TOWARDS AN APPRECIATION OF SYMPHONIC MUSIC: THE ROLE OF THE PERFORMING THEATRE

by

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DECLARATION

I hereby declare that this submission is my own work towards the M.Arch. and that, to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Sound quality is a fundamental requirement in performing theatre and auditorium designs. Over the last century, a lot of progress has been made in the study of acoustics in relation to performing theatres. Most, if not all, have revealed that acoustics depends to some extent on the geometry of the space under consideration.

This dissertation discusses the relationship between geometry, objective parameters such as finishing materials, volume etc. and sound quality in performing theatres. It studies the development of theatre designs over the last century and reveals that for a hall, designed primarily for symphony orchestra musical concerts, to fulfill its function well it must be conceived partly as a musical instrument, like the box of a violin or the sound board of a piano. It concludes that every good performing theatre or auditorium requires more than ordinary architectural design skills; it should solve not only acoustics but also the functional problems of comfort and sightlines as well as the problem of visual coherence, all of which revolves around the shape or geometry of the enclosed space.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.0 Overview

Music has been used since ancient times to provide physical and emotional therapy as well as spiritual uplifting. It is the art of making sound in a rhythmically organized, harmonious form; either sung or produced with instruments and usually communicates some idea or emotions. Though it is virtually part of every culture, tribe or people on earth, it varies widely among cultures in style and structure.

Like language, another arrangement of sounds, music is a uniquely human form of communication with well developed rules of construction much like grammar. You can listen to someone speaking a language you do not understand and still know whether the speaker is excited or tired, angry or delighted. You would be making interpretations based upon the speech pattern: loud or soft, high-pitched or low-pitched, rapid and bitten off, or slow and smooth (Butler 2006). As a medium of expression, it carries across emotions and feelings words cannot express. For instance, the suffering and melancholy can be felt in the soulful South African a cappella of the apartheid regime and also in the Negro gospels of the slave trade era; the joie de vivre experienced in the Spanish or Latin American ballads; the list could continue.

The effective communication resulting from interpretation of such speech pattern is however affected by the environment and medium through which it is being transmitted.

For example, music produced in a church environment is different from that produced in a cinema as much as music transmitted through the radio or television is different from that produced in a concert hall. Music is common today than in ancient times where people gathered at common places to listen to music. Not only did ancient people gather for the pleasure of enjoying music but also its related arts such as drama. With the passing of time, these public meeting places have gained much importance as they developed from open spaces to enclosed ones. Today performing theatre design has come to be established as both art and science. Some acousticians even term it engineering art. The need for more research in this direction cannot be over emphasized, as some performing theatres are considered wonderful, especially for symphony music performances while others are considered appalling.

1.1 Background to the Study

The focus of this thesis was on Symphony Orchestra Performance. In order to achieve a desired output of such musical performance, there is the need to know what goes into such performances – history, instrumentation, organizational structure etc. The situation as it pertains in the country was also considered a worthwhile study.

1.1.1 Symphony Orchestra

An orchestra is a large group of instrumentalists who play together as an ensemble, led by a conductor, usually comprising four main sections, namely strings, woodwind, brass and percussion. The term orchestra is derived from the name for the area in front of an ancient Greek stage reserved for the Greek chorus. The orchestra grew by accretion throughout the eighteen and nineteenth centuries, but changed very little in composition during the course of the twentieth century. Symphony is an instrumental passage in a long musical work, which consists mostly of singing, divided into several 'movements'.

The word symphony was derived from a Greek word which literally means "sounding together". The instrumental introduction to a song was, at one time, called the opening symphony. The 'Pastoral Symphony' in Handel's 'Messiah' is so called in contrast to the vocal numbers. Gradually the term was applied to an orchestral piece, such as the *sinfonia avanti l'opera*, and then to a completely separate work. The form and style grew partly from the Italian overture and partly from the concerto grosso.

A smaller orchestra of about forty players is called a chamber orchestra. A full size orchestra, about hundred and four players may sometimes be called a "symphony orchestra" or "philharmonic orchestra"

Fig. 1.1 Symphony Orchestra Performance (Source: Wikipedia 2007)

A symphony orchestra will usually have over eighty musicians on its roster, in some cases over a hundred, but the actual number of musicians employed in a particular performance may vary according to the work being played, and the size of the venue. A leading chamber orchestra might employ as many as fifty members; some are much smaller than that (Wikipedia 2007).

1.1.2 Instrumentation and Proportions

The typical symphony orchestra consists of four proportionate groups of similar musical instruments generally appearing in the musical score in the following order:

a) The woodwinds: 2 flutes, piccolo, 2 oboes, cor anglais, 2 clarinets, bass clarinet, 2 bassoons, contrabassoon

b) The brass: 2 to 6 horns, 2 to 5 trumpets, 2 trombones, bass trombones, tuba

c) The percussion: timpani, snare drum, bass drum, cymbals, triangle, celesta, piano etc.

d) The strings: harp(s), 16 to 30 (or more) violins, 8 to 12 (or more) violas, 8 to 12 (or more) cellos, and 5 to 8 (or more) double basses.

Fig. 1.2 Percssion Instrument, Snare Drum
(Source: AltaVista 2007)

Fig. 1.3 String Instrument, Cello
(Source: Wikipedia 2007)

e) Occasionally, traditional wind ensemble instruments appear, such as the saxophone and euphonium (Wikipedia 2007).

1.1.3 Organization

Between the instrument groups and within each group of instruments, there is a generally accepted hierarchy of leadership. Every instrumental group or section has a principal or soloist who is generally responsible for playing solos within and leading the group. The violins are divided into two groups, first violin and second violin, and therefore have two principals. The principal first violin is called the concertmaster or leader and is considered the leader of not only the sting section, but of the entire orchestra, subordinate only to the conductor.

The principal trombone is considered the leader of the low brass section, while the principal trumpet is generally considered the leader of the entire brass section. Similarly, the principal oboe or sometimes the principal flute is considered the leader of the entire woodwind section. The horn, while technically a brass instrument, often acts in the role of both woodwind and brass. Most sections also have an assistant principal (or co-principal, or associate principal) or in the case of the first violins, an assistant concertmaster, who often plays a tutti part in addition to replacing the principal in his or her absence.

A tutti or section string player plays unison with the rest of the section. Where a solo part is called for in a string section, for example in the violins, that part is invariably played by the section leader. Tutti wind and brass players generally play a unique but non-solo part. Section percussionists play parts assigned to them by the principal percussionist.

In modern times, the musicians are usually directed by a conductor, although early orchestras did not have one, using the concertmaster instead or the harpsichord playing the continuo for this role. Some modern orchestras also do without conductors, particularly smaller orchestras and those specializing in historically accurate performances of baroque music and earlier.

The most frequently performed repertoire for a symphony orchestra is Western classical music or opera. However, orchestras are sometimes used in popular music and are also used extensively in film music (Wikipedia 2007).

1.1.4 Early History of the Orchestra

In the 15^{th} and 16^{th} centuries in Italy, the households of nobles had musicians to provide music for dancing and the courts. With the emergence of the theatre, particularly opera, in the early 17^{th} century, music was increasingly written for groups of players in combination: which is the origin of orchestral playing.

Opera originated in Italy, and Germany eagerly followed. Dresden, Munich and Hamburg successively built opera houses. At the end of the 17^{th} century opera flourished in England under Henry Purcell, and in France under Lully, who with the collaboration of

Moliere also greatly raised the status of the entertainments known as ballets, interspersed with instrumental and vocal music.

In the 17th century and early 18th century instrumental groups were taken from all of the available talent. A composer such as Johann Sebastian Bach had control over almost all of the musical resources of a town, whereas Handel would hire the best musicians available. This placed a premium on being able to rewrite music for whichever singers or musicians were best suited for a performance- Handel produced different versions of the *Messiah* oratorio almost every year.

As nobility began to build retreats from towns, they began to hire standing bodies of musicians. Composers such as young Joseph Haydn would have, then, a fixed body of instrumentalists to work with. At the same time, traveling virtuoso performers would write concerti that featured their skills, and travel from town to town, arranging concerts from whoever was there. The aristocratic orchestras worked together over long periods of time, making it possible for ensemble playing to improve over time (Wikipedia 2007).

1.1.5 The Mannheim School

This change, from civic music making where the composer had some degree of time or control, to smaller court music making and one-off performance, placed a premium on music that was easy to learn, often with little or no rehearsal. The results were changes in musical style and emphasis on new techniques. Mannheim had one of the most famous orchestras of that time, where noted dynamics and phrasing, previously quite rare, became standard.

It also attended a change in musical style from the complex counterpoint of the baroque period, to an emphasis on clear melody, homophonic textures, short phrases, and frequent cadences: a style that was later to be defined as classical. Throughout the late 18th century composers would continue to have to assemble musicians for a performance, often called an "Academy", which would, naturally, feature their own compositions. In 1781, however, the Leipzig Gewandhaus Orchestra was organized from the merchants' concert society, and it began a trend towards the formation of civic orchestras that would accelerate into the 19th century. In 1815, Boston's Handel and Haydn Society were founded, 1842 the New York Philharmonic and the Vienna Philharmonic were formed, and in 1858, the Hlalle Orchestra was f in Manchester.

There had long been standing bodies of musicians around operas, but not for concert music: this situation changed in the early 19th century as part of the increasing emphasis in the composition of symphonies and other purely instrumental forms. This was encouraged by composer critics such as E.T.A. Hoffmann who declared that instrumental music was the "purest form" of music. The creation of standing orchestras also resulted in a professional framework where musicians could rehearse and perform the same works over and over again, leading to the concepts of a repertoire in instrumental music (Wikipedia 2007).

1.1.6 Situation in Ghana – the Ghana National Symphony Orchestra

"The man that hath no music in himself, Nor is not mov'd with concord of sweet sound, Is fit for treasons, stratagems and spoils."

----William Shakespear

Music is a powerful tool. It has strong influence over man's mind, both physically and emotionally, and has been used as healing therapy to affect health and behaviour. The idea of music as a healing influence which could affect health and behaviour is as least as old as the writings of Aristotle and Plato. Seeing the role music will play in the total development of the citizenry and the nation as a whole, Osagyefo Dr. Kwame Nkrumah, the first president of Ghana, ordered the establishment of the National Symphony Orchestra, now the Ghana National Symphony Orchestra (GNSO), by the late Philip Gbeho in 1959 (GNSO 2004). Basically, the orchestra was established with the principal objectives of

a) Developing the performance skills of Ghanaian artistes
b) Promoting music education in Ghana and
c) Projecting African art music.

It was not the intention of Dr. Nkrumah, and the Government at the time for that matter, for the orchestra to generate funds. It was a Government funded institution. This led to a kind of less activity by the orchestra as they only had 'ordered' performances. It got to a point where government could not fund the orchestra any more. The orchestra therefore had to sign a performance contract with government where Internally Generated Funds (IGF) could be created by projecting a targeted amount for a particular year. Government however continued to pay the salary of workers of the orchestra.

The Ghana National Symphony Orchestra started regular and intensive performances with the African Composers Series, purely African compositions, in 1992. This is a programme initiated to give opportunity and exposure to various African Composers who write large as well as small works for the Orchestra. Sunday at '5' with the Symphony, a combination of local and western classical was added later. The orchestra however finds it difficult to advertise their programmes due to lack of funds. This is because monies realized at concerts ends up being used to pay for the venue.

Table 1.1 Summary of composers featured by the Orchestra in the Composers Series

Year	**Performances**	**Venue**	**Composer**
1996	3	National Theatre	G.W.K. Dor Acquaah Harrison
1997	4	"	Acquaah Harrison Ken Kafui Gyimah Larbi
1998	3	"	C. K. Mireku Sharon Katz (South African)
2001	2	"	Acquaah Harrison
2002	3	"	A. Dzokoto
2003	2	"	Oscar Sule

(Source: Ghana National Symphony Orchestra, 2004)

Most of the programmes are performed at the National Theatre and the Accra International Conference Centre. It cost nine million cedis (¢9,000,000.00) per night for the Orchestra to perform at the National Theatre, while that for the Conference Centre is twelve million cedis (¢12,000,000.00) per night. Due to lack of funds these programmes are no more performed regularly.

The instrumentation of the National Symphony Orchestra is made up of western classical and African musical instruments such as violins, flutes, trumpets and heavy fontomfrom drum sets, bells etc. The numerical strength of the orchestra stands at sixty-six, the number of performers being forty-eight and an administrative staff of eighteen. The National Symphony Orchestra has initiated the development of a Youth Orchestra which is almost three years old. In this direction it has to its credit thirty young ones who have already started a training programme and have successfully sat for the ABRSM Exams in Theory Grade V and to a large extent, progressed in the practical quite remarkably. It also has State Drummers who are trained percussionist whose performances include repertoire drawn from the length and breadth of the country.

The Orchestra is engaged in various programmes ranging from educational, state functions, cultural festivals, fund raising, entertainments, anniversaries, school speech days, weddings and funerals etc.

1.2 Aims and Objectives of the study

Every architect relies on the acoustic consultant for good sound quality when the design of auditorium is concerned. Acoustics quality however depends on variability of a wide scope to which the architect can help address at the inception of design rather than over burden the acoustician when design is complete. The aim of this thesis, therefore, was to describe the extent to which the geometry or shape of an auditorium impacts on the acoustic quality of performing theatre.

The objectives of the research were to describe:

a) architects' approach to auditorium designs.

b) the factors that affect or contribute to sound quality in performance halls.

c) technical requirements necessary for auditorium and performance hall design.

The chief end is to gather and also come out with knowledge base information for any architect who will be commissioned as a consultant in the future for such construction as an auditorium or performing theatre, especially one for the Ghana National Symphony Orchestra to avoid what would be termed disaster for orchestral music.

1.3 Research Question

Most at times when we attend musical concerts we either leave by commending the performers for a good show or are appalled by their performance. In Europe, not that much in Ghana, commendation or otherwise of a concert is attributed much to the performing theatre rather than the performers. The performing theatre is seen as a major contributing factor for the success of any musical performance. This has led to some performing theatres being noted and labeled good for musical concerts while others are considered poor for similar events. For example, the Boston Symphony Hall is considered one of two or three great concert halls in the world. On the other hand, the Royal Albert Hall in London was a very bad example of a performing theatre. It had all the faults and none of the virtues of a room intended for either music or speech until its exterior restoration and interior remodeling in 1971 (Izenour 1977:254, 307)

The study wished, therefore, to answer the following questions:

a) How has architects' of some auditoriums approached their design?

b) What are the factors that enhance sound quality in performance hall?

c) How has technical issues been addressed or handled in some auditoriums?

1.4 Significance

Music is the soul of life and because we are what we listen to, it is important to know that the kind of music we listen to has effect on us, either positively or negatively, as individuals and as a society. Most ancient Greek philosophers – Aristotle, Plato and Socrates – believed that listening to music based on certain modes in use at the time was beneficial to the development of a young person's character, and warned that listening to music based on certain other modes would have harmful effects. For centuries, Chinese beliefs about music were influenced by the philosophy of Confucius, in which music was not to entertain but to purify one's thoughts (Butler 2006).

These assertions can be ascertained by the bible story as recorded in I Samuel 16:14-23. The spirit of the Lord had departed from Saul and he was being tormented by an evil spirit from God. He sought David to play the harp for him. "Whenever the spirit from God came upon Saul, David would take his harp and play. Then relief would come to Saul; he would feel better, and the evil spirit would leave him" (I Samuel 16:23).

In like manner music has been used as a therapy, a healing influence to affect health and behaviour. After World War I and II, American community musicians of all types, both amateur and professional, went to veteran hospitals to play for the thousands of veterans suffering both physical and emotional trauma from the wars. The patients' notable physical and emotional responses led the doctors and nurses to request the hiring of musicians by the hospitals. (American Music Therapy Association 2007).

Osagyefo Dr. Kwame Nkrumah, the first president of Ghana, held the opinion that for this nation to develop there is the need for us to change our attitudes through the mind. One way to do this was through music – instrumental music. The Ghana National Symphony Orchestra was established to champion this cause. Almost fifty years after independence, however, the orchestra has done its best but not much has been achieved in terms of the desired mental attitudinal change. This can be attributed in part to the fact that we have overlooked and underrated how enclosed environments like the performing theatre contribute to stage performance. For economic reasons, we always end up with a multi-purpose building whenever we need an auditorium for any specific purpose. It is hoped that this research will go a long way to help us see the need, as a nation, to get a designed and purpose-built auditorium whenever the need arises to build such edifice as a performing theatre, especially for the Ghana National Symphony Orchestra.

1.5 Scope of Thesis

This work attempts to shed light on how the shape or geometry, as a basic design consideration, affects the sound quality and music output in a concert hall. It presents historical development and current trends of performing theatres. It also presents case studies on some auditoriums and finally analyzes geometrical forms.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter of the dissertation looks at the evolution of performing theatres and the factors that play major role in the design of concert hall or auditorium. It reviews the technical and special studies applied to the design of performing theatres and also undertakes case studies of three performing theatres: two foreign and one local. Finally, this chapter will seek to understand the role of performing theatre, as a building, in the performance of musical concerts.

2.1 Evolution of Performing Theatres

The history of theatre development spans over two thousand five hundred years (Neufert 1936:476). Tracing from the Hellenistic periods, buildings were improved for dramatic and athletic activities. The Greeks developed further these unroofed performing spaces into three parts: the auditorium (cavea or koilon), the orchestra or dancing floor and the stage building or skene (Fletcher 1996:158,160). The auditorium was the seating area for the audience of thousands. The chorus of each play danced and sang at the orchestra. Behind the orchestra was the stage building, a temporary structure that acted as a back cloth. It was separated from the auditorium by a passage to the either side. (ibid 160)

Though theatrical performances took place during Byzantine times and the middle ages, no theatres were built to house them during the 1,100 to 1,200 hiatus, and that when theatre began again in the late Italian Renaissance the influence on design, similar to architecture in general, stemmed from the ancients primarily by method of Vitruvius' De architectura (Izenour op cit: preface). The academy, ducal court theatres and grandes salles of north Italy in the late sixteenth and seventeenth centuries were instrumental in developing public performance of drama, opera, ballet and absolute music. This set a formula – the horseshoe-shaped auditorium – for the design of court and public theatres throughout Europe that was adhered to until late in the nineteenth century (Izenour op cit: preface).

Hellenistic and Roman designers were first to make a building of a theatre. In the Hellenistic period, the auditorium was a permanent feature of the theatre and was of stone construction much as the seating and stage building. The orchestra was circular and retained its shape as an essential element in theatre design. It was however reduced to semi-circle and used for seating in the Roman periods (Fletcher 1996:160). It was characteristic of theatres to be situated against hill slopes, particularly of the Greeks, taking advantage of the natural slope for seating. As unroofed structures, theatres were used for political meetings where majority of the people could gather.

The Athenian theatre, 452-330 BC, in the sanctuary of Dionysus was initial design of European theatres. Built against the south slope of the Acropolis, it had only wooden seating (ibid 160). Contrary to this theatre was the Marcellus theatre, which was first to be built in Rome. It was entirely of stones. During the medieval period, the stage building was gradually being organized into a well organized space. Temporary platforms and fittings were adopted for the stage or orchestra. The Dionysus and Marcellus theatre became the bases and were improved upon for subsequent theatres from the Renaissance to the Contemporary times.

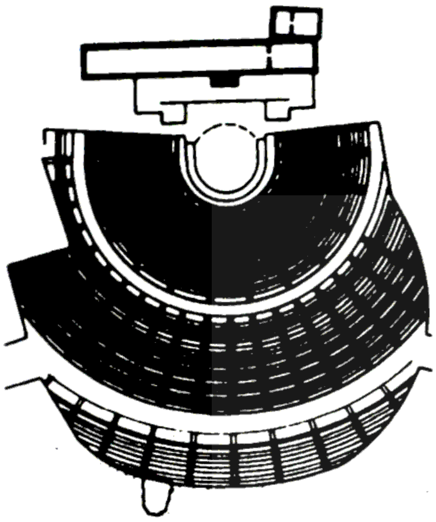

Fig. 2.1 Dionysus theatre, Athens, 452/330 BC (Source: Neufert 1936:476)

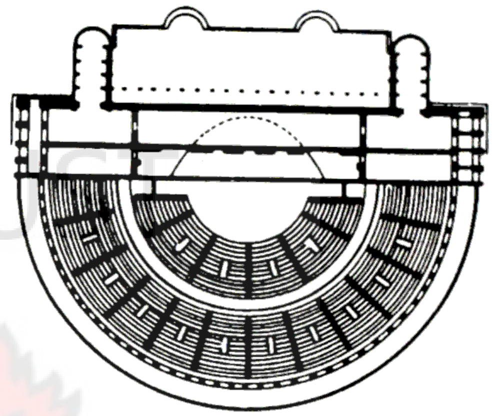

Fig. 2.2 Marcellus theatre, Rome: 11500 seats 11BC (Source: Neufert 1936:476)

2.2 Current Trends in Performing Theatres

Performing Theatres follow two trends in this contemporary time:

a) Preservation, restoration and modernization of the previous theatres of the 19th and up to the middle of the 20th century. By this conscious effort is made at maintaining old structures and their style while improving their acoustic quality through modern technology.

b) New buildings with "experimental" open space features, eg. Theatre on Lehniner Platz. These are new buildings that are either modeled after old patterns and are flexible to adapt to new materials and modern technology (Neufert 1936:477).

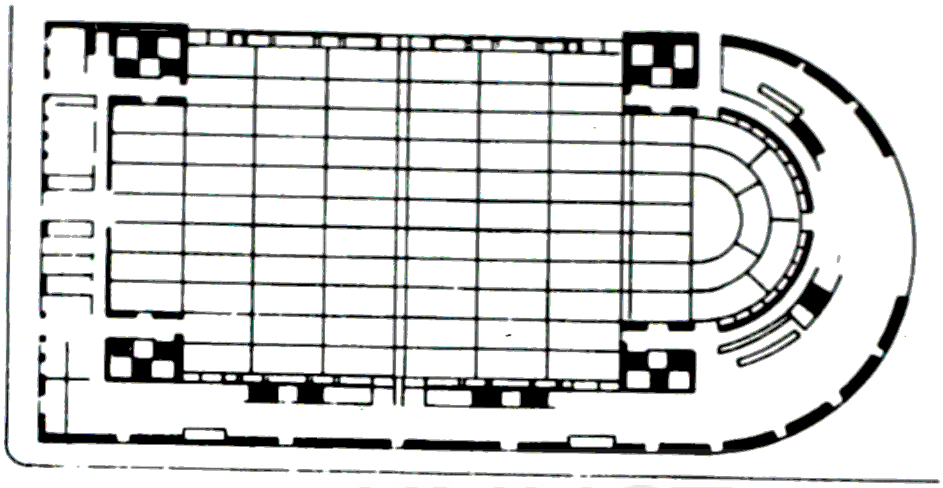

Fig. 2.3 Theatre on Lehniner Platz, Berlin 1982 (Source: Neufert 1936:477)

There are however two different expressions of theatre for performing arts: the Opera and the Theatre.

The Opera, used for operas, is in the tradition of the Italian Opera buildings of the 18th and 19th century. It is characterized by a clear spatial-architectural separation between the audience area and the stage by orchestra pit and through large seat numbers of about one thousand to four thousand seats (ibid 477).

The Theatre, used for musical concerts, is structurally in the tradition of the German reform theatres of the 19th century. It is characterized by the stalls arrangement where the audiences sit in a large ascending curved area and by a distinctive front acting stage, an area in front of the proscenium in the auditorium. Theatres, however seek in particular the tradition of the English theatre where the acting area is in front of the auditorium (ibid 477).

2.3 Factors for Consideration: Concert Hall Design

Every performed art is a performer – audience shared experience entirely dependent upon the sensations of seeing and hearing. The objective of theatre design is to make complementary the limited (visual) and controlled (aural) environment necessary for the performer - audience experience. It is axiomatic that good lines for sight are also good lines for hearing. History shows that the Greeks and Romans found out by empirical means that speech and hearing are essentially directional and that speech and sight are both straight-line phenomenon. Thus, if a sound source is within a reasonable distance and can be seen; it can also, with due consideration of ambient conditions be heard. These two systems constitute the separate studies of vision (optics) and hearing (acoustics). They share common properties of reflection, refraction, diffraction and absorption, a precise understanding of which, within the operative ambient environment of performer and audience (provided by a building or other structure) is the basis for theatre design (Izenour op cit: preface)

2.3.1 Acoustics

In auditoriums and performing theatres, there are two forms of sound:

a) Primary Sound: This is the sound radiated from the performers on the stage directly unto the audience.

b) Secondary Sound: This is the reflected sound from various surfaces (walls, ceilings, floors etc) within the hall.

Since ancient theatres were open air and outdoor for that matter, greater subtlety and nuance of sight and sound was transmitted possibly in a direct conversation between two people close together. This great fundamental limitation in the ancient outdoor theatre resulted in use of the speaking orifice of the face mask to extend the aural field. The modern theatre, being enclosed, uses the building itself as the principal means for conversation and redirection of the acoustical field (Izenour op cit: preface).

Today, electro-acoustic has provided an expanded acoustical dimension. In addition to electro acoustics, safe artificial lighting of interior space imposes reasonable finite limits and accentuates as never before the enclosed visual field. Until the development of electric light, the theatres of the ancient world, Renaissance, Baroque and the late 19^{th} century were, unless confined to daylight use, subject to severe visual limitations as well. The openings in an enclosed space (open windows, clerestories, roof lanterns, doors etc.) which for visibility let light energy in also let sound energy out. Also, open combustion of light sources was unsuited to either efficient concentration or redirection of light output. The need to reconcile these two energy systems is a major challenge that eluded auditorium designers (Izenour op cit: preface).

2.3.2 Reverberation Time

Designing concert halls with good acoustics was a matter of sheer luck in the past. No one really understood what made one hall sound wonderful and another appalling. Many concert halls failed and were destroyed as a result; not until the early 1900s when Wallace Clement Sabine developed a more precise science for the study of architectural acoustics. Using the Fogg Art Museum's lecture hall for his experiment, he delved into the scientific study of room acoustics and concluded that sound energy produced in any room takes some amount of time to decay; and that the amount of time, known as reverberation time (RT), depends on the room volume and materials (Concert Hall Acoustics 2004). He formulated the following equation:

$$RT = \frac{0.16V}{S(\alpha)}$$

where V is volume in cubic meters, S is total surface area of the room in square meters, and α is the average absorption coefficient in the room.

The reverberation time (RT) is the time it takes for a sound to decay by 60dB. It is one of the few concert-hall criteria which can be defined precisely and measures with reasonable accuracy. When sound is produced in a room it does not die straight away but continues to be heard for some time due to reflections from walls, ceilings, floors and other surfaces. This secondary sound will mix with later primary sound and produce what is known as the reverberant sound. It is this reverberant sound which can assist understanding or help convey an atmosphere to an audience (Smith et al 1982:34). The reverberation time however varies for different functions.

Following Sabine's foundation, others have developed empirical methods for ideal reverberation time. Two of such formulae are attributed to "Stephens and Bate" and "Eyring", while another method uses a set of graphs.

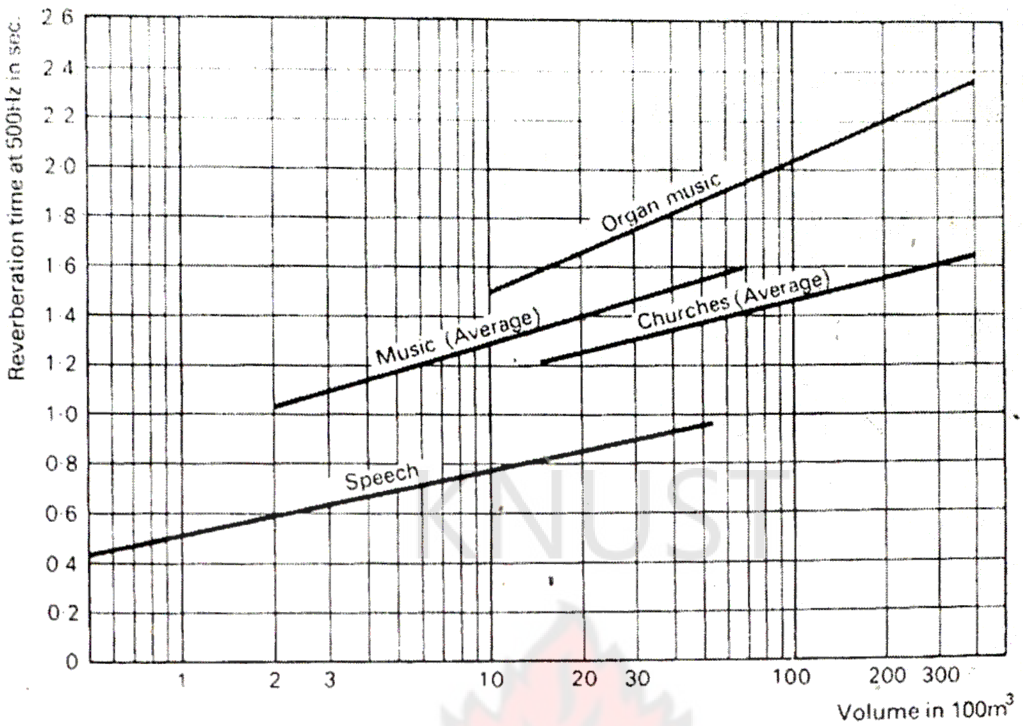

Fig. 2.4 Optimum reverberation time for auditoria of different sizes (Source: Smith et al 1982:36)

2.3.3 Volume

In order that the optimum listening conditions are obtained, it is essential that a hall has the correct order of volume for its use. All the formulae that have been developed show that reverberation depends on the volume per person in the auditorium and especially for Sabine, reverberation time is directly proportional to the volume of the auditorium. The volume per person is however dependent on the purpose for which the building is to be used. Speech and music have totally different characteristics and requirement. Music played in a hall with too small volume is likely to lack fullness, whereas speech in a hall with a very large volume for its seating capacity can be expected to lack clarity (ibid 34). The table below shows a general pattern of volumes to which nearly all of the best concert halls and opera houses in the world fit into.

Table 2.1 Optimum volume / person (m^3) for various types of halls

	Minimum	Optimum	Maximum
Concert halls	6.5	7.1	9.9
Italian-type opera houses	4.0	4.2 – 5.1	5.7
Churches	5.7	7.1 – 9.9	11.9
Cinemas	–	3.1	4.2
Rooms for speech	–	2.8	4.9

(Source: Smith et al 1982:34)

2.3.4 Materials

The acoustic environment is a major determinant of perceived sound quality because most of the sound emitted by a source (*e.g.*, a loudspeaker) typically arrives at the listener through a multiplicity of paths. The acoustic environment is the complete set of all objects and their respective physical properties having an influence on the sound field that surrounds a listener (Keith Yates 1998-2001). When sound energy hits a surface or boundary, some of it is reflected, some is absorbed, and some is transmitted through the boundary. The percentage of sound reflection, absorption and transmission depends on the properties of the boundary material. The properties of the material affect how much each frequency component of the sound wave is absorbed and how much is reflected back into the environment (ibid 2001). Choice of finish materials for walls, floors, ceilings, seats etc. should be made carefully. From Sabine's formula it is seen that the greater the absorption properties of the finish material, the smaller the reverberation time and vice versa. In general, soft porous materials absorb sound better than hard materials.

Placing more soft materials in the room will reduce the amount of sound energy in the room, while more hard materials will keep the sound energy in the space for a longer period of time.

2.3.5 Geometry

One overpowering fact that bridges the gap in time between ancient and modern performers and audience was the desire of both to be seen and to be heard and to see and to hear. Ancient theatres had its origin "in the round". That is from the Greek classical open-air theatres. This could not remain for two main reasons:

a) Discrimination between and consequent separation of participants and audience, essentially by virtue of unequal hierarchical position or talent, resulting finally in emergence of the performer and

b) Inclusion of ever larger audiences until the whole free population of a small town came to a single performance (Izenour op cit: preface).

Modern theatre design is concerned with manipulation of three basic geometries that control design.

a) The originating system is the circular, unified and essentially democratic one of the classical theatre.

b) The horseshoe-shaped, fragmented and vertically stratified system of the baroque (derived from a misinterpretation of the design intent of the Roman theatre) and

c) The wedge (fan) shaped plan of the last 100 years; derived from the reassertion of the design principles of the Greek theatre (Izenour op cit: preface).

The second represents a departure from classical principles. The latter is a return to those principles but is in somewhat different context.

Today there is infinite variation both rectilinear and curvilinear within the parameters of these separate seating geometries. In the classical period, 1750-1820, for example, the horseshoe plan was used frequently. It offered much lateral reflections from the side wall and so was considered perfect for performing theatres. The need to overcome visual limitations resulted to experiential forms: the fan shape, reverse fan shape, theatre in the round or arena seating, where the stage is in the middle of the auditorium, and the vineyard terracing. Further experimentation resulted to a combination of some of these forms. Example is the Berlin Philharmonie, which is a combination of theatre in the round and vineyard terracing. It resolves the relationship between audience and performers, aurally much than visual.

Beyond the seating, and sighting for that matter, the role geometry plays in enhancing acoustics cannot be over emphasized. Geometry of the enclosed space – corner edges, openings, shape, size, – often influence sound in ways more complex than just reflection, including diffraction, refraction and diffusion.

2.4 Technical and Special Studies

Performing Theatre, much like the Operating Theatre is more technical than art; there is therefore the need to follow certain technical requirements in its design. Technical and Special Studies revealed the following fundamental requirements as means to achieving both comfort and safety.

2.4.1 Auditorium

Various plan shapes can be satisfactory acoustically, but square rather than long proportions are preferable because sound paths are then more equal in length. This helps in obtaining a steady decay of reverberation. Gallery should be shallow to avoid sound shadows and non-reverberative 'pockets'. The ceiling, if shaped, should provide progressive reinforcement of sound towards the rear, but the surface should be broken to contribute towards background reverberation. The diagram below show acceptable width limits for auditorium. In simple terms, the width is about 0.5 to 0.6 of the length.

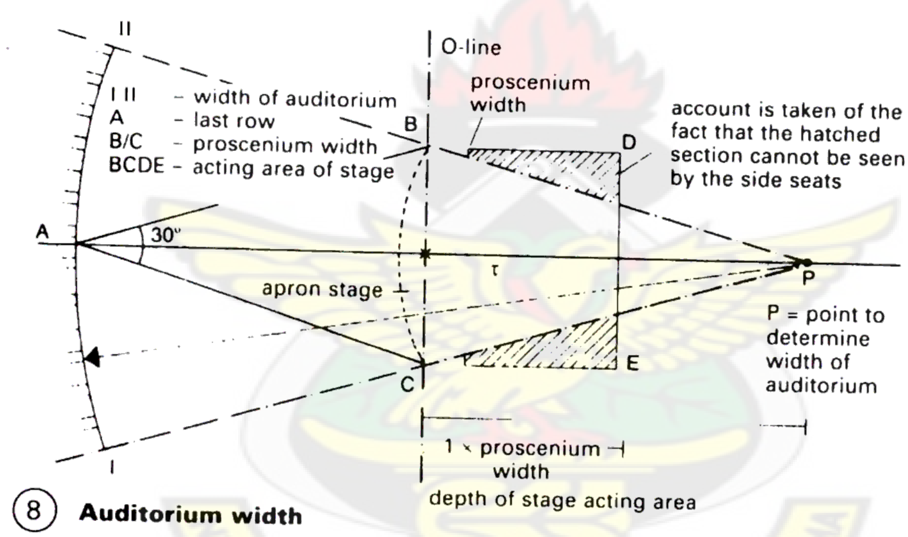

Fig. 2.5 Auditorium width limits (Source: Neufert 1936:478)

Sight distance: For modern acting technique, the furthest seats should not be more than 30m from the centre of the acting area. It is noted that expressions on actors' faces are indistinguishable beyond 22.5m as this is a better acoustic criteria. A sight distance however varies with respect to function, type and scale of performances. For opera and musicals discerning facial expressions is less critical and distances can be 30m. For dance the audience needs to appreciate the body movement and facial expressions; distance not to exceed 20m. For symphonic concerts, acoustic considerations predominate. A fan-shape auditorium has the advantage of placing majority of the audience at some distance from the orchestra, providing them with a more balanced hearing of the orchestral ensemble. For slide, video, television and overhead projections visual limitations are determined by their respective technologies (Neurfert op cit: 478)

Sight lines: The lines of vision are used to determine the elevation of seating (gradient) in the auditorium. These lines are valid for all seats, stalls as well as circles. Audience sits in 'gaps', therefore only every second row requires full sight elevation (12cm). Seating should be raked for two reasons: first, to provide strong direct sound and the clear receptive of transients. 'Transient' is the musical term for the initial sound produced by an instrument. It has a different quality from the remainder of a sustained note; second, to allow each spectator to have clear view to the focal plane. Raking should have an average gradient of 1:10 (6^o) or 1000mm threads by 100mm. A maximum gradient of 1:6 (10^o) or 900mm threads by 150mm risers is acceptable but above this steps should be used for seating tiers. (Neurfert op cit: 478)

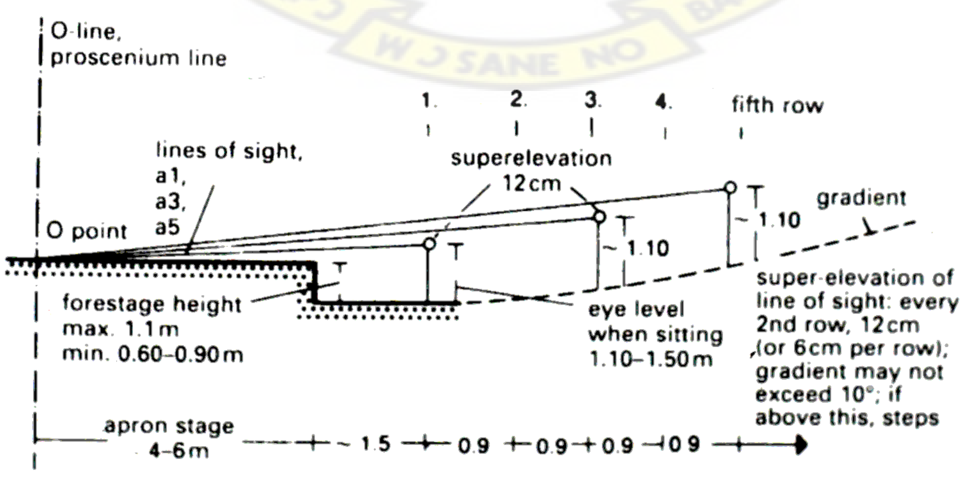

Fig. 2.6 Super elevation of seating (Source: Neufert 1936:479)

Seating geometry: Seats are preferably laid out in curved rows to focus towards the stage. Other forms are angled row and straight row. Straight rows emphasis blocks of seats and are often used.

Seats per aisle: Seating and aisle arrangements should be as economic as possible, to reduce the distance of rear seats from the stage. On average, each person or seat should occupy an area of 0.5 square metre and have a maximum of 16 seats per aisle with gangway at only one end. 25 seats per aisle is however permissible if there are gangways at both ends of row, with side exit door 1m minimum width per 3- 4 rows of seats (Neurfert op cit: 479).

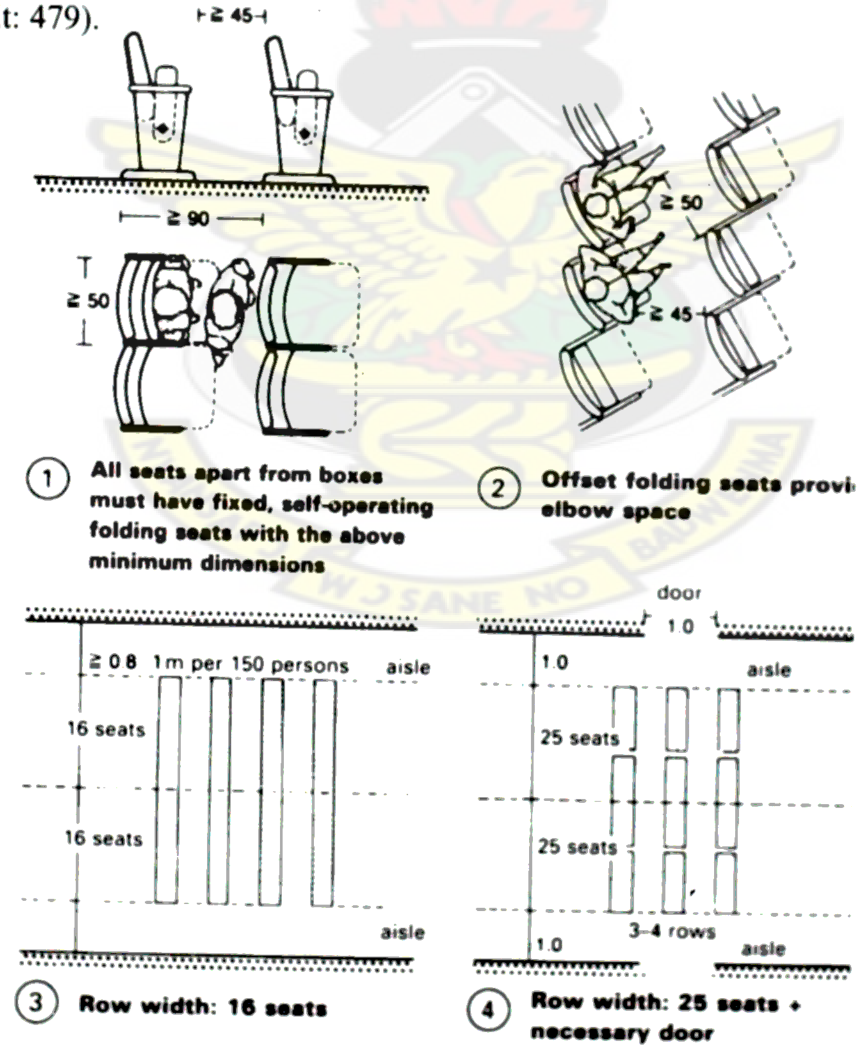

Fig. 2.7 Audience seat and access requirements (Source: Neufert 1936:478)

Stage: The performing area should fall within boundary defined by 110⁰ angle of peripheral spread of vision from seats at the middle of front row. According to Nuefert, this is the maximum perception angle without head movement; within this field everything which takes place between the corners of the eyes is perceived. For middle seat at centre row, stage should be 60⁰ for good view with slight head and eye movement, while that for middle seat at back row should be 30⁰ without head movement but slight eye movement. (Neurfert op cit: 478).

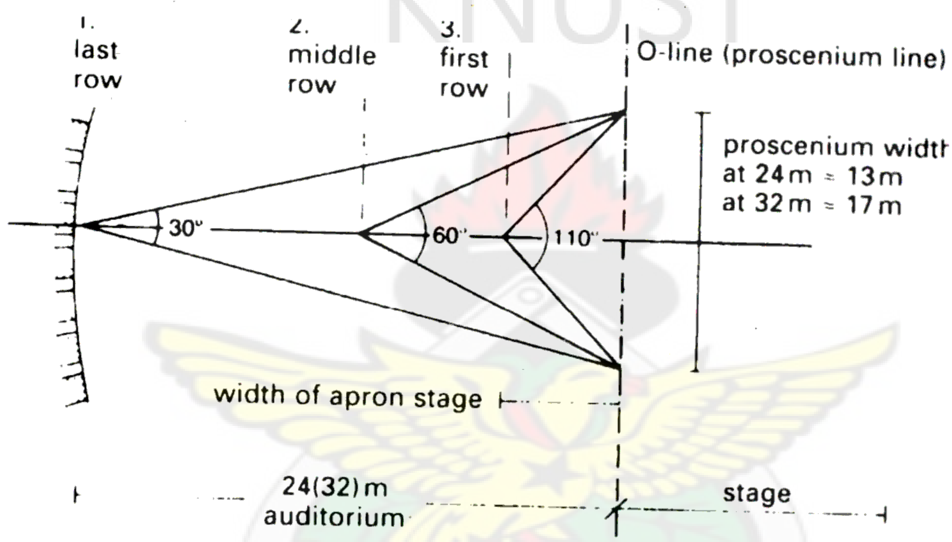

Fig. 2.8 Proportions of the traditional auditorium (Source: Neufert 1936:478)

2.4.2 Circulation

Exits: exit doors should open outward and follow a general rule of 1.6m width for 250 people.

Corridor width: up to a 100 people, 1.1m is necessary.

Stairs: should be positioned to avoid creating any form of obstruction. It should enhance free flow of movement.

2.4.3 Lighting

There are different requirements for lighting in an auditorium.

Performance lighting: lighting is an integral part of the stage for theatre, opera and dance with lighting placed not only at the stage level but also at ceiling level within the auditorium, on side and rear walls and balcony fronts.

Backstage lighting: for performers and service staff, the corridors and escape routes must always be kept lit whenever building is occupied.

Normal lighting: this is for workshops and changing rooms. These may be fitted with detectors to ensure lighting goes off when rooms are not occupied.

House lighting during performance: certain lighting is responsible to come on automatically in emergency situations.

House lighting at other times: working level of light is also necessary for cleaning purposes, maintenance and during rehearsals.

2.4.4 Sound Insulation

Auditoriums need to be isolated from noise. To achieve appropriate Noise Reduction (NR), the following measures are taken into consideration:

a) Auditorium should be isolated structurally.

b) There should be noise reduction to air-condition ducts.

c) There should be sound locks or lobbies to all doors at points of entry.

d) Services areas should be acoustically sealed (Egan 1988).

2.5 Case Studies

Case studies were conducted on two foreign and one local performing theatres; the Morton H. Meyerson Symphony Centre (USA), Berliner Philharmonie (Germany) and Accra International Conference Centre (Ghana). It is an attempt at studying what went into the design of these buildings and how they contribute to performances.

2.5.1 The Morton H. Meyerson Symphony Centre, Dallas (Texas) – U.S.A

Fig. 2.9 Meyerson Symphony Centre, Perspective

The plan of the Morton H. Meyerson Symphony Centre is a combination of overlapping geometric forms. It starts with a rectangle set at an angle within a square and is enveloped by segments of a circle. The central rectangular form houses the performance hall. Surrounding it, under a sweeping glass canopy, are various layers of programmed and unprogrammed public space, including an expensive sky-lit lobby, a garden court restaurant and sculpture garden. The total structure is tilted toward the skyline to establish a visual connection with the city's emerging Arts District and with Dallas' urban centre.

Fig. 2.10 Meyerson Symphony Centre, Plan

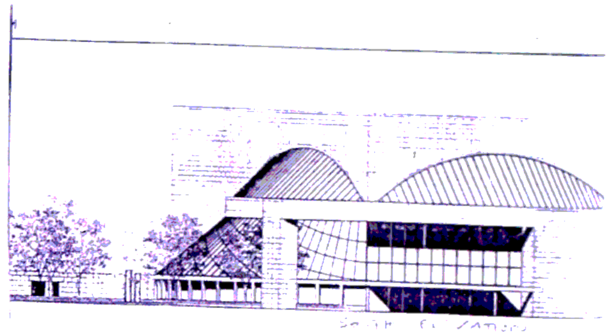

Fig. 2.11 Meyerson Symphony Centre, Elevation

The building programme required a design that would accommodate two different, but related, functions. Of paramount importance is the performance hall. Its form and shape are the result of rigorous adherence to the acoustician's requirements for audience distribution, unobstructed sight lines and acoustical excellence.

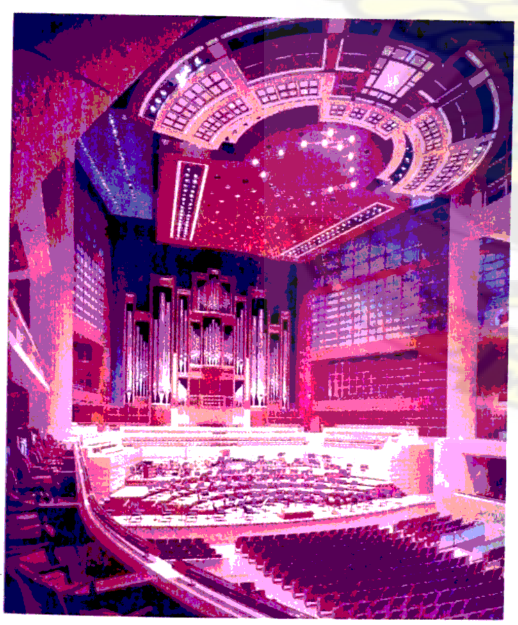

Fig. 2.12 Meyerson Symphony Centre, Interior view towards stage

Fig. 2.13 Meyerson Symphony Centre, Interior view towards entrance

Seating 2,062 people on four levels, the concert hall focuses on the performance platform and on the grand concert organ. Suspended above the orchestra is a back-lit acoustical canopy which, together with three smaller flanking canopies, can be mechanically raised or lowered for perfected symphonic sound. Notwithstanding technical constrains, the hall was designed to possess a quality of ambience that gives pleasure to the making of, and listening to, music.

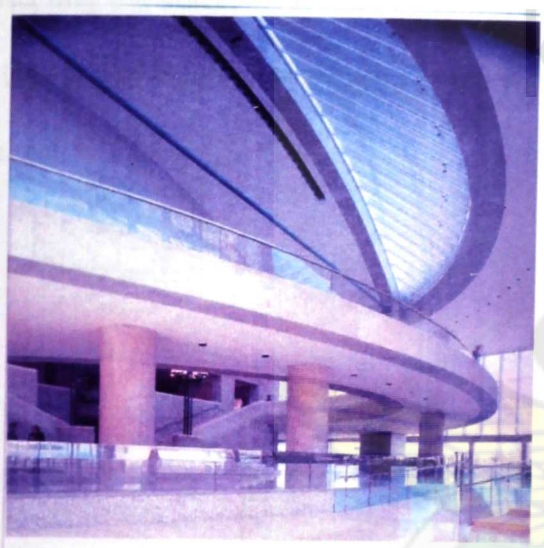

Fig. 2.14 Meyerson Symphony Centre, Sky-lit lobby

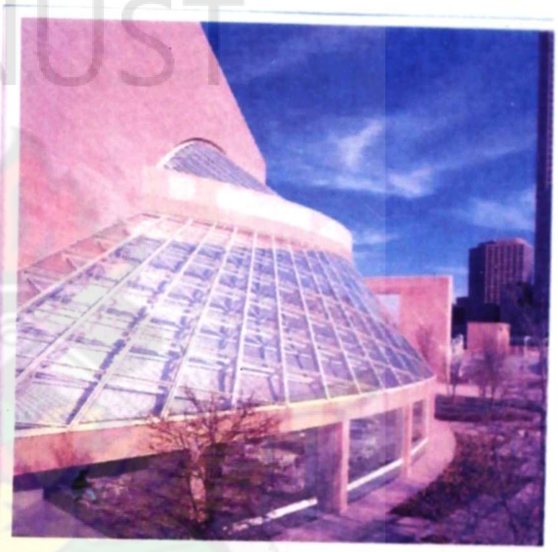

Fig. 2.15 Meyerson Symphony Centre, Garden Court Restaurant & Sculpture Garden

In contrast to the necessarily closed character of the performance hall, the surrounding public areas are transparent by day and night, offering an inviting place to congregate when performances are not in progress. These intricately glazed spaces have been designed to provide visual excitement through the manipulation of light, movement and changing perspectives. In this way, the Meyerson Symphony Centre reaches out to a larger public than those attending performances; it helps to anchor and enliven the Arts District while enriching the city as a whole (Pei I. M, September 1989).

2.5.2 Berliner Philharmonie, Berlin – Germany

Berliner Philharmonie design was as a replacement for a traditional rectangular single-ended concert hall of the same name destroyed in World War II, is one of the most controversial auditoria designed specifically for absolute music in the Western World. It has been and still is both highly praised and damned. Study of the plan and perspective section reveals that about 70 percent of the audience is placed in front of a transverse line bisecting the stage, with the remaining 30 percent behind and to the side of the shallow, wide, centre stage, this imparts to the room a long and short axis as much psychological as real.

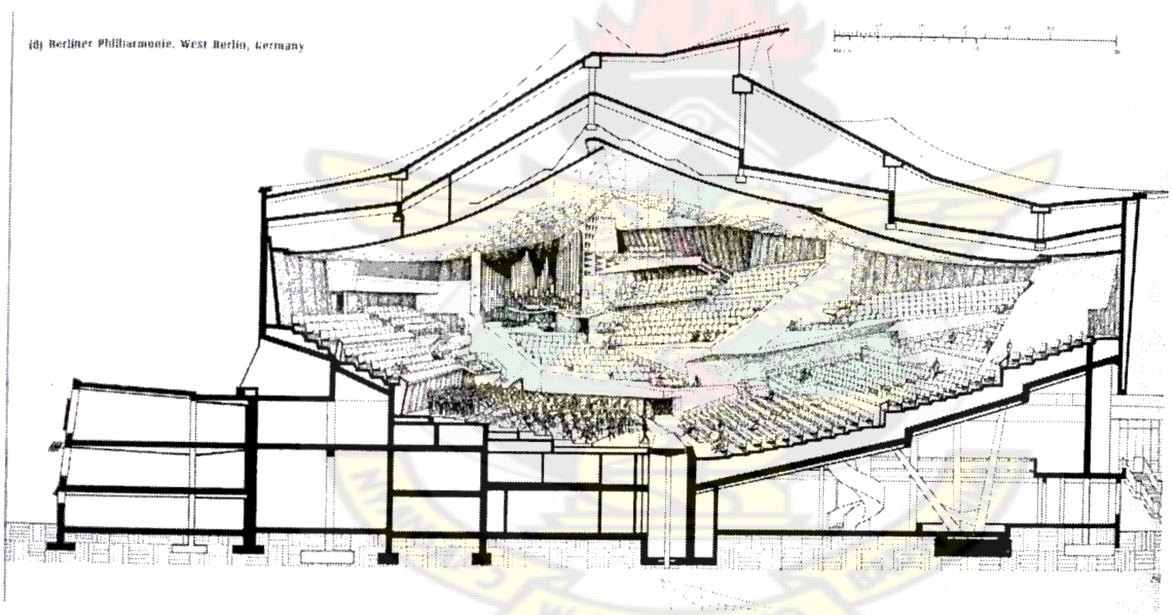

Fig. 2.16 Berliner Philharmornie, longitudinal perspective, section A-A' (Source: Izenour 1977: 256).

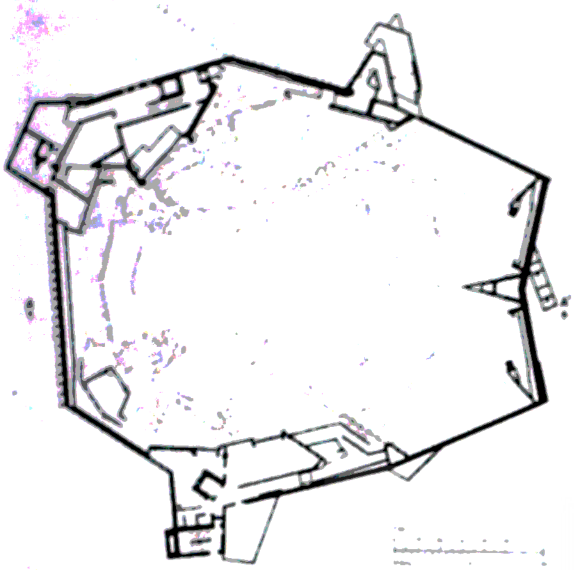

Fig. 2.17 Berliner Philharmonie, plan
(Source: Izenour 1977: 256).

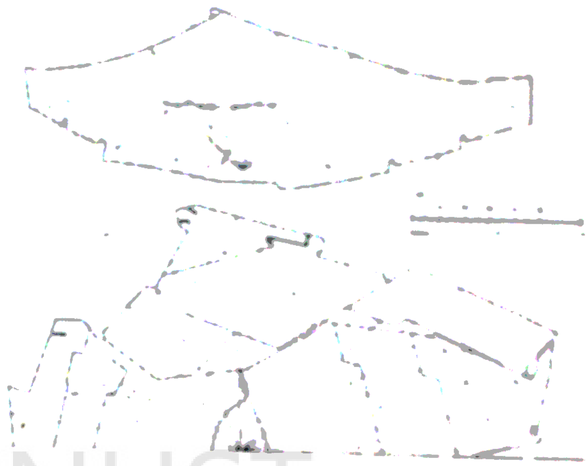

Fig. 2.18 Berliner Philharmonie, half-plan and section, first reflection analysis
(Source: Izenour 1977: 256).

The vertical sight lines have been carefully determined so that every seat has an unrestricted path for direct sound from the stage. The same can be said for early first energy reflections. There are, however, more controversial considerations:

a) Use of the movable overhead convex reflectors in lowered position over the stage and

b) Soloist with or without orchestra.

Both are unresolved problems and are still actively debated by professional musicians, critics, and acousticians as well as by members of the audience. There is general agreement that the symphony musicians hear each other better when the overhead panels are lowered and high frequency response is certainly improved in that proportion of the auditorium within 15m of the stage as well. Maestro Herbert von Kárajan, music director of the Berliner Philharmonie Orchestra, does not agree with this, however; he prefers to keep the panels high up and in a line with the lower extremities of the convex curved high ceiling. But the principal controversy is over the problem of the soloist; this has not been solved to the satisfaction of either the soloist himself or that part of the audience seated behind and too far to the sides of the platform.

The symphony orchestra, being a large, more or less diffused aggregation of instrumentalists, is not subject to the same difficulties in the round as the single instrumentalist or vocalist, whose energy field is acutely more directional than the orchestra's. The problem of audience envelopment for the vocalist in a room as large as this one is similar to that for the actor playing in the round for two reasons:

a) The radiated energy field behind the performer lacks strength and projection, and

b) The audience seated behind cannot lip-read, and this inhibits understanding of sung lyrics.

The acoustical problem for the instrumentalists is similar but somewhat different. It is a fact that an instrumental soloist's body, string and woodwind particularly, severely shadows the energy field to his rear, and the concert grand piano with lid raised does the same. That the human vocal and manual manipulatory apparatus places both the energy orifice or the mouth and a musical instrument in front of him, and that the sensory systems of the audience are directional as well, are physical facts not easily disregarded where effective concert hall design for the entire audience is concerned.

Despite these problems, the acoustical consultant uses the convex curves of the ceiling to great advantage and in this large-volumed room achieves for the symphony orchestra and organ a lush big sound. A 2-second reverberation time that is not boomy in the bass is achieved by discreet use of Helmholtz resonators in the ceiling and some thin paneling on selected side wall areas that reflect high and middle frequencies but absorb in the bass. Except for the movable overhead panel system over the centre stage, there is no acoustical adjustability in the hall. This is contrary to practice in the Western Hemisphere, where auditoria are oriented to multiple uses and require acoustical adjustment (Izenour op cit: 256).

2.5.3 Accra International Conference Centre, Accra – Ghana

Fig. 2.19 Accra International Conference Centre, frontage view

The Conference Centre in Accra is among unique and large conference centres Energoprojekt has built all over Africa (Lusaka, Libreville, Harare, Kampala etc.). It is a Yugoslav government sponsored project for the Ghanaian government in 1991 to host the Non-Aligned Movement Conference. It was built on a six-hectre site at Osu near the Accra Sports Stadium and opposite the Parliament House. Its total floor area is 15,000 square metres. The Conference Centre has a main hall with 1600 seats, equipped with all mass media communication facilities indispensable for such an edifice.

The hall contains the central part of the building otherwise designed on the bases of the classical symmetry and is linked with other facilities, all of them extremely interconnected. These are: another two halls for conference committees with 200 seats each, separate cabins and rooms for translators and a press centre for 80 journalists with most sophisticated telephone and audio-visual equipments. The press centre has been conceived as a functional autonomous unit which also has 180 separate seats in the main hall. Other facilities provided include a VIP lounge, big car park and services area (at sub-basement). Among other functions that take place here include musical concerts, beauty pageants and national arts and cultural performances.

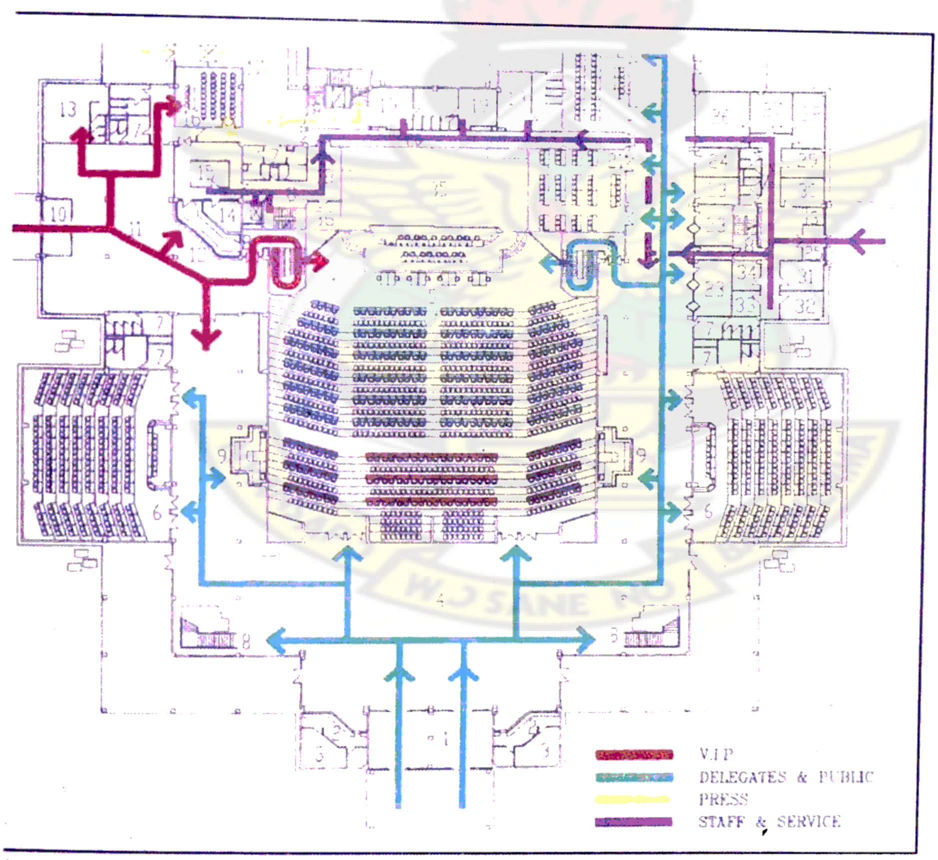

Fig. 2.20 Accra International Conference Centre, plan showing circulation for various users

The architectural concept of the building is unusual with its two stylistic associations: the first concerns a successfully incorporated vernacular architecture, the effect being underlined with local vegetation: the other includes the stylized and reduced forms which together remind of the element abundantly used in the post-modern architecture; hence a rarely successful combination and intertwining of traditional and international design styles (Energoprojekt Profile 1995).

Structure and Material

The type of foundation used for this building is raft foundation (ripped-waffle slab system). This type of foundation takes good load. A look at the structure reveals extensive use of concrete. Some parts are in pre-cast construction with others being in-situ. The ones in pre-cast required special properties and so they are all factored in at the factories.

Fig. 2.21 Accra International Conference Centre, Interior View of Main Hall

Fig. 2.22 Accra International Conference Centre, Foyer

A critical look at the big columns and beams at the foyer shows the structure itself is post and beam system of construction. Columns are 6m apart and are 500mm x 750mm in size. The foyer is spacious and free of columns; 48m x 18m on plan and three volumes in height. Stairs at the foyer have been placed at the extreme ends making free the foyer.

The foyer has polished porcelain floor tiles and anodized aluminum ceiling. The stairs here has bronze handrails. These are more durable. For the main conference hall, the ceiling, walls and seats are all padded with acoustic based materials. The floor is also carpeted to be sound absorbent. Apart from the main conference hall which has truss system of roofing, the adjourning spaces have flat concrete roofing. The roof space is over 3m high, giving room, more than enough, for air-condition service ducts.

Lighting

The foyer has adequate natural lighting. Contrary to this are non-glaring floodlights (artificial lighting), interspersed with spots lights for the main hall.

Electricity, being the main power source, is supplemented by a generating plant.

Fig. 2.23 Accra International Conference Centre, Truss system of roofing to accommodate services

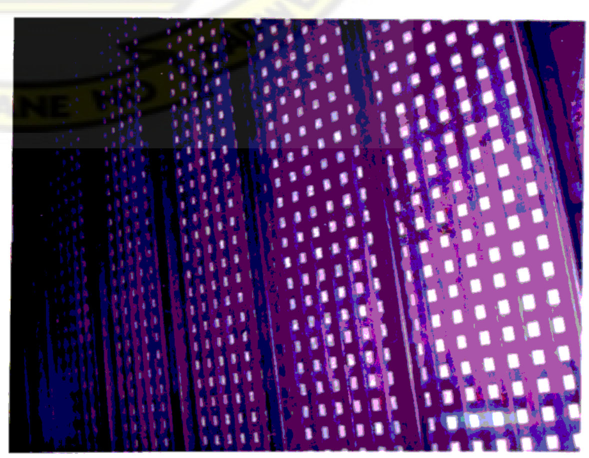

Fig. 2.24 Accra International Conference Centre, Interior Wall finish

Air-Conditioning

The facility is air conditioned from the foyer through to all other spaces. The central air condition system was used for all the spaces except the foyer which has packaged unit. The chillers for the central air conditioned system were sited away from the building. At the basement are the air handling units. The conditioned air is carried by ducts that run through roof space within the trusses, for distribution into the various spaces.

Fig. 2.25 Accra International Conference Centre, Air handling unit at the sub-basement

Fig. 2.26 Accra International Conference Centre, Open & Spacious service area

Security and Communication

Closed circuit television monitoring room (for security) can be found at the basement. This means cameras have been placed at vantage points from which all activities in and around the building is monitored. Security sensors have been placed at the security lobby where the public is screened before entering the main foyer. There is provision for telecommunication for the public. Transmission and translation rooms are also provided.

Fire Protection

Fire extinguishers have been provided at the entrance lobby for prevention purposes. Doors to the main halls are also big and many, to serve as fire escapes.

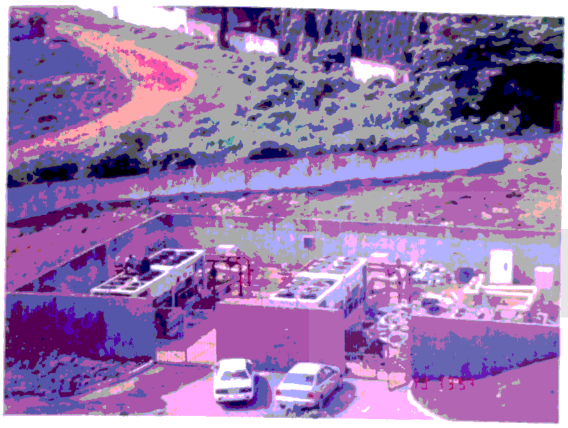

Fig. 2.27 Accra International Conference Centre, Air condition chillers sited far off the building

Fig. 2.28 Accra International Conference Centre, wide Fire Escape Doors

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

The study was undertaken with the aim of describing the extent to which the geometry or shape of an auditorium impacts on symphony orchestra performance. The research was conducted using the following qualitative approaches:

a) Literature / Internet searches and

b) Case Study.

This chapter describes the methods used in gathering information for each of the above methodology as well as the limitations encountered.

3.1 Literature / Internet Searches

The literature search was conducted using the Kwame Nkrumah University of Science and Technology (KNUST) main library, the KNUST internet café, the KNUST College of Architecture and Planning library, and archives from the Ghana National Symphony Orchestra. It was done using both published and unpublished literature, text books, journals, periodicals, video recordings on theatre and auditorium related issues that reported qualitative data on

a) The situation of Symphony Orchestra performance in Ghana.

b) How the orchestra uses compositions by Ghanaian and African composers

c) How the Orchestra adapts traditional tunes and sets them to symphonic measures.

Data was also retrieved from various internet sites and reviewed. Those relevant and referenced were

a) http://en.wikipedia.org/wiki/Orchestra (accessed 2007 January)

b) http://www.keithyates.com/glossary.htm (accessed 2004, January 26)

c) http://www.musictherapy.org (accessed 2007 February 17)

d) http://www.concerthalls.unomaha.edu/foundations/history.htm (accessed 2004, January 26)

3.2 Case Studies

Case studies of three buildings were conducted, namely the Morton H. Meyerson Symphony Centre (USA), Berliner Philharmonie (Germany) and Accra International Conference Centre (Ghana). With the first two being foreign buildings, information was gathered by way of the Architects' opinions and that of architectural critics. These offered much insight into to what is entailed in these designs.

The third case study, Accra International Conference Centre, being a local building called for a thorough information gathering. Methods use for data collection included visual observation, physical measurements, measured drawings and photographs.

3.2.1 Visual Observation

This was in the form of personal observations and visual surveys made especially during visits to some selected auditoria in Ghana like the National Theatre, Great Hall of the Kwame Nkrumah University of Science and Technology and the Accra International Conference Centre. Critical observation was made in and around these buildings. This aided in documenting the spatial organization and their related activities. The various materials used for construction were also recorded by visual observation especially for the Accra International Conference Centre. These buildings were also observed in relation to the surrounding physical environment.

3.2.2 Physical Measurements

As the main local building documented in the research, physical measurements of the stage, auditorium length and width, tiers and balcony height were taken for the Accra International Conference Centre. This information was compared with other standard requirement to see how different or similar they are.

Existing facility used by the Orchestra was also measured. Ghana has an orchestra but does not have any purpose built theatre for orchestra performance. Physical measurement of facility used by the orchestra was necessary in order to draw useful conclusions for special requirements.

3.2.3 Photographs

Photographs were taken as another means of documenting information. It served as a library of information that was readily fetched whenever need be. This brought to light some of the realities of the findings made but lost or forgotten along the line. They were also used to complement some sketches made during the process. Among photographs taken were exiting conditions at the Ghana National Symphony Orchestra, Accra International Conference Centre, National Theatre and the Great Hall of the Kwame Nkrumah University of Science and Technology.

3.3 Limitations

This research work was not undertaken without limitations. Lack of experiencing live performances in auditoriums such as those used for the foreign case studies, with respect to symphony orchestra, proved a great short-coming in the build-up to this write-up.

3.4 Conclusion

The information derived using the above methodology was analyzed by way of comparing existing situations with standard technical requirements as in Architects' Data and Neufert. Following this, four basic shapes were analyzed. The findings were discussed in chapter 4 and the results interpreted.

CHAPTER 4

FINDINGS AND DISCUSSIONS

4.0 Introduction

This chapter is mainly two parts. The first part deals with findings from the various case studies conducted and in line with objectives of the thesis. The second part is an analysis of various geometrical forms.

4.1 Findings from Case Studies

While acoustics as a fundamental issue has been addressed in each auditorium under study, issues of lighting, sightlines and circulation stands out in the Meyerson Symphony Centre, Berliner Philharmonie and Accra International Conference Centre respectively. This is not to say that these issues are exclusive to the individual buildings.

4.1.1 The Morton H. Meyerson Symphony Centre, Dallas (Texas) – U.S.A

Architects' Approach to the Design

The architect's approach to the Meyerson centre was that of fluidity; a design that allows free flow of movement for circulation and natural or day lighting. Free flow of movement is seen in the interplay of square and semi-circular plan forms whiles flow of natural light is seen in the use of glass canopy. This flow of forms perhaps would have been extended to the performance hall. The architect however admits the form and shape of the performance was the results of rigorous adherence to the acoustician's requirements for audience distribution, unobstructed sightlines and acoustical excellence.

Factors that enhance sound quality

Performance hall of the Meyerson Centre is four levels higher, increasing the volume which according to Sabine is directly proportional to the reverberation time. Electro acoustic panels have been employed for sound reinforcement. Flow of sound energy between audience chamber and outer chamber is controlled within a set of large concrete doors. This has provided variability and inconvenience between clarity and reverberation.

Assessment of Technical requirement

The floor of the performance hall should have been raked to give clear sight to the stage. This was not done but has been compensated for by raising the stage well above seating plane for clear sight. Sensitivity toward disabled wheel chair users is shown by provision of wheel chair seating.

4.1.2 Berliner Philharmonie, Berlin – Germany

Architects' Approach to the Design

Hans Scharoun, architect of The Berliner Philharmonie, was mainly concerned with resolving the relationship between audience and performers in order to create a sense of congregation for one of the biggest performance hall. He decided to fused 'theatre-in-the-round' with the 'vine-yard terrace' concept for this design; hence the break away from traditional forms – rectangular, horseshoe, fan shaped – for irregular experimental forms while still bearing in mind audience comfort and sightlines.

Factors that enhance sound quality

The success of this performance hall is due to modern technology and materials. The 'vine-yard terrace' – blocks of seating jutted out into the main body of space – provides enough surfaces for sound reflection (Fig. 2.18). Adjustable overhead panels, when lowered, also reflect high frequency sound within 15m radius of the stage. Helmholtz resonators and paneling on selected side walls enhance acoustics by reflecting high and middle frequency sounds. By drawing a greater percentage of the audience closer to the performers, intimacy is achieved; the audience feels part of the performance than just being spectators. These create environment that prevents discomfort and uneasiness that not only keep the audience from relaxing enough in the flow of the music to perceive fine details, but also keep the musicians themselves from relaxing into the flow of their own performance.

Assessment of Technical requirement

Experimental as it may be, vertical sight lines (every-other-row vision) have been carefully determined so that every seat has an unrestricted path for sound from the stage. Movement within the hall during performance does not create obstructions due to the jutting of blocks of seating.

4.1.3 Accra International Conference Centre, Accra – Ghana

Architects' Approach to the Design

For the Accra International Conference Centre, the architect approached the design with its use in totality as a facility, in mind. First, the building was a conference centre, not a musical performing hall. As a facility for high profile dignitaries, circulation was of paramount importance for various users: VIP, delegates & public, press, staff & service. All users have their circulation path as they flow in the facility as shown in Fig. 2.20.

Factors that enhance sound quality

The main hall has medium carpet, on solid concrete, floor finish. The stage has wood boards on joist or battens. The side and rear wall has plywood panels mounted over air space on solid backing at the lower portion to a height of 1.65m and medium fabric laid straight and close to wall at the top portion.

The hall has soft finish mainly due to its purpose of design as a conference room. The soft finishes tend to absorb sound to avoid echoes.

Assessment of Technical requirement

Physical measurement revealed that the main auditorium is almost a square: it measures 33mm long by 36.5mm wide. This is contrary to the technical require which indicates that the width should be about 0.5 to 0.6 of the length.

The stage is 16.5m long by 15m wide and 1m high. The seating tiers have 150mm risers and 950mm threads. The main hall has two double entrance doors from the foyer and two double doors from the stage end of the auditorium. There are also two sets of escape doors on each side wall strictly for emergency purposes. All these doors measure 1.5m each.

4.2 Analysis of Geometrical Forms

It is realized from the literature review that the acoustic of any auditorium is determined by the reverberation time. The reverberation time also depends on the volume of the enclosed space and the absorbent or reflective property of internal surfaces (finish material). The geometry is a fundamental issue. The following basic forms are used to demonstrate how fundamental the geometry is to any auditorium design. The points X, Y and Z are the first row, middle row and last row positions within each auditorium. These points show the viewing angle to the stage as 110º, 60º and 30º respectively. Points A, B, C and D are few positions on each side wall at which reflection takes place. Point 'O' is the centre of the stage and assumed to be the sound source. The diagrams below were sketches the research drew taking into consideration standard technical requirement as given by Nuefert and the Architects' Data.

4.2.1 Rectangular-shaped Hall

The auditorium measures 32m by 18m which satisfy technical requirement by Neufert and the Architect's Data. The rectangular-shape hall creates an even distribution of sound energy from the side wall. It also requires shorter distance; hence short time, for reflected sound energy to reach the central part of the hall. The more rectilinear the shape, the narrower the auditorium; hence the back seats get farther from the stage and affect vision

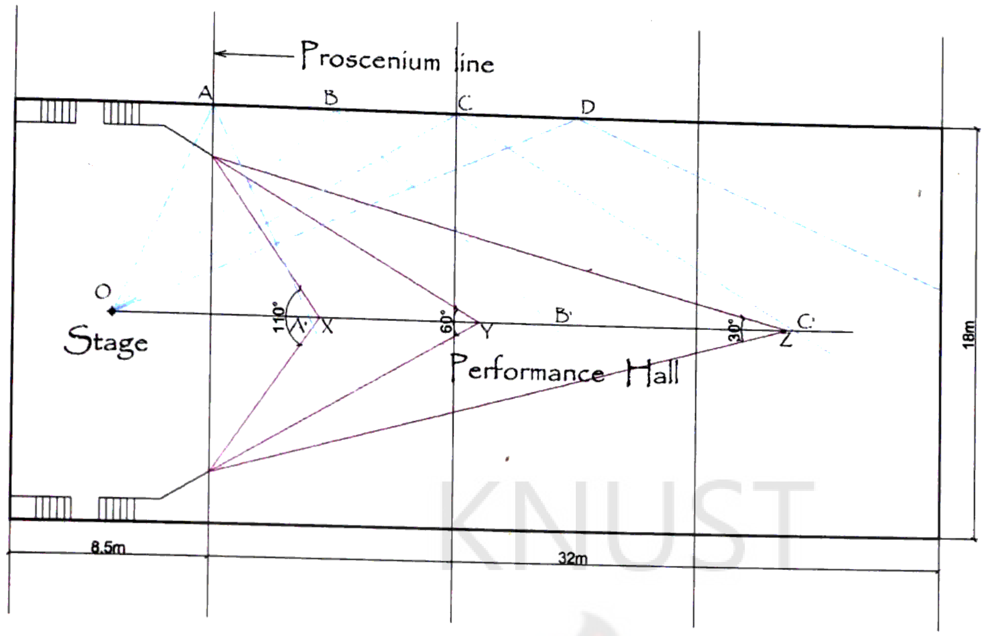

Fig. 4.1 Acoustical Study of a Rectangular-shaped Hall

(OA + AA') – OA' = (9.95 + 9.95) – 8.5 = 11.4m

(OB + BB') – OB' = (13.14 + 13.14) – 19.15 = 7.13m

(OC + CC') – OC' = (17.41 + 17.41) – 29.18 = 5.02m

4.2.2 Fan-shaped Hall

Looking at this shape, one can see the fan-shape takes more audience and draws a greater percentage to the stage or sound source compared to the rectangular-shape hall. There is also a lot of useful sound energy reflected to the back of the auditorium. Even though the analysis may be similar for the rectangular and fan-shape halls, it can be seen that there is much useful reflection beyond point 'C' to the rear of the auditorium. This means audience at the rear of the auditorium get equally clear sound intensity as those at the back.

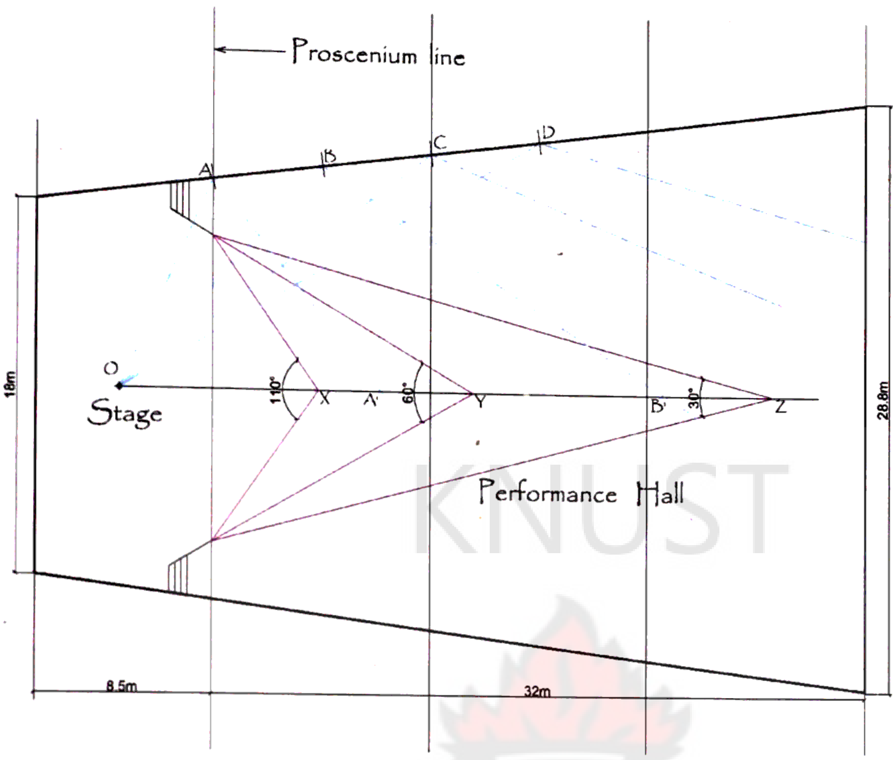

Fig. 4.2 Acoustical Study of a Fan-shaped Hall

$$(OA + AA') - OA' = (11.07 + 13.02) - 12.69 = 11.4m$$

$$(OB + BB') - OB' = (14.62 + 20.0) - 26.24 = 7.80m$$

4.2.3 Square-shaped Hall (theatre-in-the-round)

In this hall, sound energy from source reaches audiences seated on any side of the stage evenly. It would be much better to have the stage at one end instead of being at the centre for a square shape. For a theatre for symphony orchestra however, the weakness will be the inability of the audience, to the back of the performers, to lisp-read and appreciate song lyrics better. Worse will be the weakness to transient.

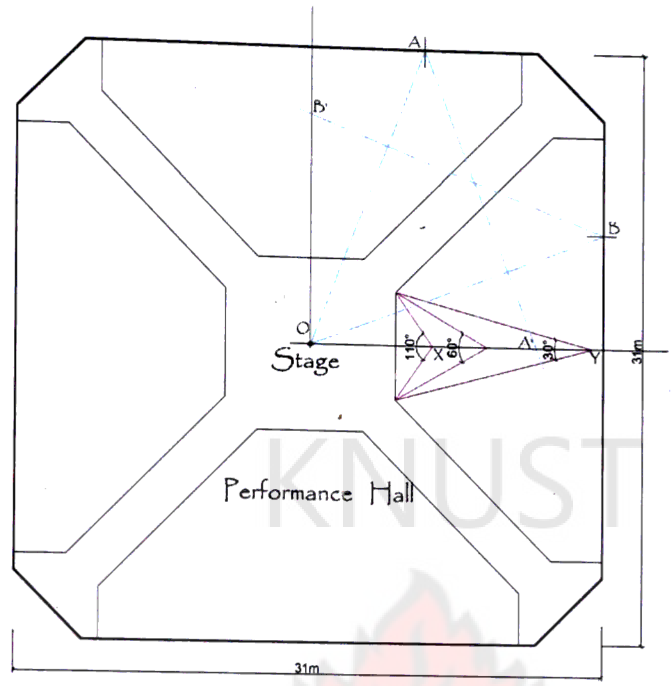

Fig. 4.3 Acoustical Study of a Square-shaped Hall (theatre-in-the-round)

(OA + AA') – OA' = (16.61 + 16.61) – 11.96 = 21.26m

(OB + BB') – OB' = (16.61 + 16.61) – 11.96 = 21.26m

4.2.4 Circular-shaped Hall

Circular plan form gives a concave internal surface which in turn gives greater sound concentration at the centre of the hall unlike the rest. It would have fundamental problem of focusing sound, therefore the tendency to produce places with excessively loud sounds or dead spots. Although it creates a sense of belonging among audience, it takes much time for reflected sound to reach audience at the central part of the auditorium. The calculation below shows, comparative to the rest, that it requires more distance – implying more time – for reflected sound to reach the central portion. The position of the stage also plays an important role in that worse would have been the scenario if it had been in the middle.

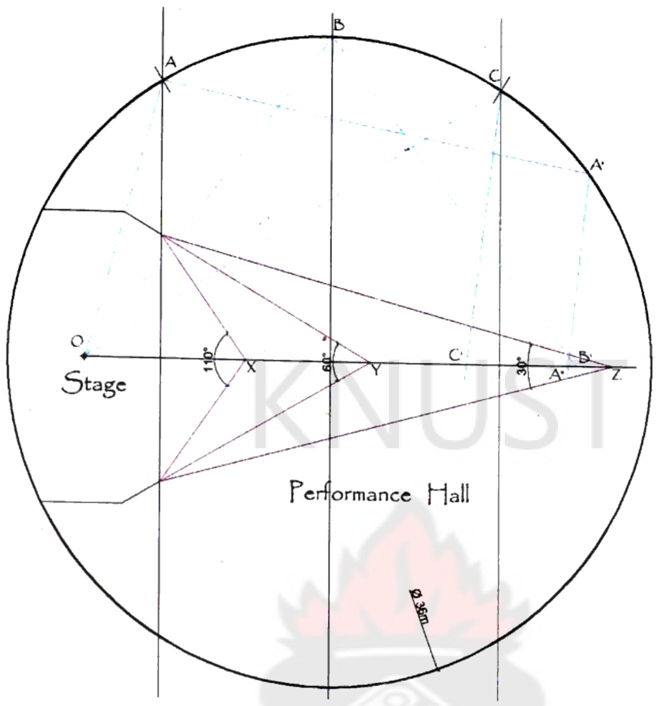

Fig. 4.4 Acoustical Study of a Circular-shaped Hall

(OA + AA' + A'A") – O A" = (15.87 + 24.37 + 10.8) – 27.07 = 23.97m

(OB + BB') – OB' = (22.65 + 22.65) – 27.5 = 17.8m

(OC + CC') – OC' = (27.84 + 15.4) – 21.36 = 21.88m

4.3 Conclusion to Findings

Good acoustic is important in concert hall designs. It is not a matter of merely applying to the walls and ceilings, materials that aid in the reflection, absorption and transmission of sound. Though acoustics and sight lines are the major consideration factors, their success or otherwise depend on other factors; size, shape, volume are all important factors which have great bearing on the acoustics.

The use of the auditorium is the main factor for acoustic design. Different use requires different acoustic quality, for example, speech, drama and music, all have different acoustic requirements. The differences of requirement of music and speech are in the length of reverberation. Music is more effective with a longer reverberation than speech and this should influence the shape of the hall. Different forms of music also require different reverberations for full effectiveness, thus choral music requires longer reverberation than instrumental music. This is why the former is often so effective in a church where the reverberation is generally long.

Sensitivity to hearing symphonic music extends at mid-frequency from below 25dB to over 100dB, called dynamic range. Optimum reverberation time for symphonic music should range from 1.7 – 2.3(s); that for multipurpose ranges from 1.4 – 4.6(s). Auditoriums for a range of performances are challenging since each performance type has its own acoustics requirements. There is therefore the need to have a careful balance between sound reflective surfaces, that maintain acoustic liveliness on the one hand, and excessive fabric and porous materials that absorb and hence reduce liveliness on the other. The right specification for interior surfaces and finishes is important for creating the right atmosphere for the equalization of direct and reflected sound.

Acousticians in the twentieth century have also identified the following qualities of sound as also very important in concert hall acoustics: Clarity, Intimacy, Loudness, Brilliance, Warmth, Spaciousness and Background noise. These issues were not studied because of the scope of this thesis.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0 Conclusion

We can enjoy music through various medium (vocal, radio, microphone etc) and different environment (church, concert, party etc). For concert performance, music is enjoyed when an atmosphere or environment is created in the enclosed space. Modern performing theatres use science and engineering to make an acoustic which embellishes and enhances the artistry of the musicians. A good acoustic, or any acoustic for that matter, is essentially a product of the shape of the enclosed space. The shape is a fundamental aspect which if carefully considered will impact on the choice and cost of finish material. An auditorium that does not have harmonious proportions will never have a good acoustic, no matter what one does with it.

5.1 Recommendations

Architecture is both art and science; more so the design of a performance theatre. The art aspect requires creativity which is not restricted by anything. The science aspect must fulfill basic requirements; in this case the acoustics. There is the need to marry both art and science. One should not be used to curtail the other. There is, therefore, no hard and fast rule to any design; yet, in view of the findings of the study, the following are considered useful and necessary recommendations:

a) When a performance hall is to seat a small size population of say one thousand (1000 people), the shape will not matter much. When it is to seat more people, however, the shape should be critically considered.

b) Subject to sight lines, a wide, rather than a deep auditorium is recommended. It brings the audience nearer to the stage to achieve better mutual perception.

c) Fan-shaped hall should be preferred to rectangular shape for a hall meant for symphony orchestra. It seeks to draw or seat audience closer to the sound source.

d) 'Vine-yard terrace' is most suitable for symphony orchestra since they are known to provide enough surfaces for useful reflection.

e) 'Theatre-in-the-round' may be preferable, but not highly commendable, for symphony orchestra especially where an instrumental soloist performs; except the situation where careful attempt has been made to reduce the number of audience behind the performers.

f) Concave surfaces should be avoided, especially for rear wall; reflections from such surfaces create "hot spots" and echoes and may have to be broken up with diffusing or absorbent materials.

g) Circular-shaped auditorium may be best adopted for small sized halls for meetings, conferences etc. as well as those used for heated debates such as parliamentary chambers.

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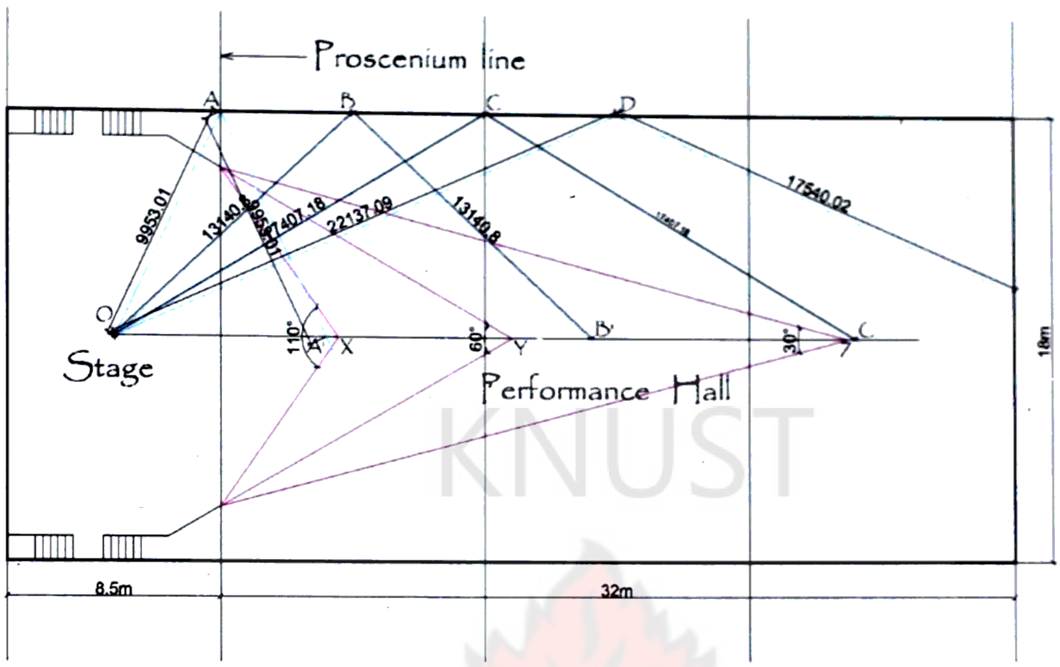
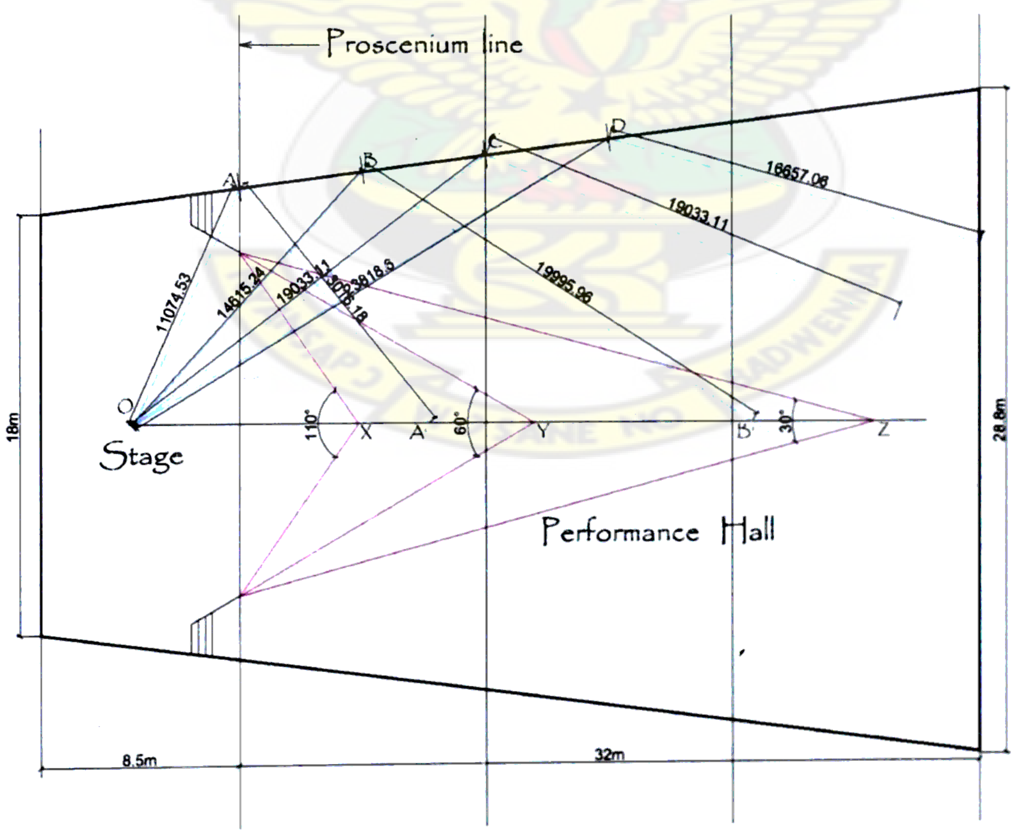
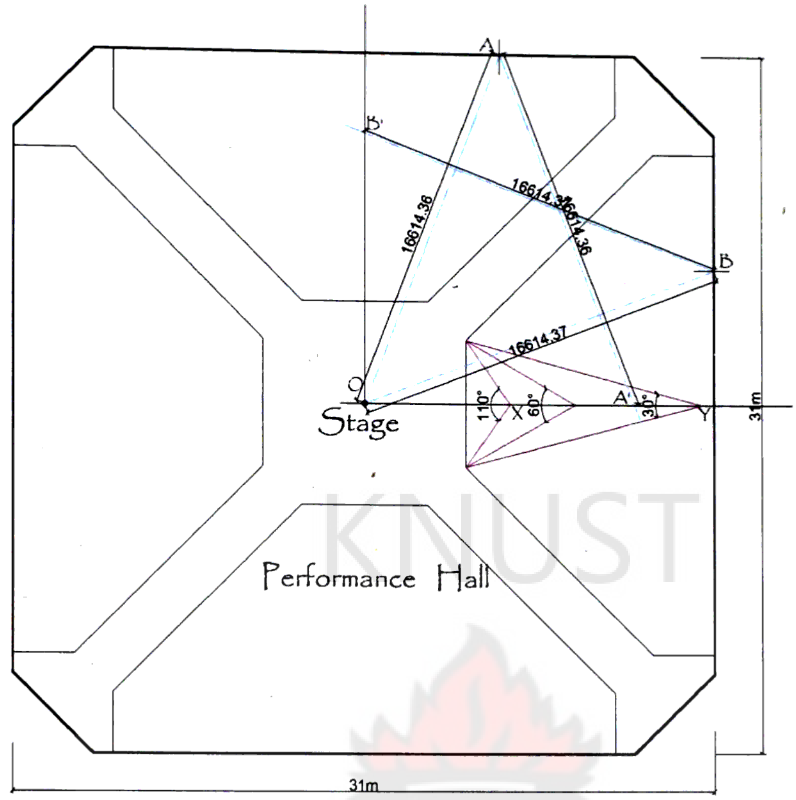
5.3 Appendices



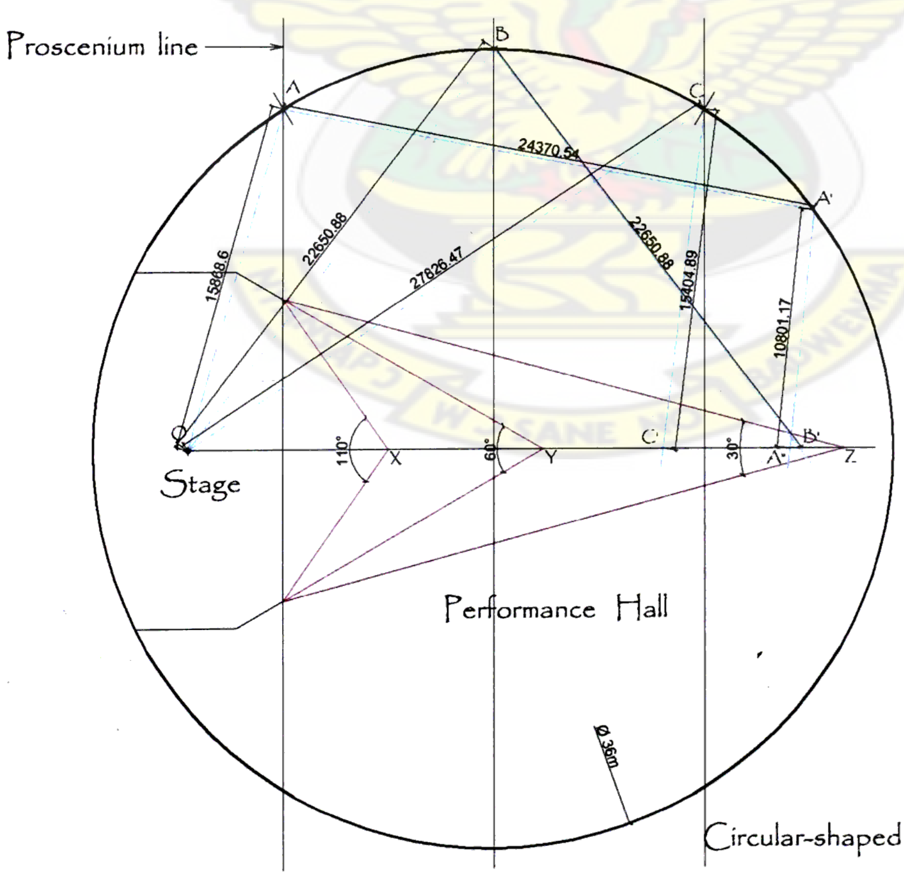
Rectangular-shaped Hall



Fan-shaped Hall



Square-shaped Hall



Circular-shaped Hall

AICC - main hall

ff - carpet (woolen)

risers - 150mm

thread - 950mm

Side walls - wood panell down to abt. 1.65m
- nylon (upholster) up ranging from (1.0m×2) to (1.0m×6) underneath ~~balcony~~ gallery soffit

Rear wall - height to soffit of gallery is 3.4m

~~Height~~ from lower floor level to soffit of balcony - 750×3 + 750×6
= 750×9
= 7500
-750
6750mm

Average length of Auditorium (from lowest level) is 12m

Two main escape on ~~doubledoor~~ each side wall -

Two main entrance doors (double) from foyer into hall -

Two exit (doubledoor) at the ~~st~~ stage end of the auditorium. - 1.5m each (3m here, 3m there)

Two exit (doubledoor) at stage side (wall) of auditorium - 1.4m

Ceiling - I want to believe it's POP

Auditorium length ~~width~~

$950 \times 8 = 7600$ 1,950

$930 \times 17 = 15,810$ 2,580
5,000

32,940

Stage (length 3.7 + 12,700) × width 15,000

Stage height 1m
Stage ff - wood (T & G)

Auditorium width
3m + 30,500 + 3m = 36,500 mm = 36.5

AICC findings.

Total length = 32.94 + 16.4 = 49.34m

L/W ratio = 49.34 / 36.5 = 1.35

eye-sight level = 150mm

H/L = 2.1 / 1.8 | 2.75   H/W 2.75 / 2.1 = 1.30

140
28
168
2
336

Physical Measurement of Accra Int. Conference Centre.