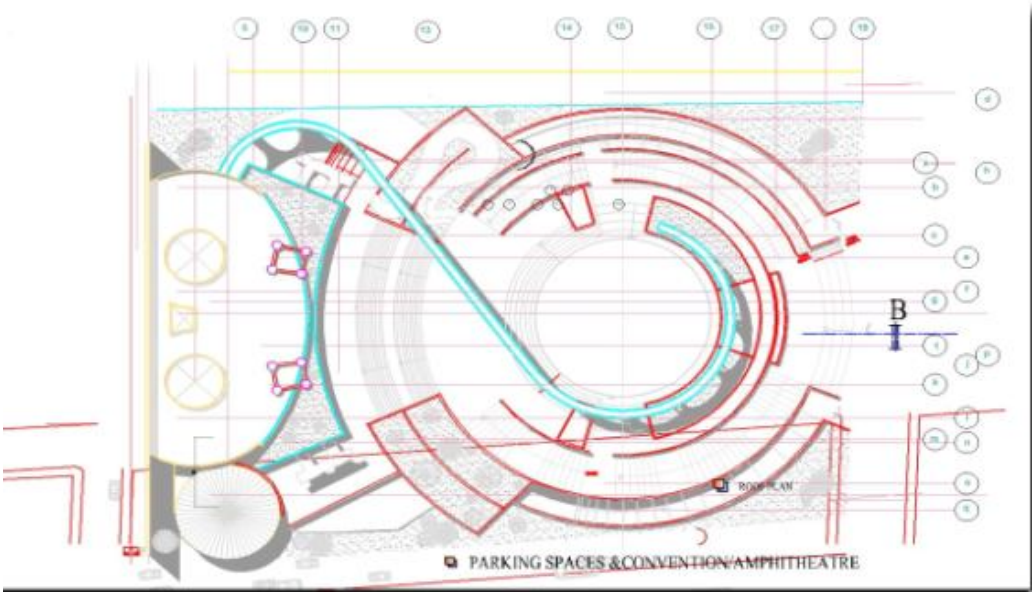


APPENDIX 6 Showing the right and left side elevation for the Theatre.



APPENDIX 7 Showing the Amphi-Theatre which is oval in shape.

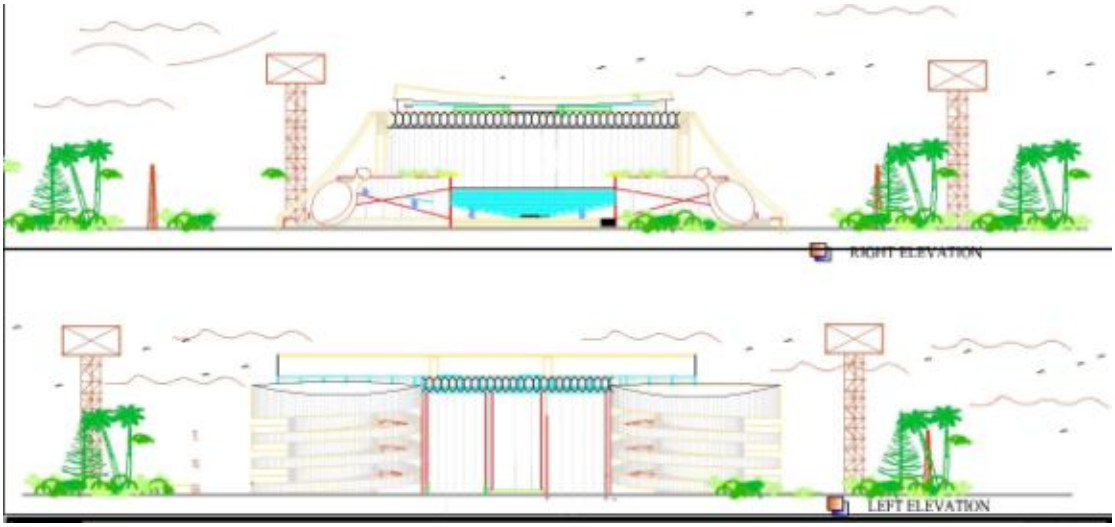
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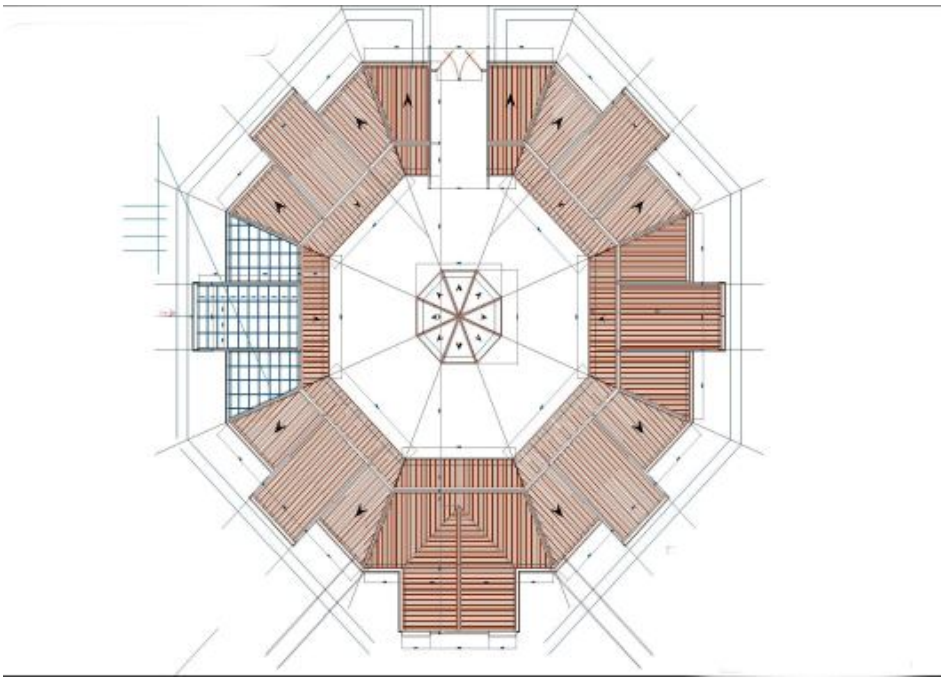
APPENDIX 8 Showing the plan layout for the propose Amphi-Theatre



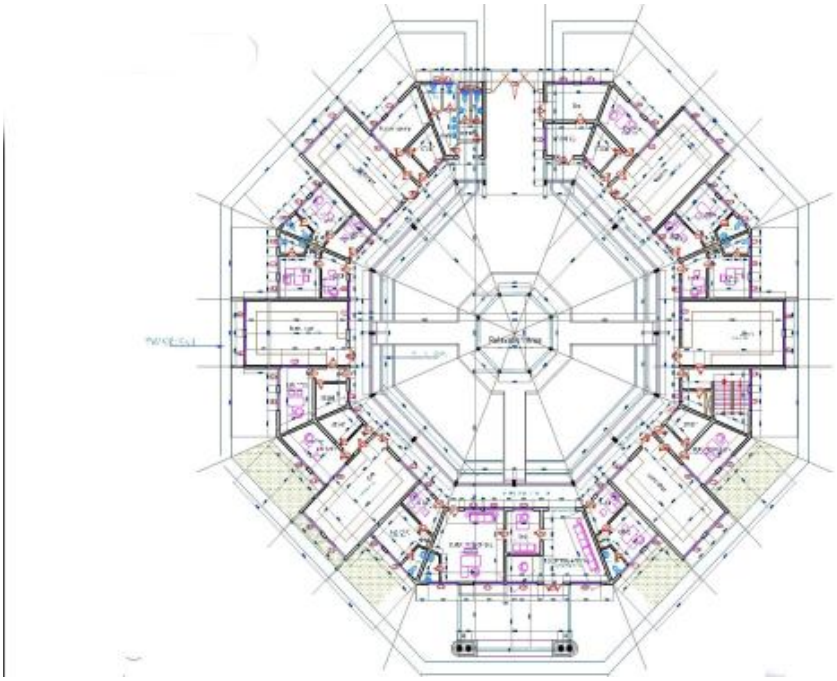
APPENDIX 9 Showing the Approach and Rear elevation of the Amphi-Theatre.



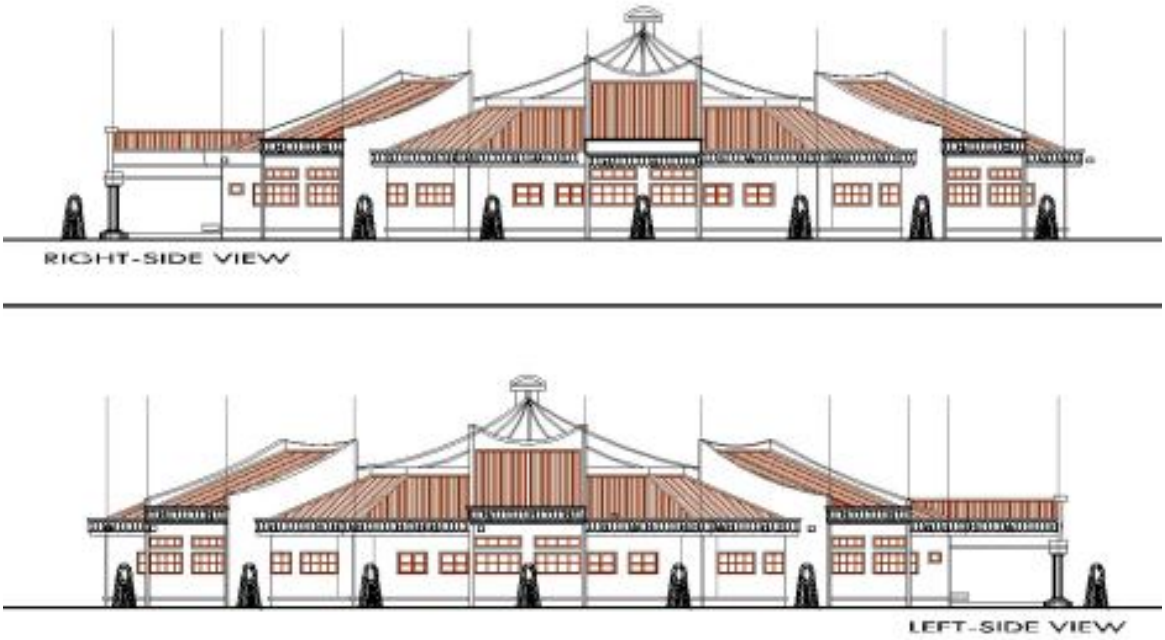
APPENDIX 10 Showing the left and right elevation.



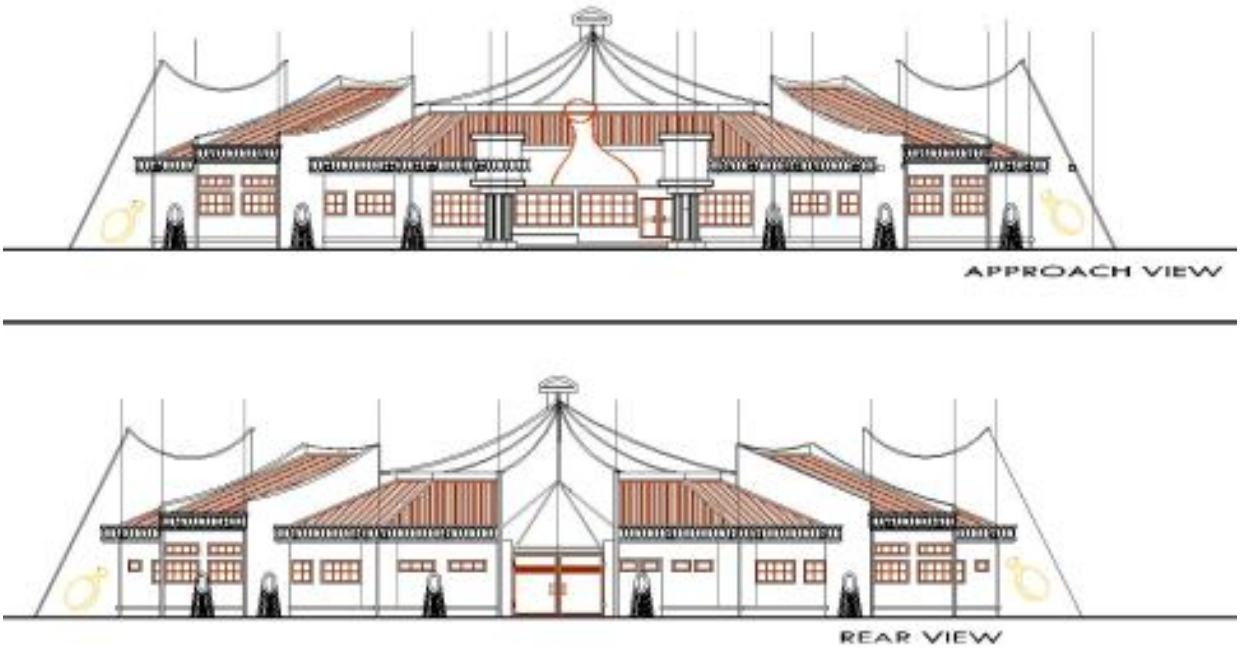
APPENDIX 11 Showing the roof plan for the Administrative block.



APPENDIX 12 Showing the floor plan to the Administrative block to the cultural centre.



APPENDIX 13 Showing the right and left elevation to the Admin



APPENDIX 14 Showing the Approach and Rear elevation.