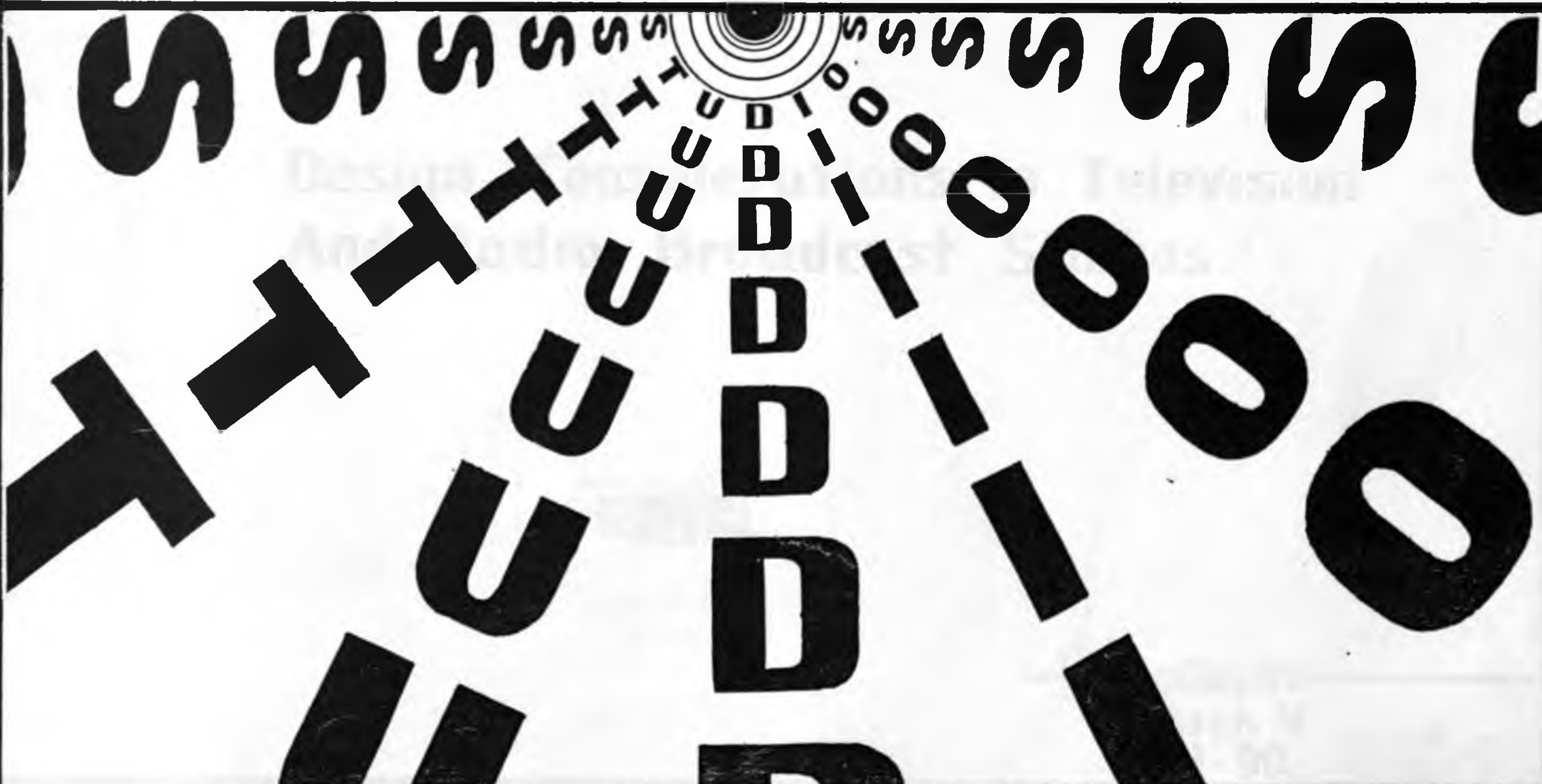
TELEVISION & RADIO BROADCAST



Design Considerations In Television And Radio Broadcast Studios.

Ngũnjiri
B.Arch V
1989 - 90

INSIGHT

"The tower of human knowledge which we are in the process of building is endangered by the curse of Babel and many who are in its construction have ceased to be intelligible to any of their fellow workers except those actually working on the same part of the building".

- Alexander Wood 1947.

(First Summer Symposium of the Acoustics Group of the Physical Society).

DEDICATION

TO

NGUNJIRI WA MUGAI

NA

WACUKA WA GIKONYO

My Parents

DECLARATION

This investigation report is my own original work, and to the best of my knowledge, has never been submitted for the award of a degree or any other academic qualification in this or any other institution.

Sign: ______________ 31.5.90

Ngunjiri, F.K.
(Author)

It is presented in the 1989/90 Academic Year as a partial fulfilment of the Examination Board Requirements for the award of the degree of Bachelor of Architecture (B.Arch) at the department of Architecture in the University of Nairobi.

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This document is not the fruits of my own effort alone. I am very much indebted to all those who have consciously or subconsciously contributed to its substance and preparation; and especially the following:-

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- Mr. Y. Asante - For his initial inspiration and encouragement.
- The Director K.B.C.[*] - For his honoured permission to carry out my case study at the Voice of Kenya.
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- Mr. Koinange - Head of design section K.B.C.
- Mr. Munyua - K.B.C. -
- Mr. Ole Tiampati - Studio Incharge.
- All other K.B.C. staff whose assistance and corperation I enjoyed.
- My entire family for providing both moral and financial support.
- To Grace for her concern and dedication.
- To Mrs. Thiong'o for tirelessly typing this report.
- To the authors of the publications listed in the Bibliography.
- To all those that are regarded to be my friends.

* K.B.C. - Kenya Broadcasting Corporation

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INTRODUCTION

The architect is usually faced with the problem of identifying some basic technical requirements that have to be integrated in his design work. Most architects leave all these requirements in the hands of specialists who in turn, never integrate them with other elements of design to achieve a satisfactory and coherent structure.

The architect does not only possess the prime responsibility of designing the building and seeing that it is executed according to his instructions, but he has also the additional task of integrating the inputs of all other consultants to achieve the design criteria set down in the brief.

This study sets out to investigate such an area where the architect has the responsibility of handling the basic technical design before the consultants comes in - The design of studios.

In the design of studios, acoustics remains a prime consideration. However, as a primary concern, the architect has to understand the elements and components that enhance a good acoustic design. Acoustics, as an attribute of architectural space, should be given as much attention as the attributes like structure and mechanical systems.

Fundamental acoustic considerations in studio design should be established in initial stages of design to eschew acoustic pitfalls or subsequent alterations to produce satisfactory work. This design technique aids the architect in integrating his work with other elements of design.

Broadcasting and television studios -basic design considerations have been reviewed in this study to show that the technical requirements of acoustics and sound insulation in studios can only be enhanced by careful architectural design considerations.

AIM OF STUDY

(i) To broaden the understanding of basic design considerations of studios where acoustics is a prime requirement.

(ii) To understand the role of an architect in a technical field where a specialist is needed.

(iii) To ensure a background understanding of design techniques to be undertaken in my design project - A Radio and Television Broadcasting centre.

METHODOLOGY

This study adopts an approach to establish both theoritical and practical aspect of acoustic design in Television and Broadcasting studios. These aspects are analysed and evaluated and finally concluded with an appropriate case study. This evolves certain deductions that remain important to an architect's understanding and application. The study is broken into three parts:-

Part I

This part constitutes of a theoritical background of sound as well as design criteria in both Television and Broadcasting studios.

The primary source of information is from relevant literature. This is then expounded to bring out certain characteristics valuable for studio design.

Part 2

This part gives a practical approach to an existing situation in Kenya. The studios chosen are used for normal daily broadcasting and telecasting to the whole nation. The aim here is to bring out the components and elements that are integrated in selected studios. An evaluation of both qualititive and quantitative analysis of these studios is considered to ascertain their performance.

Part 3

This part concludes the entire study by arriving at certain deductions and recommendations already cited in the study. The aim here is to depict the real situation response versus theoritical requirements already considered in the study.

SCOPE AND LIMITATIONS

The scope of this study shall be limited to Broadcasting and Television studios only. However, the basic sound theory shall be considered to attain a more comprehensive study.

The study shall also attempt to outline most architectural solutions to acoustic design in these studios.

PART ONE

PART ONE

THEORITICAL BACKGROUND

This Part constitutes of two chapters which are aimed at establishing a theoritical background of sound as well as design criteria in both television and broadcasting studios.

Chapter One

CHAPTER ONE

BASIC SOUND THEORY

This chapter deals basically with the theoritical properties of sound aimed at determining certain fundamental considerations in the design of studios. The word sound here shall refer to noise, speech or music. The main source of defination is extracted from relevant literature.

The characteristic behaviour of sound in both indoor and outdoor spaces has been evaluated to bring out design implications of these characteristics into design.

CHAPTER I.

CONTENT OUTLINE

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1:5:1 Absorption coefficient
1:5:2 Sound Absorption media
1:5:3 Sound Absorbent materials
1:5:4 Total Absorption
1:5:5 Reverberation time

Sound	Frequency (H3)	
MALE VOICE, Vowel sounds	100	H3
MALE VOICE, Sibilants	3000	"
BASS SINGER, Bottom note	100	"
SOPRANO, Top note	1200	"
PIANO, Bottom note	25	"
PIANO, Middle C.	260	"
PIANO, Top note	4200	"
PICCOLO, Top note	4600	"
BASS VIOL, Bottom note	40	"
ORCHESTRAL RANGE	45-4500	"
AUDIBLE RANGE	20-1600	"

Table 1,1

Some typical frequencies

(Moore, London 1961 Pg. 13).

1:1:0 NATURE OF SOUND

Sound can be defined as vibration in a material medium such as solids, water or air. In the light of this investigation report, only sound propagation in solids and air shall be considered.

1:1:1 Frequency of Sound

This is the number of complete cycles per second a given molecule of the medium vibrates about its neutral position. Its measure is the Hertz (H3). The audible range of frequencies ranges from 20 - 16,000 H3[1] with the upper limit diminishing with age. Some typical frequencies are listed on Table 1.1 in order to give a clear picture of sound sources and their frequencies.

The audible range of frequencies can be divided into octaves from meaningful analysis. An octave band representing the frequency interval can be classified as shown on Table 1.2.

For some purpose of this study, the octave band in Table 1.3 shall deem necessary for acoustic design and reverberation time determination in the studios. These frequencies can give a good sampling of a frequency spectrum for both speech and music.

1:1:2 Velocity of Sound

The transmission of sound waves depend on the physical properties of the medium in which it travels. These properties are mainly elasticity and density. The denser the material, the faster the speed. Table 1.4 gives examples of sound velocities in some construction materials at room temperature.

1-Moore, London 1961 Pg. 13.

Table 1.2
Audible Range Octave Band
(Parkin & Humphreys London 1969 Pg. 246).

OCTAVE BAND (Hz)	31.5	63.0	125	250	500	1000	2000	4000	8000	16000
CLASSIFACATION	Low Frequency Sounds				Mid Frequency Sounds		High Frequency Sounds			

Table 1.3
Octaves used in Studio Design
(Parkin & Humphreys London 1969 Pg. 129).

SELECTED OCTAVE (Hz)	125	250	500	1000	2000	4000
CLASSIFACATION	For Low Frequency Sounds		For Mid Frequency Sounds		For High Frequency Sounds	

Table 1.4
Velocity of sound in some construction materials
(Asante, B. Arch. III classwork 1988).

MATERIAL	VELOCITY (M/s)
Air	345 M/s
Concrete	400 "
Masonry	2000 "
Cork	450 - 530 "

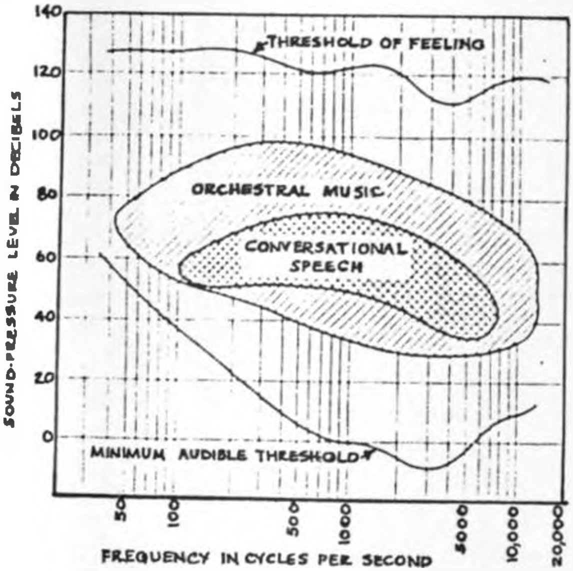


Fig. 1.1 chart showing the minimum audible threshold v's frequency and threshold of feeling (Knudsen, New York 1950 Pg. 21).

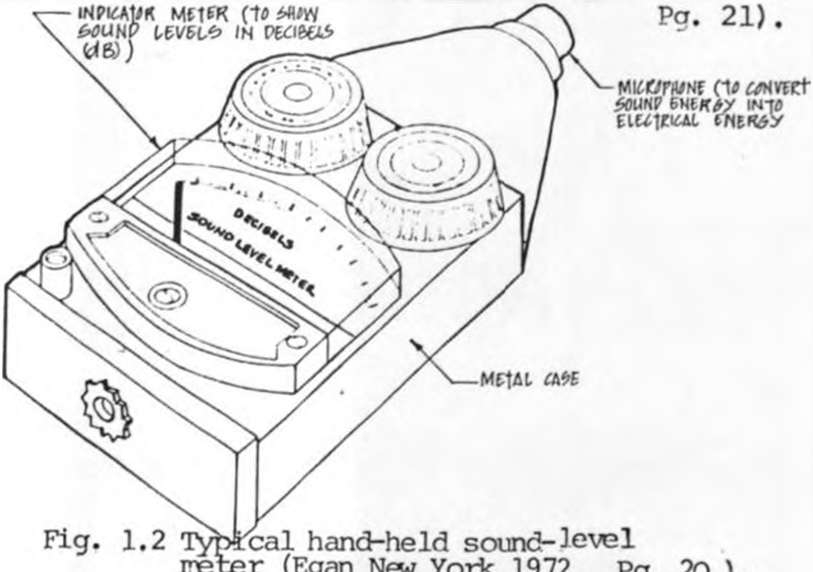


Fig. 1.2 Typical hand-held sound-level meter (Egan New York 1972 Pg. 20.).

1:1:3 Wavelength

This is the distance travelled by sound during the period complete vibration. The wavelength of vibration is relat velocity and requency by the following equation;

$$\lambda = \frac{v}{f}$$

λ = Wavelength

v = Velocity of sound

f = Frequency

1:1:4 Sound Pressure Level

When sound is produced, the vibration set in the air prod pressure vibration which is directly proportional to the of the sound. The sound pressure is measured on a relati rithimic scale called the decibel scale (dB). This gives pressure levels and can be defined by the equation;

$$S.P.L\ (dB) = 20 \log_{10} P/Po$$ Where SPL = sound p

P = average compare

Po = referen taken a

Fig. 1.1 represents the relationship between frequency and pressure level (S.P.L.). The S.P.L. are measured by a sou meter which indicates the S.P.L. in Decibels (dB). A typi sound level meter for such measurements is shown on Fig. I scales of measurements of S.P.L.; the phons and sones shal in this study for simplicity reasons. The S.P.L. shall be equal to the sound intensity level (S.I.L.), the rate at wh energy is transmitted.

Table 1.5

Molecular Absortpion of sound by air (Parkin and Humphreys London 1969 pg. 250).

MOLECULAR ABSORPTION OF SOUND BY AIR

Octave Band (Hz)	Attenuation in dB/1000 m					
	21°C			2°C		
	Relative Humidity			Relative Humidity		
	40%	60%	80%	40%	60%	80%
600 1200	3	3	3	10	6	0
1200 2400	13	6	6	33	16	3
2400 4800	33	16	16	49	49	33
4800 9600	130	82	49	82	130	82

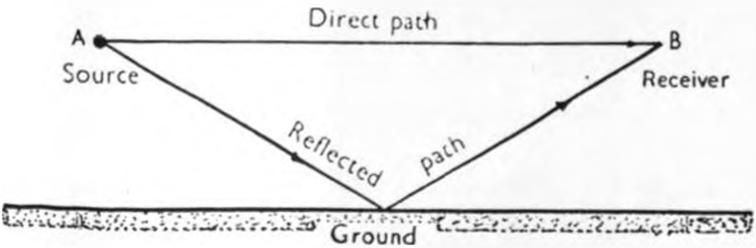


Fig. 1.3 Illustration of Reflected Ground Wave.
(Parkin and Humphreys, London 1969 Pg. 171).

1:2:0 SOUND BEHAVIOUR IN OUTDOOR SPACE

In outdoor spaces, the unrestricted sound waves are diffused in space which is equal on all direction. However, sound is affected by several factors creating a decrease in sound intensity from the source. These factors are important since the indoor acoustic environment has a strong link with the outdoor acoustic environment.

1:2:1 Inverse Square Law

Each time the distance between the source and the receiver is doubled, the sound pressure level decreases by 6dB. The S.P.L. is iversely proportional to the distance. This is an important phenomenon to be observed when zoning out acoustic requirements in an outdoor set up. The quiet areas in a building should be set up as far as possible from all noise sources.

1:2:2 Molecular Absorption of Sound in Air

At frequencies above $2000H_3$, its noticeable that sound attenuation occurs due to some energy being used to overcome intermolecular friction in the air. This attenuation is proportional to the distance from the source and may vary due to temperature and humidity as shown by the figures given in Table 1.5.

1:2:3 Ground Attenuation

Sound may be absorbed or reflected depending on the nature of the ground on which it falls. Soft grounds are absorbers while hard grounds are reflectors of the sound waves. Fig. 1.3 shows how sound travels from a source to a receiver.

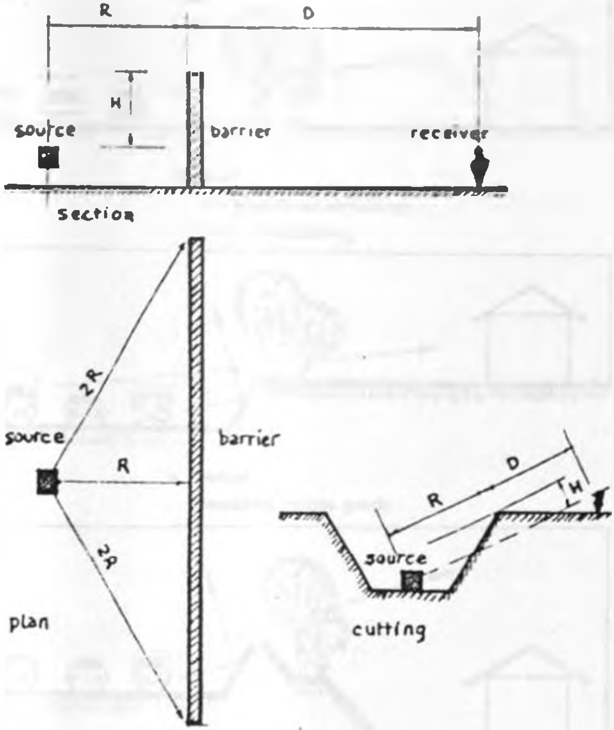


Fig. 1.4 Artificial barrier, source and receiver relationship. (Lawrence England 1970 Pg. 64).

The architect should bear in mind the need to select the nature of ground texture in order to enhance the desirable outdoor acoustic environment.

1:2:4 Natural and Artificial Obstacles

Screens and barriers can be used to reduce the sound intensity especially at high frequencies. In low frequencies, diffraction (bending of sound waves) may occur thus reducing the effect of the obstacles. Cuttings have similar effect to barriers and care should be taken to avoid parallel walls which would cause intereflections of the sound waves.

In order to attain better attenuation, barriers should be designed with the following factors in mind:-

(i) The barrier should be placed as close as possible to the sound source or receiver.

(ii) The attenuation is enhanced by the height of the barrier; the greater the height, the more the sound level reduction.

(iii) The barrier should be solid and airtight.

The sound level reduction given by a barrier or cutting can be easily worked out by using the following relationship. Fig. 1.4 illustrates a typical source barrier and receiver relationship.

$$\text{Sound level Reduction (dB)} = 10 \log_{10} \left(\frac{20H^2}{\lambda R} \right)$$

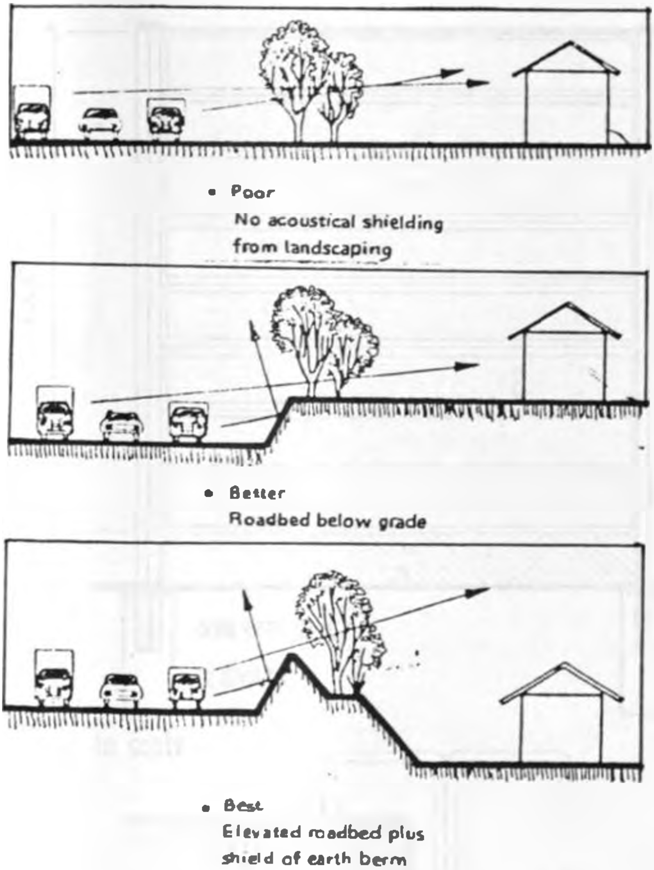


Fig. 1.5 Natural Barriers Configurations
(Egan, New York 1972, Pg. 91).

Where H = Effective height above barrier in meters (m)

λ = Wavelength of sound (m)

R = Distance between source and barrier (m)

D = Distance between barrier and Receiver (m)

The distance from the barrier to the receiver (D) should be much greater than the distance from source to barrier. Likewise, the distance from the source to the extent of the barrier should always be greater than twice the distance from the barrier to the source (R) to prevent diffraction occuring around the ends.

In planning of buildings, traffic noise can be reduced by such barriers like walls, sand banks, hedges etc. Fig. 1.5 illustrates attenuation level given by various natural barrier configurations while Fig. 1. 6 shows details of proprietary sound absorbing screen panel which can be adequately used along side of roads to achieve sound attenuation of up to 27 dB[2]

2-Lord & Templeton England 1986 Pg. 54.

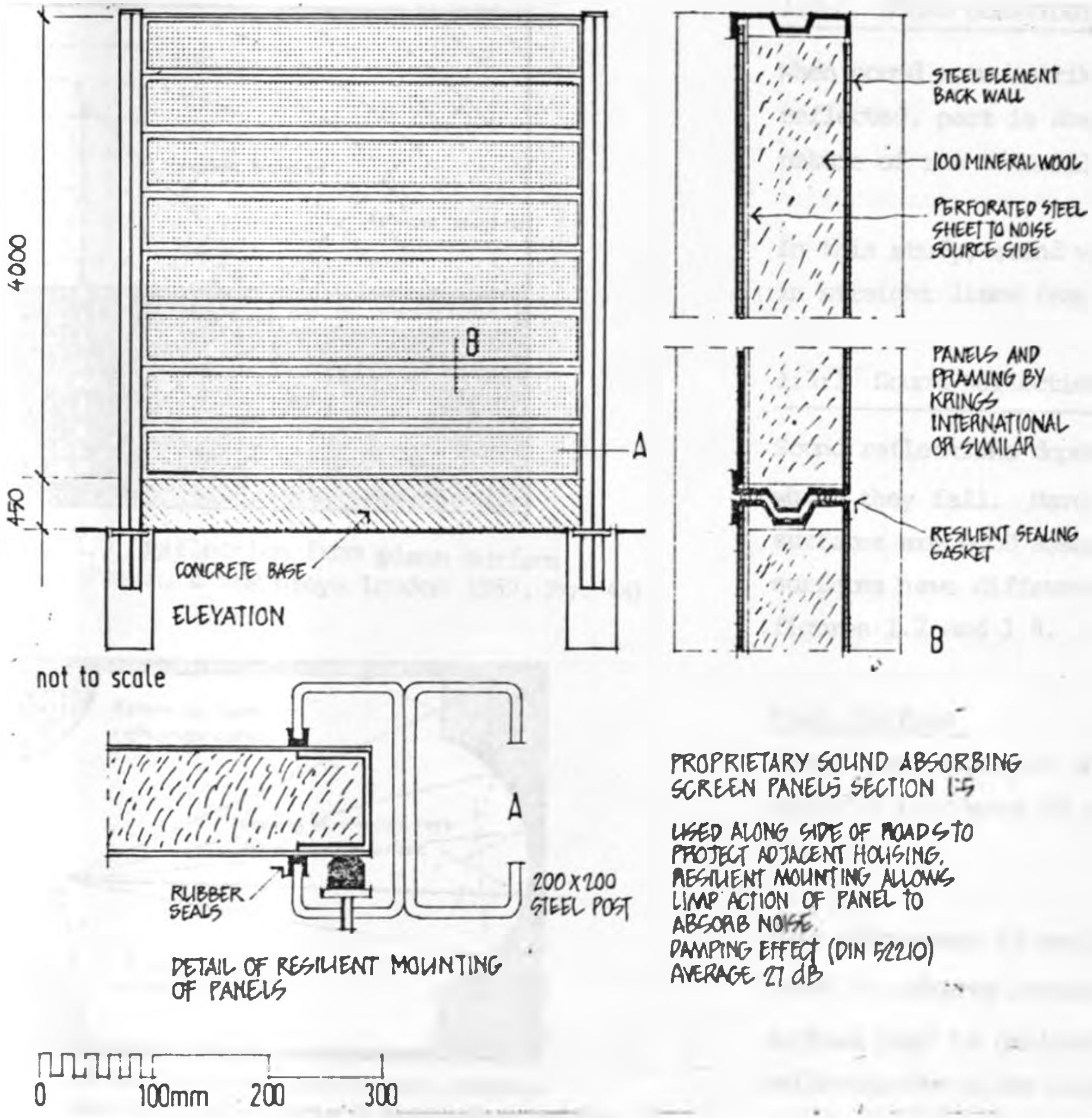


Fig. 1.6

Proprietary sound absorbing screen panel.
(Templeton, London, 1986 Pg. 54).

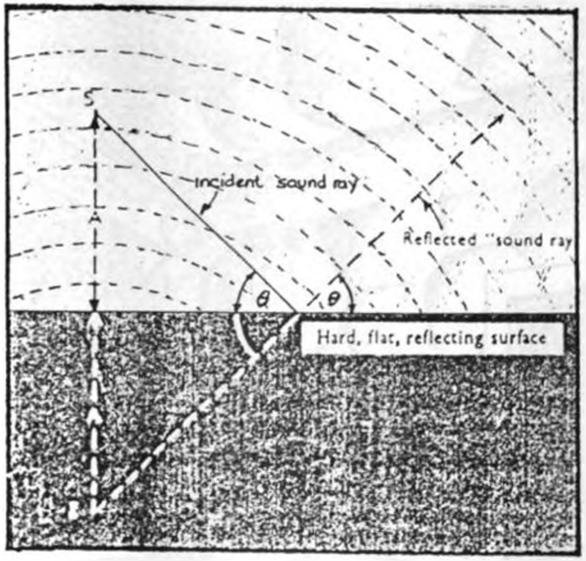


Fig. 1.7 Reflection from plane surface (Parkin & Humphreys London 1969, Pg. 44).

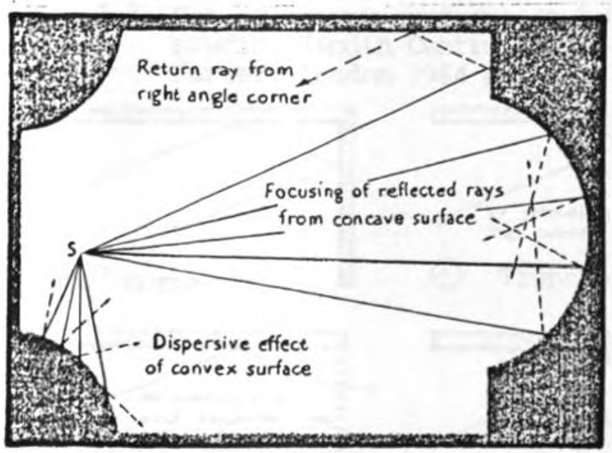


Fig. 1.8 Reflection from curved surface and corners (Parkin & Humphreys London 1969, Pg. 45).

1:3:0 SOUND BEHAVIOUR IN AN ENCLOSED SPACE

When sound waves strike a surface in an enclosed space, part of it is reflected, part is absorbed and part is transmitted depending on the nature of the material on which it falls.

In this study, sound waves shall be visualised as sound rays travelling in straight lines (Ray or Geometrical acoustics).

1:3:1 Sound Reflection

Sound reflections depend on the nature and shape of the surface on which they fall. Hard surfaces are good reflectors while soft porous surfaces are good absorbers. The plane, concave and convex shaped surfaces have different effect on sound reflection as shown in figures 1.7 and 1.8.

Plane Surface

Sound waves incident on a plane surface are reflected such that the angle of incidence is equal to the angle of reflection as depicted on fig. 1.7.

This phenomenon is analogous to optical laws of light reflection. In order to achieve better reflection from any reflecting surface, the surface must be designed to be larger than the incident wavelength. Reflection by plane surfaces bears the advantage of reinforcing sound waves in a room.

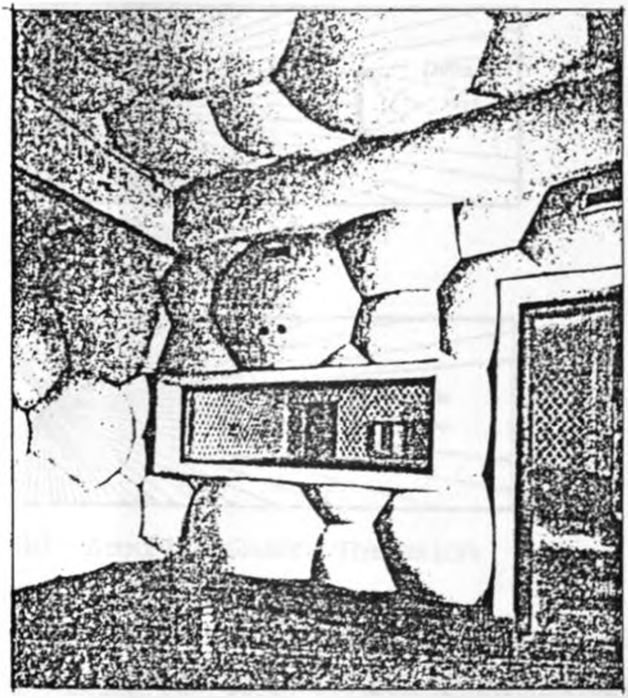


Plate 1.1 Use of convex surfaces in broadcasting studio. (Rodin Centre Paris) Furrer, London 1964 Pg. 80.

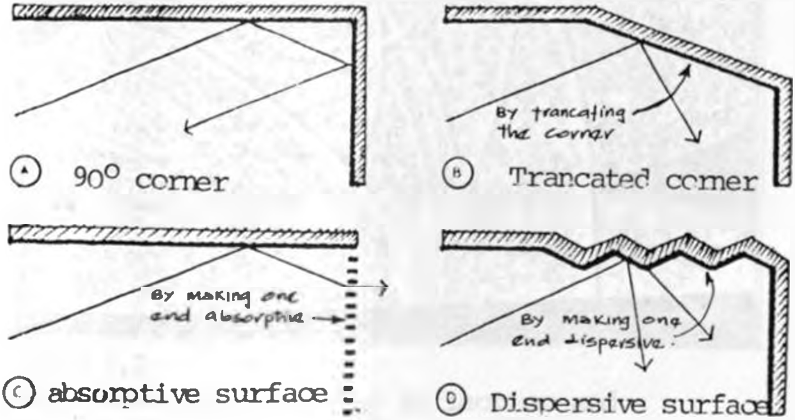


Fig. 1.9 Treatment of corner to avoid unwanted sound intereflections.
(Moore, London 1978 Pg. 30).

Convex Surface

Sound waves incident on convex surfaces are dispersed in many directions as shown on fig. 1.8. Convex surfaces can be used for sound diffusion especially if they are larger than the incident wavelength. These surfaces are used extensively in both television and broadcasting studios to enhance diffusion of sound waves and to assist in prevention of echoes and unwanted cross reflections. Plate 1.1 illustrates the use of convex surfaces in the walls and ceiling of a broadcasting studio in Rodin Centre, Paris.

Concave Surface

Sound waves incident on a concave surface are concentrated on a focus region relative to the source as shown in fig. 1.8. The concentration increases the sound intensity and this may cause undesired acoustic effect in audition spaces. Concave spaces should therefore be avoided when designing such spaces like studios and theatres.

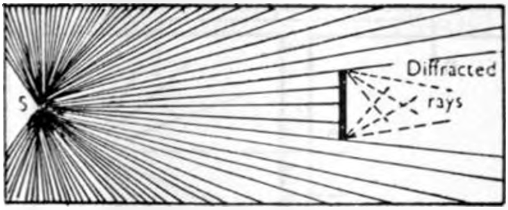
If in any case such concave shapes are used, their focal centres should be off the enclosed space.

Corners

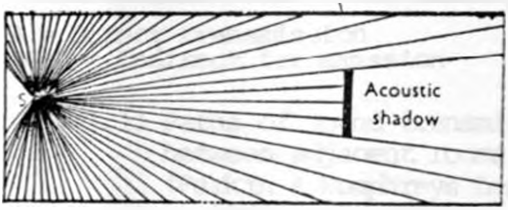
Sound entering in a right angled corner gets reflected back to the source as shown in fig. 1.8. This has the disadvantage of presenting unwanted echoes unless the corner is treated as shown in fig. 1.9.

1:3:2 Sound Diffraction

Diffraction is the change in direction of propagation of sound waves due



(a) Diffraction of sound



(b) Acoustic Shadow Formation

Fig. 1.10 Sound Diffraction
(Parking & Humphreys, London 1969 Pg. 46).

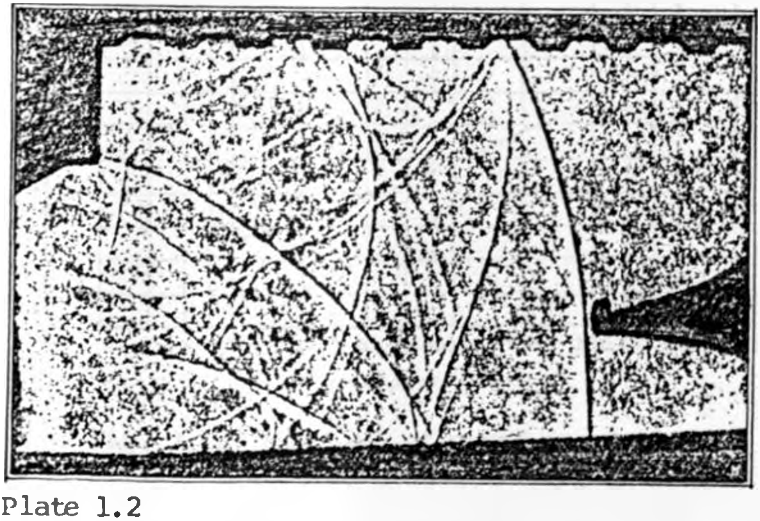


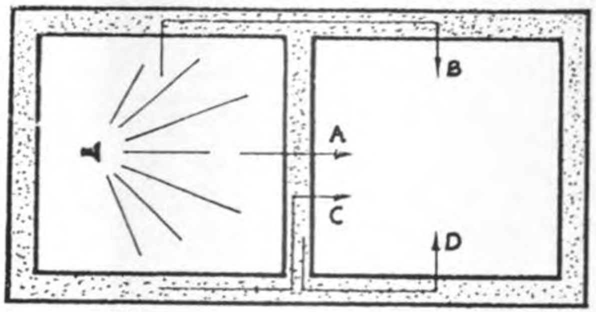
Plate 1.2
Spark photograph showing reflection and diffractions from a coffered ceiling in an auditorium.
(Knudsen,New York, 1950 Pg. 55).

to their passage around an obstacle. This occurs more for low frequency than for high frequency sound waves as illustrated in Fig. 1.10 Figure (b) illustrates the formation of sound shadows in high frequency sounds.

In studio spaces, where music and speech are conducted, the wide range of frequencies would have to be diffracted selectively. Most of the high frequency sound would be reflected while the low frequency sounds would be diffracted. Reflective and absorptive surfaces in a room may also cause diffraction as depicted in plate 1.2. The many wavelets originating from the ribs of the coffers are accounted for by both reflections and diffraction. The edges of the coffers being smaller than the wavelength of the incident sound diffract and diffuse the sound.

Discontinuities in the placement of the sound absorptive treatment on the walls and irregularities on the surface wall helps to bring about diffraction which is a desirable condition for good acoustics. When designing studios and other audition rooms, the architect should be aware of the kind of materials and placements to be made on the surfaces of the room in order to enhance diffraction of sound waves.

———— o ————



A = Direct transmission
BC&D = Indirect transmission

Fig. 1.11 Paths of sound transmission between adjacent rooms (Parkin & Humphreys London 1969 , Pg. 178).

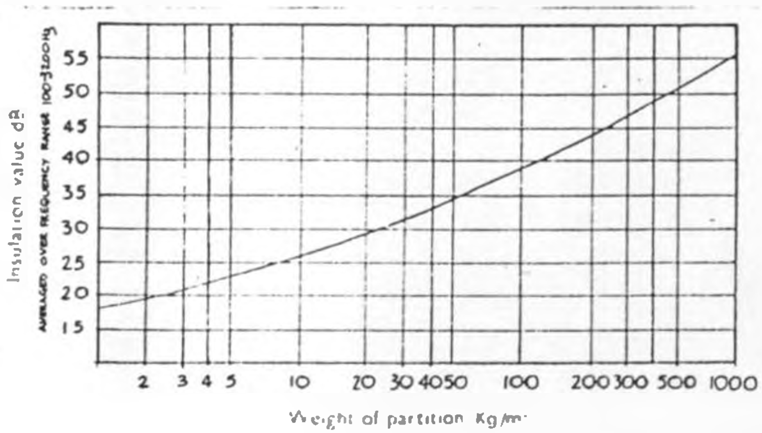


Fig. 1.12 'Mas Law' of sound insulation (Moore, London 1978 Pg. 70).

1:4:0 SOUND INSULATION

Sound insulation is the reduction of sound intensity from one room to another. The insulation offers more sound reduction than sound absorption. Insulation of sound due to impact sound and air-borne sound should always be considered especially in the design of studios. This is one section that the architect has to understand thoroughly as far as the design of studios is concerned. Studios require maximum sound insulation to make sure that no external noise gets into them.

1:4:1 Air-Borne Sound Transmission

Sound can be transmitted between two adjacent rooms as shown in Fig. 1.11. Path A shows the most obvious direct transmission while the others show how sound falling on the walls of the source room can also be transmitted indirectly into the receiving room.

Mass Law

The amount of insulation offered by the partition walls depend on their mass, construction and on the frequency of the incident sound. For every mass doubling of a single-leaf wall, the sound insulation increases by 5dB; and for every doubling of frequency, the sound insulation also increases by 5dB. Therefore, for single walls, the average insulation depends on the weight per unit area ('Mass Law' of sound insulation)[3]. Fig. 1.12 gives the relationship between partitions with a range of

3-Parkin & Humphreys London 1969 Pg. 179.

Weak Links

In most buildings, windows, doors, rooflights, ceilings etc. provide weak paths for air-borne sound transmission. An open window or a flimpsy door would bring about a very low insulation value to an otherwise highly sound insulating wall. Windows and doors have to be well designed to provide good indoor acoustic environment.

Doors which should exclude as much sound as possible should be heavy and fit tightly with resilient stops. In studios, sound lobbies treated with absorbent materials and sound proof doors are provided. This is dealt with more thoroughly in Chapter Two.

1:4:2 Impact Sound Transmission

This kind of sound transmission occurs when source of the sound is generated in the structure of the building and transmitted through it. This transmission may be through the floor, the walls, ceilings or the roof. The impact sound may be created by footsteps, dragging furniture, falling objects etc. The loudness of such impact sounds in the receiving rooms shall depend on the construction of the floor and floor surface. (See Fig . 2.9 Pg.. 55)..

Floating Floor

Resilient materials such as carpets, rubber or cork are used to damp the energy transmitted through the structure. However, these materials may loose their practicability with increase of the impact.

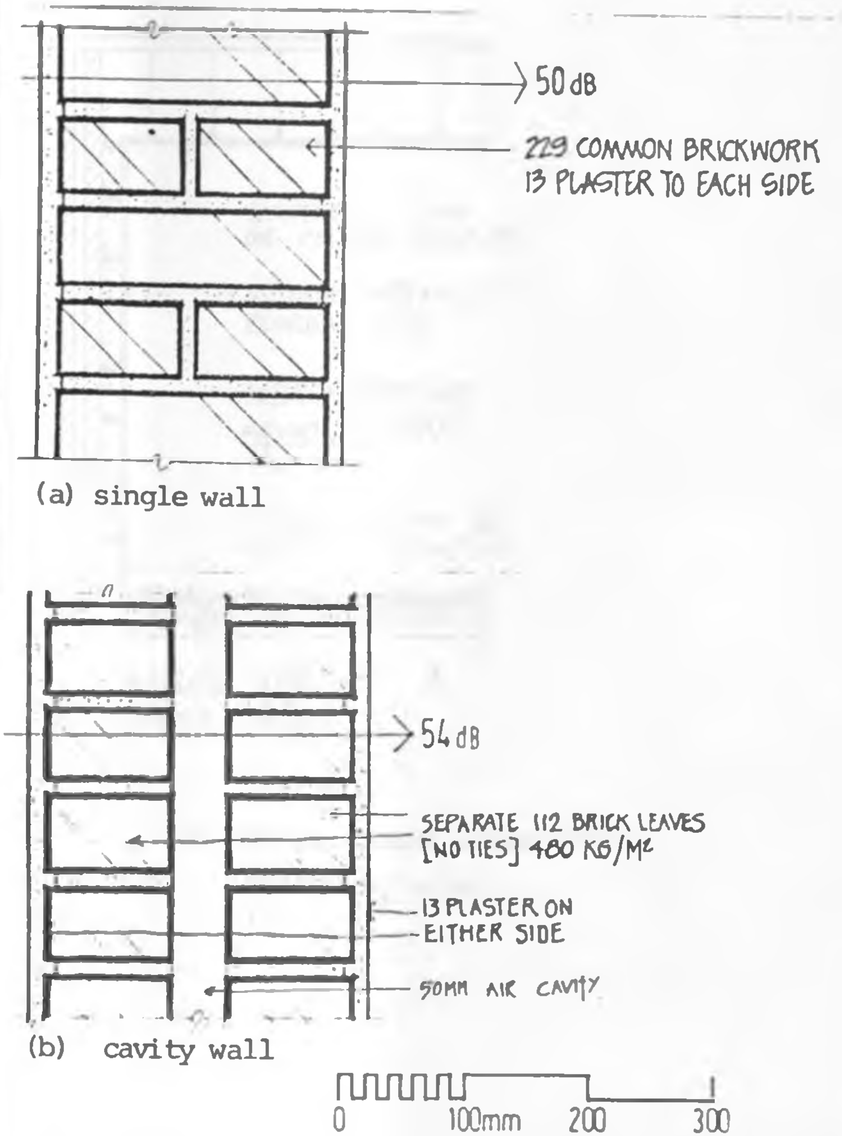


Fig. 1.13 sound insualtion in single
and cavity walls
(Lord & Templeton London 1968)
Pg. 42,43.)·

superficial weights (Kg/m^2) and their insulation values (dB).

Cavity Wall

In order to achieve more sound insulation values through a partition wall, use of doubleleaf wall construction is adopted. A double leaf wall with an air cavity between the two leafs gives more sound transmission loss than a single leaf wall with the same weight per unit area.

Fig. 1.13 shows a comparison of sound insulation values given by two brickwork walls, one single leaf and the other double leaf with a 50 mm air cavity and 480 kg/m^2 mass per unit area. Figure (a) represents the single leaf wall offering an insulation value of 50db while figure (b) represents the same wall thickness with the air cavity offering an insulation value of 54 dB. According to the mass law, this insulation can be offered by almost doubling the size of the single leaf wall.

In the light of this inference, its seen that a more economical and effective solution to attain high sound insulation values can be attained by the way a wall is constructed. A cavity wall is therefore an appropriate solution to good sound insulations especially in studio designs.

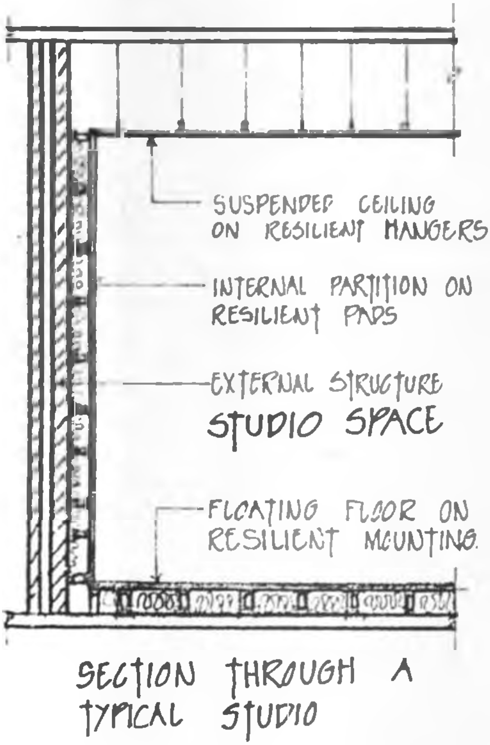


Fig. 1.14 Discontinuous Construction.
(detail by author).

In that case, the floating floor construction which acoustically isolates the floor finish from the structural floor is used (see Fig. 2. 9 Pg 55). This type of construction does not only insulate impact sound, but also improve the air-borne sound insulation as well.

Discontinuous Construction

In broadcasting and recording studios, greater insulation from both air-borne and impact sound is required. In this case, a discontinuous construction is used which creates a double skin structure with the studio being an acoustically independant room within another room as shown on Fig. 1.14.

In this type of construction, the external noise incident on the structure are broken by the air space and by the resilient materials giving a sqund insulation of 60-65 dB[4]

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4-Moore, London 1978, Pg. 79.

1:5:0 SOUND ABSORPTION

Sound absorption is the removal of sound energy that is converted into heat when sound strikes a surface. The nature of the surfaces on which the sound waves fall determines how much sound will be absorbed. Hard rigid non-porous surfaces provide least absorption while soft porous surfaces and those that can vibrate absorb most of the sound.

1:5:1 Absorption Coefficient

This is the number that rates the efficiency of the absorption process. This number varies from zero for a case where no sound is absorbed to one - a case where all the sound is absorbed. This coefficient is for those sounds arriving on the surface at all angles of incidence. The absorption coefficient varies with the type of material and the frequency of the incident sound. Coefficients of sound absorption for various materials are given in Appendix I (Pg. 113-115).

1:5:2 Media of Sound Absorption

Sound in a room may be absorbed by air, bounding surfaces, furnishings as well as the audience.

Air Absorption

Small amount of sound is absorbed in the passage of direct and reflect sound through the air in a room due to intermolecular friction of air. This is only of significant effect for sound frequencies above 1000H$_3$.

Surface Absorption

Absorption occurs in bounding surfaces depending on the nature of the material and surface treatment. The absorption coefficient of the material is the prime factor in surface absorption. Soft porous materials are better absorbers while hard solid materials are good reflectors.

Absorption by Furnishings

Sound is also absorbed by furniture, curtains, drapperies etc. Seats should be highly absorbent to reduce acoustic variation due to changing audience in a room. Furniture in studio spaces should be porous or made of absorbent materials to prevent reflections of the sound to the microphones.

Absorption by audience

Absorption by the audience is due to the clothings that they wear. This is a major factor to be taken in a room because the number of people present per occasion can alter the room acoustics perceptibly.

1:5:3 Sound Absorbent Materials

Absorbent qualities of different materials vary with the frequency of the incident sound waves. Different materials are used in a room to absorb different ranges of frequencies. Some type of absorbent materials used are; porous absorbents, membrane absorbents, resonant absorbents and perforated panel absorbents.

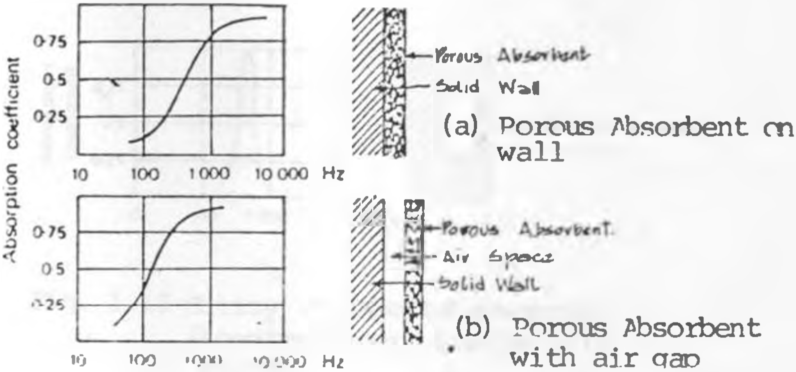

Fig. 1.15 Porous Absorbents
(Koenigsberger, London, 1973 Pg. 185)

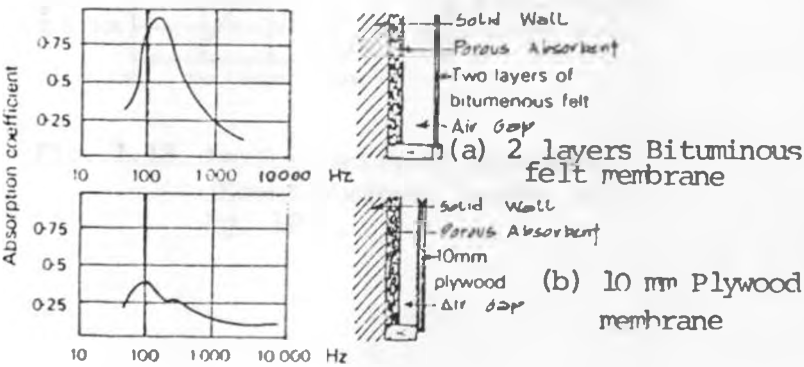

Fig. 1.16 Membrane Absorbent
(Koenigsberger, London 1973 Pg. 185)

Porous Absorbents

These are materials that have tinny holes which are open t
the room. Examples include; mineral wool, glass wool, fo
wool slab, carpets, curtains and other soft furnishings.
absorbents absorb best for the higher frequency sounds.
how porous absorbents absorb sound at different frequencie

Increasing the thickness of the porous absorbed or spacing
a solid backing increases absorption at low and middle fre
shown in the graph in figure (b).

Membrane Absorbents

These type of absorbers consist of a thin air tight skin.
include; plywood spaced some distance from a rigid wall,
ceiling and timber floors. These membranes absorb best at
as shown by the graphs in Fig. 1.16.

The efficiency of the absorbent can be increased by increa
thickness or by putting a soft porous absorbent in the air
the membrane.

Resonant Absorbents

These absorbents have an enclosed air chamber connected to
a small opening. Examples include the Helmholtz resonator
absorbents have very selective absorption and can be tuned
frequency desired. These are good for use in auditorial a

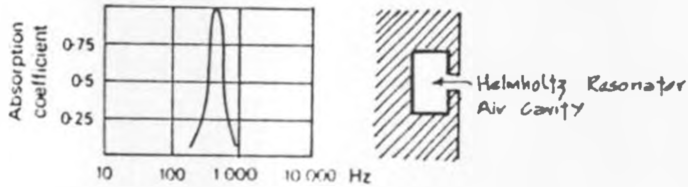

Fig. 1.17 Cavity (Helmholtz) resonator
(Koenigsberger, London 1973
Pg. 185).

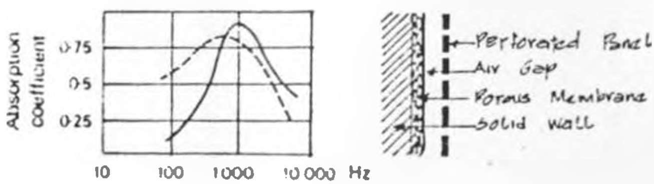

Fig. 1.18 Perforated Panel absorbent
(Koenigsberger, London 1973
Pg. 185).

broadcasting and television studios where some long vibrations may be experienced at a single frequency. Fig. 1.17 gives the example of the performance of a typical cavity (Helmholtz) resonator.

Perforated Panel absorbents

This is a combination of both porous and resonant absorbers. They are best in medium frequencies; but can be adjusted to suit various frequencies by variation of the hole size, shape and the nature of the backing material. The performance of such a perforated panel absorbent is shown on Fig. 1.18.

Application

Selection of the absorbents to be used should be according to the frequency of the desired sound. The placement will depend on the effect desired (whether absorption or reflection) and also on the possibilities of damage that can be caused on the type of material. The ceiling, with little damage exposure should always be prefered for any slight absorption consideration. The same degree of total absorption at all frequencies should be provided. This makes it necessary to mix the materials selected to balance out the selective absorption.

1:5:4 Total Absorption[5]

This is the sum of the product of the areas of the different types of surface and their absorption coefficient. The unit used for the absorption is the sabin

Total Absorption, $A = \alpha_1 S_1 + \alpha_2 S_2 + \ldots\ldots\ldots\ldots + \alpha_n S_n$

5. Parkin & Humphreys London 1969 Pg. 51.

Where $S_1 \ldots\ldots S_n$ are areas in m^2

$\alpha_1 \ldots\ldots \alpha_n$ = are absorption coefficients of the materials at various frequencies.

The total absorption is a determinant parameter towards achieving the overall reverberation time in a room.

1:5:5 Reverberation Time[6]

The time taken by the sound to decay by 60dB is called reverberation time. This dying away of the sound depends on the absorption in the room and the volume of the room.

For a great majority of spaces, Sabines formula is sufficiently accurate to be used as a standard formular for the reverberation time calculatio

$$R.T = \frac{0.16V}{A}$$

Where R.T = Reverberation time in seconds

V = Volume in M^3

A = Total Absorption in M^2 Sabins.

From the Sabine's formular, its clear that absorbent materials tend to reduce the reverberation time while greater volumes tend to increase it.

In design of studios, the reverberation time calculations requires the modification of the Sabine's formula in order to overcome its anomalities In this case, the Eyrings modification is oftenly used for the calculations.

6 - Parkin & Humphreys London 1969 Pg. 51,52,53.

By this formular,

$$R.T = \frac{0.16\,V}{S\left[-\log_e (1-\bar{\alpha})\right]} + (xv)$$

Where R.T. = Reverberation time in seconds

V = Volume of the space in M^3

xv = Air Absorption (only important for large volumes and frequencies above 1000H3)

$$\bar{\alpha} = \frac{\sum S_1\alpha_1 + S_2\alpha_2 + \ldots + S_n\alpha_n}{S}$$

S = Total surface area in M^2

α = Absorption coefficients of the materials at various frequencies.

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Chapter Two

CHAPTER 2

STUDIO DESIGN

This chapter sets out to achieve the design criteria in television and broadcasting studio which the architect should bear in mind in early stages of design.

Studio design is a function of many factors with acoustics as the most stringent criteria. Good acoustics design must be enhanced by good planning, layout, materials, surface finishes, shape, choice and design of service systems. The architect should consider this to be the backbone of a successful acoustic solution.

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[illegible]

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2:1:0 SOUND ISOLATION

The internal and external noise sources can greatly affect the noise levels in a building. It is therefore essential to control such noise problems to the acceptable noise levels in order to maintain a good acoustic environment.

2:1:1 Site Selection

The required internal and external noise climate in a broadcasting studio set up depends a lot on the site location. All the perceived noise levels in a chosen site depends on the intensity of the noise source and should be measured to ascertain the range of the background sound level. Such external and internal noise sources should be well controlled to achieve the desired noise levels.

It is important to predict the nature of any future developments that are likely to take place around the site. These developments would greatly affect the noise climate and hence sound control precautions should be compreheaded early enough to avoid later disappointment.

2:1:2 Site Planning

In the overall planning and design of broadcasting and television studios, there should be proper orientation of the building to reduce noise exposure of occupied and critical spaces.

The noise sensitive spaces such as studios should be placed as far away as possible from external and internal noise sources.

The architect should attempt to give a significant separation of quieter areas from noiser ones.

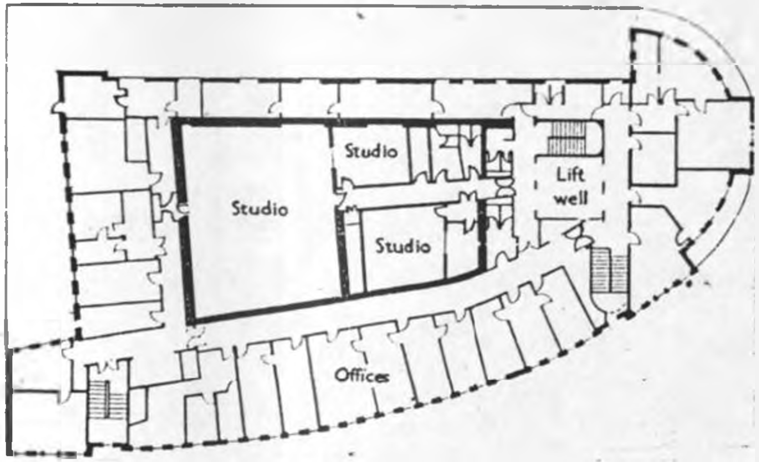

Fig. 2.1 Plan of Broadcasting House London. (Parkin & Humphreys , London 1969 (Pg. 201.)

2:1:3 Internal Planning

In the internal planning of a broadcasting and television studio centre, quieter studios should be separated from noiser areas by less critical spaces acting as barriers to the exterior noise; for instance use of offices to shield the quieter studio spaces from external noise in the Broadcasting House, London (see Fig. 2.1).

Studios require quiet ambient background (25-30 dB) and hence buffer spaces are prefered between them and other noisy spaces. Adequate sound insulation both from the interference of outside noise and between adjacent internal areas and the studios must be provided.

Maximum degree of insulation between the studio and adjoining spaces should be achieved by proper construction as already outlined partly in chapter one (see Fig. 1.14 Pg. 22) as well as in the consecutive text; construction with careful attention given to reduction of any indirect noise transmission from the surrounding spaces. Observation windows and doors form acoustic weak links in these spaces and should therefore be specially designed to reduce any sound transmission through them (see Figs. 2.13, 2.14, 2.15, on Pg. 57-58).

Any spaces above any studio should be provided with resilient floors to reduce any impact sound transmission to the studio. The studio

should have suspended ceiling to increase sound insulation from spaces above it.

2:1:4 Background Sound Levels

Background noise levels are taken to determine the best position of a building on site. The most quiet part of the site can be found out by the noise survey.

The acoustical environment in an occupied space is the resultant of the noise arriving at the space from both internal and external noise sources.

Internal noise sources in a studio may be caused by mechanical systems, electrical services, circulation services and human traffic, while the external noise sources may be caused by traffic, aircraft, railway or nearby machinery.

Its mandatory to maintain an ambient acoustical background for studio spaces at 25-30 dB[6]. This range should be maintained and any unwanted noise should be isolated from these spaces to achieve a good indoor acoustic environment.

The noise control procedure of site selection, building orientation, internal planning, selection of plant and equipment and use of building materials and suitable structure should be strictly followed.

6-Burris Meyer, New York 1972, Pg. 115

There is often a change of external noise climate with time, usually increasing year after year. This may be due to progressive developments around the building location. Such future developments should be ascertained early enough to avoid significant effects on the level of the noise climate.

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2;2;0 TELEVISION STUDIOS

From earliest days of television production until presently, the need to obtain good pictures is allowed to overide the need for good acoustics.

The acoustics of television studios is not as critical as those in broadcasting studios since the performers have to be given a tolerable acoustic atmosphere in order to produce good performance.

2:2:1 Studio Types

There are four types of television studios whose sizes differ according to the performance. Acoustical requirements has little effect in governing their sizes. These studios are:-

(i) General purpose studio
(ii) Theatre type studio
(iii) Interview and announcers studio
(iv) Dubbing suites

Each of these studios are provided with ancillary technical rooms and stores around them. The access to the studios is through sound lobbies provided with sound proof doors.

2:2:2 General Purpose and Theatre Type Studios

Spatial Use

These two types of television studios are used for all types of programmes. The main difference btween the two studios is that the general purpose studio has no permanent audience seating but only makeshift audience participation while theatre type studio has provision for permanent audience seating.

Size

These studios are usually very large with volumes of up to $10,000m^3$.

A maximum clear height over the working part of the studio of 8m must be provided to elaborate the lighting grid and the cyclorama scenery gear.

Control Rooms

Each studio is provided with four control rooms for vision, sound, lighting and camera controls. An apparatus room is also provided.

Vision, sound and lighting control rooms are arranged in a suite and must have good visual link through observation windows to the studios. Out of necessity, the control suite is located one storey higher than the studio floor to give a wide view over the whole studio space.

Camera control and apparatus room does not require any visual connection to the studio and can only be located near the control rooms to avoid long runs of intercom circuit links.

The size of the control room is governed by the size of the technical apparatus which they should accommodate.

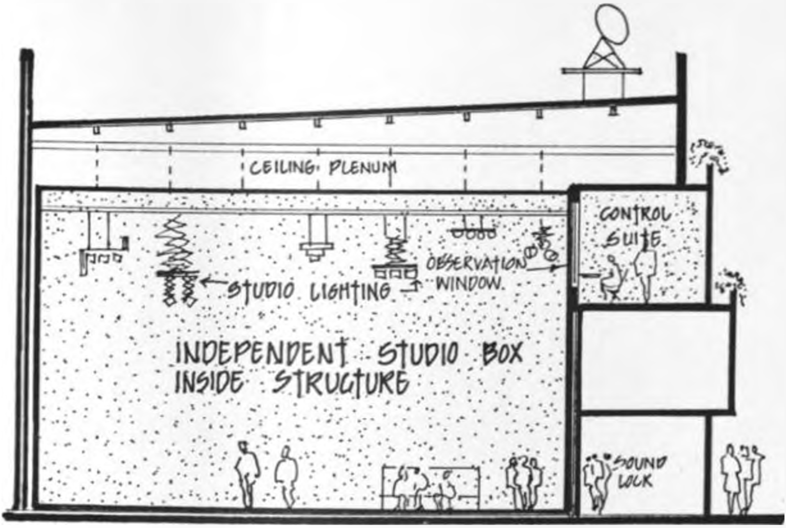

Fig. 2.2
Section across a typical television studio
(Drawing by author)

Fig. 2.2 gives a simple diagramatic section of a typical studio showing control suite position.

Other Rooms

Make up rooms, changing rooms and property stores must be provided close to the studio. The provision for audience may require public access, toilet facilities, cloak rooms, foyers and even associated bars and restaurants.

Lighting

The studio set up must be flexible enough to provide room for the lighting grid. Lighting in a television studio influences the viewers interpretation of size, shape, distance, texture and even pictorial environment of the overall picture.

A lighting gallery, a system of catwalks or even a gridded floor over the whole studio should be designed to give access for adjustment of the different types of luminants used in the studio lighting.

Ventilation

The powerful lighting system used in the television studios dissipate a lot of heat to the studio. This heat output must be reduced by effective artificial ventilation system. It therefore becomes essential to use chilled air supply air - conditioning system to lower down the temperatures to comfortable levels.

2:2:3 Interview and announcers studios

Spatial Use

Announcers studio is used for news casting while intervie
for small interviews and small group discussions.

Size

These types of studios are relatively very small compared
two cases outlined above. A minimum floor area of $60m^2$ a
height of at least 4m can serve as an adequate space for s

Control Rooms

One control cubicle is sufficient though a continuity sui
formed with other control rooms. This may comprise of pr
studio, control cubicle, central vision room, central sou
room and sound and vision quality check room. All these
the sound and vision quality check rooms should be visual
each other and to the studio.

Lighting

A lighting grid is not required for these types of studio
spot lights; the key, back and fill lights are strategica
produce required surface tones on the subject.

Ventilation

Artifical ventilation is required to reduce the heat outp

2.3 Recommended Reverberation Time for Broadcast and Television Studios (Rushin & Humphreys London 1965 pp. 33).

Adaptive Use

In some countries, old theatres have been converted into audience participation television studios. Though the stage may be adapted for television use, a number of disadvantages are prevalent; among them are the following:-

(i) The stage is usually small preventing innovation concerning scenery projection and alterations.

(ii) The proscenium arch limits the general adaptability of the stage area.

(iii) Television audience is small and the theatre audience seating capacity is usually very large.

(iv) Theatres with large stages have a large audience seating and presents difficult in adapting general seating for a smaller audience.

(v) Extra technological innovation concerning lighting, acoustics control and ventilation is needed.

The above disadvantages clearly shows that the architect should be aware that adaptation can only be done through difficulties and eventually little success is achieved.

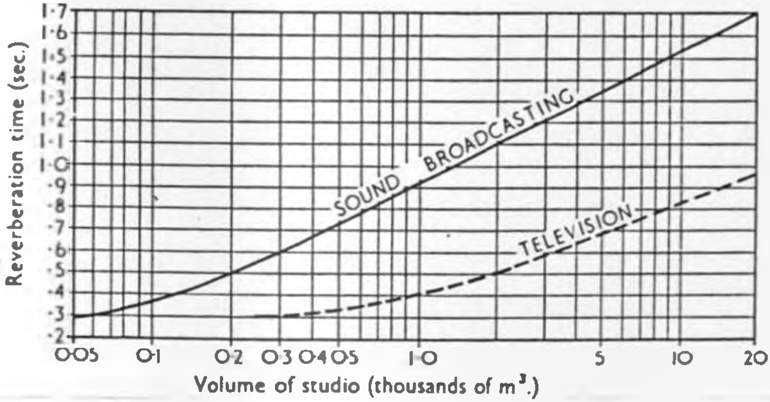

Fig. 2.3 Recommended Reverberation Time for Broadcast and Television studios (Parkin & Humphreys London 1969 Pg. 23).

these few but powerful luminants as well as supplying fresh air to the enclosed studio.

2:2:4 Dubbing Suites

Dubbing suites are projection theatres whose control cubicles and recording rooms have good unobstructed view of the screen. They are used for previewing films and dubbing commentaries from taped programmes.

2:2:5 Acoustic Design

For all television studios, the reverberation time should be adjusted to suit the volume of the studio. The volume/reverberation time relationship for both television and broadcasting studios is given in Fig. 2.3.

It is important to maintain an almost constant reverberation time at frequencies between 100 H3 and 4000 H3. This can be done by right use and placement of absorbent materials.

In audience participation studios, adequate sound coverage for the audience should be provided. A need for sound-reinforcement system becomes necessary in large studios to amplify the human voice and give good sound coverage to the audience. Low reverberation time is therefore important to prevent reverberant sound from being picked up by the microphone.

In projection theatres, sound control rooms and sound quality check rooms, the acoustic treatment should only be designed to give good listening room condition (reverberation time of 0.4-0.5 sec.).

In vision control rooms, the production technique for constant verbal communication between the producer and his assistants calls for an acoustically dead condition. An average reverberation time of not more than 0.25 seconds is prefered.

Light control rooms, apparatus rooms and central control rooms require minimum acoustic treatment such as provision of acoustic tile ceiling only.

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2;3;0 BROADCASTING STUDIOS

In a broadcasting centre, a variety of studios are designed to cater for various programmes and activities whose diversity of technical and functional requirements must be fulfilled.

The need for good sound production in broadcasting studios superoedes all other technical and functional aspects. Studios present acoustic problems whose solutions lie on the hands of a design team of architects, acousticians and engineers.

2;3;1 Studio Types

Four types of sound broadcasting studios whose functions are different are found in most broadcasting centres. These studios include:-

(i) Music studio
(ii) Variety show studio
(iii) Drama studio
(iv) Talks studio

Planning

Each of these studios are planned with high noise insulation precautions to limit any air-borne or impact sound transmission from the internal and external noise sources. A large sound transmission loss of sound produced within the studio is also required to attain a quiet ambient acoustic environment between it and its neighbouring spaces. Table 2.3 Pg. 54 gives some examples of sound transmission loss values required between some studios and their adjacent spaces. The table also gives types of walls that would be applicable in order to attain these insulation requirements.

TABLE 2.1

Music Studio size and number of performers.
(Parkin & Humphreys London 1969 Pg. 119).

Number of Performers	Minimum Studio Volume
4	42 m^3
8	110 "
16	340 "
32	850 "
64	2300 "
128	6200 "

In every studio space, a control room is required. The control room is visually linked to the studio through specially designed observation window. This window should provide an average sound insulation value of up to 40 dB or more. Fig. 2.15 (Pg. 58) gives the details of such an observation window used between a studio and a control room.

The studios gain access through sound lobbies with sound proof doors which exclude any external noise from getting inside. Fig. 2.13 Pg.57 outlines the details of such a door while Fig. 2.14 (Pg.58) gives an example of sound lock to a studio space.

2:3:2 Music Studio

Spatial Use

Large music studios are used for symphony orchestras, choirs, bands and concerts.

Smaller music studios are used as general purpose studios and are suitable for medium-sized orchestra, brass band, trios, quartets and small dance bands. This size of a studio can also be used for speech production.

Size

The size of the music studio is determined by the number of performers. Table 2.1 gives number of performers and studio volumes used by the (British Broadcasting Corporation) as a general guide.

Music studios should adequately accommodate the audience and all the physical contents in a performance including the instrumentalists and microphone placing.

Figure [illegible]
The [illegible] of a typical [illegible] studio
([illegible] Broadcasting, London [illegible]
[illegible] 138).

Large studios usually have a seating for an audience of at least one hundred and fifty people while smaller studios used as general purpose studios have a seating for an audience of less than one hundred and fifty.

Control Rooms

A control cubicle of about $20m^2$ in area is required to have a wide visual link to the studio floor through observation windows.

In the largest studios with double storey heights, it is desirable to locate the control cubicle a floor level higher than the studio floor.

Other Rooms

A recording room adjoining the control cubicle and with observation windows both from the control room and to the studio should be incorporated.

Lighting control room should be installed in theatre type of studios. For commentator build-up programmes, a commentary or narrators studio with observation windows to the studio is required.

2:3:3 Variety Show Studio

This is a theatre type studio with provision for public audience seating of up to four hundred persons. Television variety type of studio can adequately suppliment this type of studio.

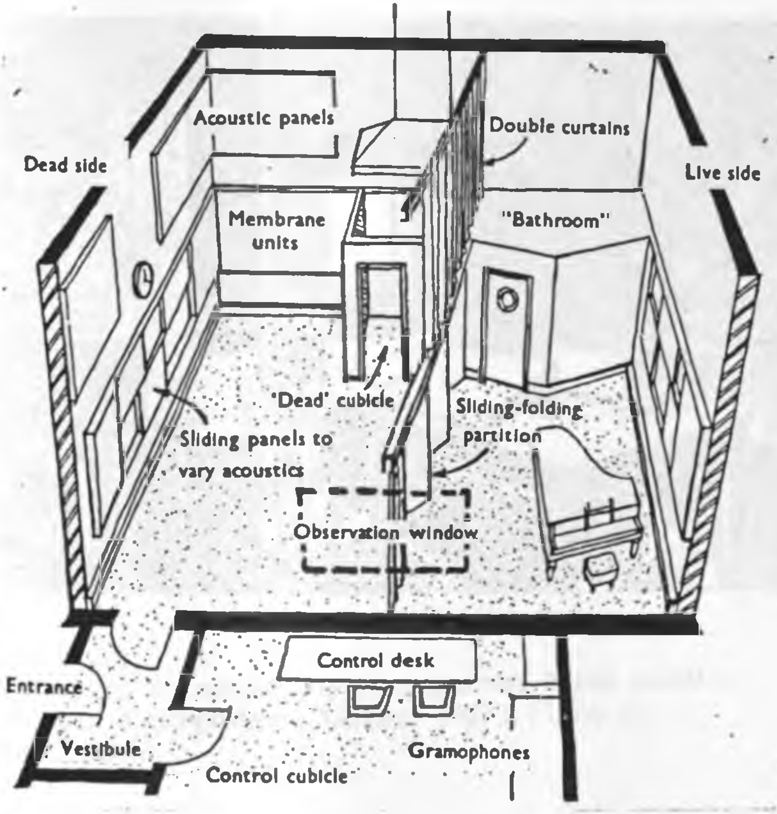

Fig. 2.5
The layout of a typical Drama Studio
(Parkin and Humphreys, London 1969
Pg. 116).

2:3:4 Drama Studio

Spatial Use

Drama studio is mainly used for drama and plays. These are normally recorded for live broadcasting.

Size

The size of a drama studio is governed by spatial requirements. A floor area of at least 60m^2 is required with two enclosures that are acoustically treated as very dead and very live. The dead enclosure area should at least be 8m^2 in area. Fig 2.5 depicts a typical drama studio set up.

When audience participation is required, it is necessary to keep the audience a certain distance away from the action area to maintain a proper performer-to-audience relationship.

The height of a drama studio should vary from three to six metres depending on their floor areas.

Control Rooms

Both the dead and live enclosures should be arranged to have direct visual link from the control room. Preferably, the control room should be situated in a slightly higher level than the studio floor.

A recording room with observation to the control room and the studio floor should also be required for most programmes.

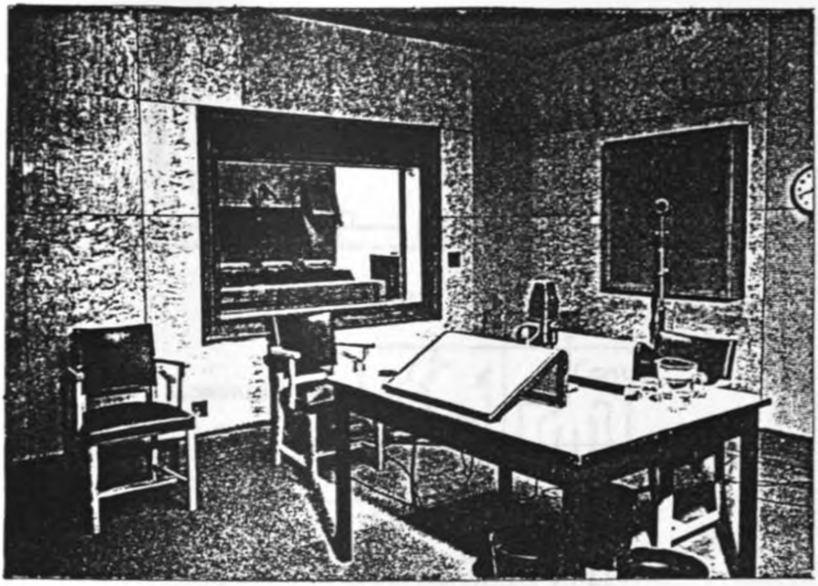

Plate 2.1
A British Broadcasting Corporation talks studio
(Parkin & Humphreys, London 1969, Plate v).

2:3:5 Talks Studio

Use

Talks studios are used for discussion programmes and also for announcements and news reading. A typical talk studio is shown on plate 2.1.

Size

The size of a talks studio is determined by acoustical requirements and by the physical space required for the participants, furniture and apparatus.

Since the acoustical properties of the room must contribute to the sound output, dimensions less than 2.4m should be avoided. The ceiling height should be between 2.4m and 3.7m in order to keep to required reverberation time.

Suites

In a broadcasting centre, talks studios can be combined to form suites. Continuity and mixer suites are the main talks studio suites found in most broadcasting centres.

Mixer Suite

Mixer suites consist of two rooms, an announcers studio and a control room. Provision is made for building up programmes from other sources such as outside broadcasting.

Record playing equipment are not accommodated in the studio but

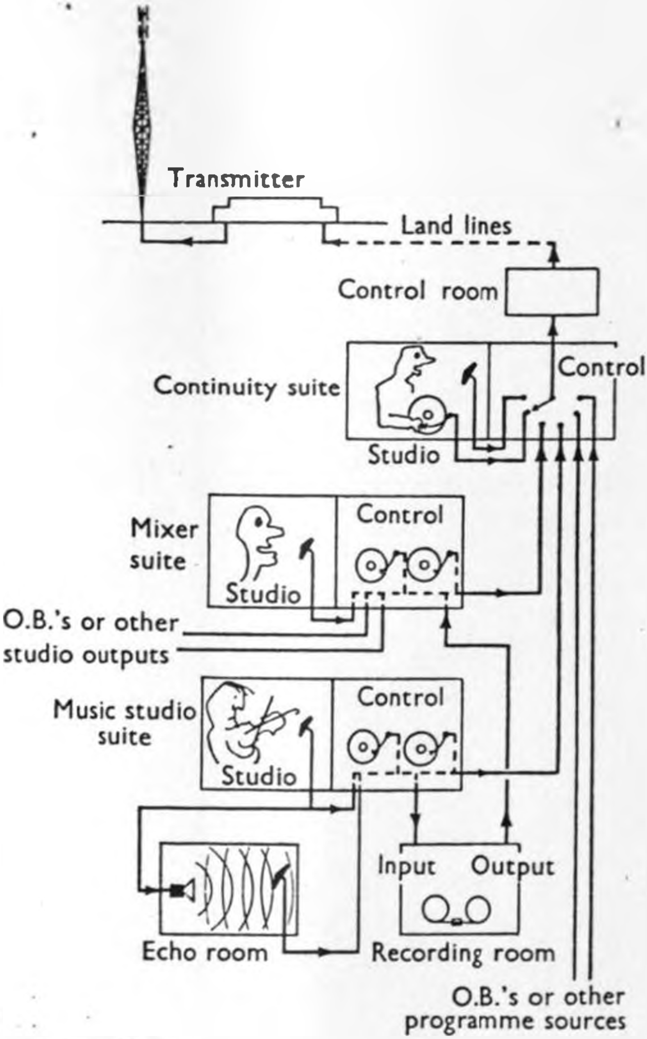

Fig. 2.6
Key Diagram of linking of studios in a Broadcasting Studio Centre
(Parkin & Humphreys Lodnon 1969, Pg. 117).

in the acoustically treated control room which has visual link to the studio through observation window.

Continuity Suite

The suite accommodates announcers studio and a control room. The announcers studio houses record playing facilities as well as the the microphone.

Sometimes a continuity suite may consist of a mixer room which is also treated as a talks studio.

Studio Link

All studios are linked together through intercom circuits to a central apparatus room before the programmes are sent on air through the transmitter. Fig. 2.6 gives a typical broadcast link.

2:3:6 Acoustic Design

Reverberation Time

The calculations for reverberation time for every octave from 62H3 to 4000H3 should be carried out and the average values checked to agree with the optimum value given in the volume/ reverberation time graph. (Fig. 2.3 Pg. 41).

Reverberation time calculations are worked out using the Erying's formular for reverberation time instead of the Sabires formula.

$$R.T. = \frac{0.16\,v}{S\left[-\log e\ (1-\bar{\alpha})\right] + (xv)}$$

Where xv = air absorption

$\bar{\alpha}$ = average absorption coefficient of all surfaces of the room.

loge = natural logarithm

s = total surface area of the materials

Absorption

The required amount of absorption at each frequency can be determined after getting the required reverberation time and volume.

Absorption of the studio contents should be ignored except in studios with provision for permanent audience participation.

Absorbents Placement

The robust hard-wearing materials such as perforated boards or wood strips should be used on walls where they are liable to suffer damage. Less rugged materials such as acoustic tiles should be used only out of reach of participants.

Absorbers are distributed so that about the same amount of absorption at all frequencies is applied to the walls, ceiling and floor.

Fig. 3.2

[illegible] absorbers on the walls and ceiling of [illegible] Studio 3A [illegible] City, New York [illegible], New York 1935, Pg. [illegible].

Various types of absorbents (Porous, membrane, Resonating Panels and Perforated Panels) are patched out and well mixed on the wall to provide maximum sound diffusion desirable in the studios at low, mid and high frequencies.

Extensive reflective areas such as the observation windows and plastered walls should not come exactly opposite one another to avoid flutter echoes.

Internal Geometry

The internal geometry should contribute to the acoustics of the studio. Curved surfaces and parallel walls that are liable to produce undesired sound effects on the sound production should be avoided.

Studio Proportions[7]

By rule of thumb, the ratio of any two dimensions of the studio should not be a whole number or close to a whole number. This may help to prevent enhancement of certain resonant frequencies which depend on room dimensions.

For small studios, a ratio of length to width to height of 1.6:1.25:1.0 is appropriate while in large studios, ratios of the order of 2.4:1.5 and 3.2:1.3:1.0 are commonly used.

Diffusion

Studios should have proper sound diffusion to increase the uniformity of the sound distribution. With proper uniform sound

7-Knudsen, New York 1950, Pg. 407.

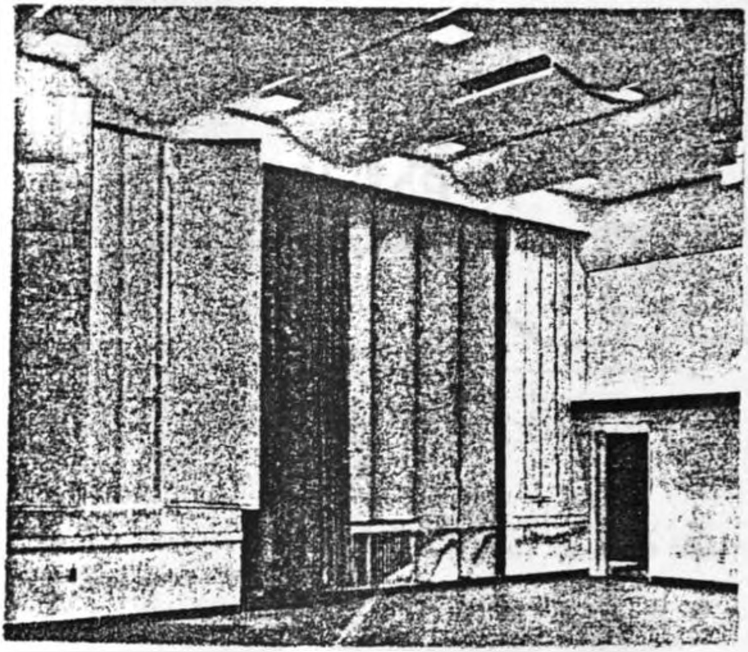

Plate 2.2

Protuberances on the walls and ceiling of N.B.C. Studio 3A Radio City, New York (Knudsen, New York 1950, Pg. 396).

distribution, microphone placement becomes less critical than it would be in a studio with little diffusion.

Diffusion may be provided by non-symmetrical placement of absorptive materials and by irregularities on the walls such as protuberances.

Plate 2.2 show a characteristic example of methods used to obtain large diffusion in a broadcasting studio in Radio City, New York.

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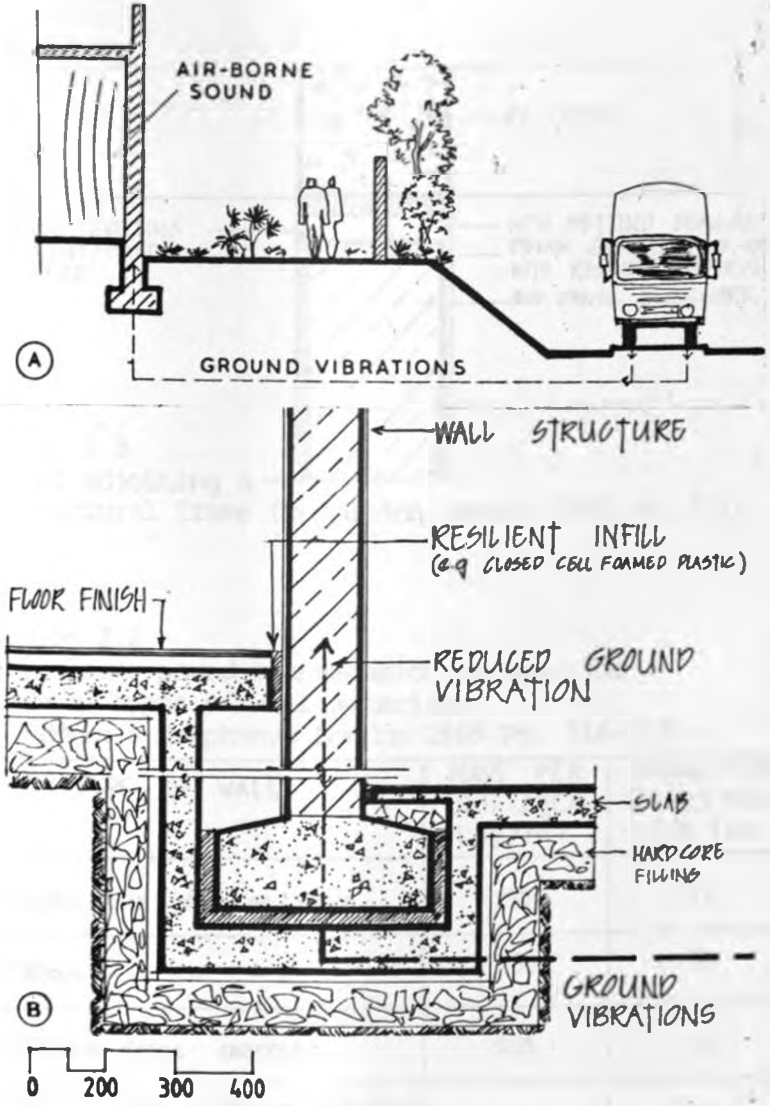


Fig. 2.8
Ground Vibrations and Foundation
Isolation DETAIL
(Moore London 1978 Pg. 86).

2;4;0 ACOUSTICS AND STUDIO CONSTRUCTION

This section advances to outline and describe construction techniques and details that the architect requires to give a sufficient fundamental acoustic solution to studio designs.

Due to the increasing variety of materials and components, the outlined details should only be interpreted as an assessment of the basic construction solution.

2:4:1 Foundation

The foundation must not transmit vibrations and other noise originating from the ground to the building structure. It must also be heavy enough to dissipate any noise and vibrations resulting within the structure.

Where ground vibrations are expected, the foundation must be isolated from it. This must be done early enough to avoid interference with other design elements later.

Where serious ground vibrations may occur, it becomes necessary to isolate the frame of the building from the foundation by use of resilient materials between the structural supports and the foundation footing.

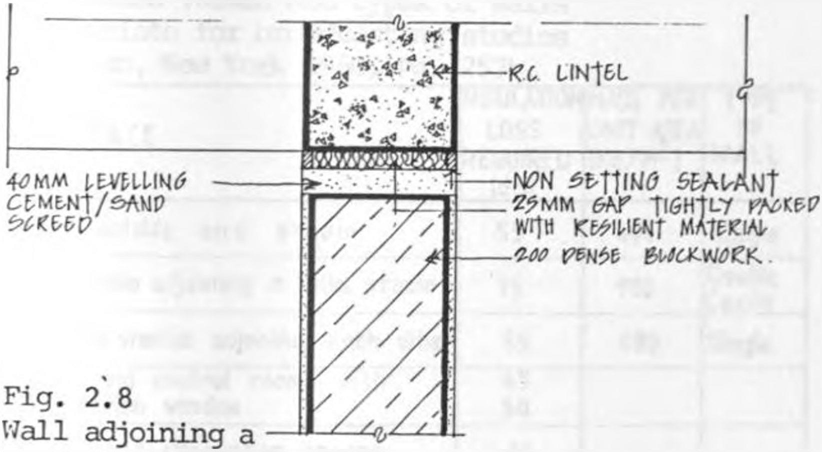


Fig. 2.8
Wall adjoining a structural frame (Templeton London 1982 Pg. 20).

Table 2.2
Air-borne sound transmission in loss for common types of wall materials
(Parkin & Humphreys London 1969 Pg. 216-217).

TYPE OF WALL	MASS PER UNIT AREA (Kg/M^2)	INSULATION TRANSMISSION LOSS (dB)
460mm solid brick or stone	950	55
230mm " " " "	450	50
100 mm dense concrete	250	45
75mm clinker concrete plastered both sides.	150	40
50mm gypsum	100	35
6mm asbestos cement	13	25
5mm glass	13	20

Fig. 2.7 (a) shows the resultant effect of ground vibration in the building while Fig. 2.7 (b) shows the use of foundation isolation to reduce ground vibrations.

2:4:2 Structure

The beam and column frame form a rigid structure that may transmit vibrations and sound from one part of the building to the other. This can be reduced by resiliently supporting the lighter frame members from the major structural elements. The manner of attachment of other elements like walls to the structure can help to reduce vibrations and noise transmission. Such an example of a wall joining a structural frame is given in Fig. 2.8.

2:4:3 Walls

Studio walls must maintain a sound barrier from one space to the next.

Insulation

Sound waves incident on a wall can set it into vibrations whose magnitude depends on the mass per unit area of the wall. For a homogeneous rigid wall, mass per unit area becomes the main insulation determinant.

As already stated in chapter one, for every doubling of mass per unit area, the insulation value improves by 5 dB (see Fig. 1.12 Pg. 19). Table 2.2 indicates the air-borne sound transmission loss averaged over the frequency range 100 to 3150 H_3 for most common types of wall materials.

TABLE 2.3
Insulation values and types of walls appropriate for broadcasting studios (Knudsen, New York 1950, Pg. 257).

SPACE	INSULATION LOSS REQUIRED (dB)	MASS PER UNIT AREA (Kg/M^2)	TYPE OF WALL
Quiet outside and studio	55	490	Single
Music studio adjoining a talks studio	75	980	Double Cavity
Two talks studios adjoining each other	55	490	Single
Studio and control rooms with observation window	45 50		
Studio and circulation spaces	50		
Control room and circulation spaces	45		
Office above studio	50		

TABLE 2.4
Impact noise reductions for various floor finishes compared to bare concrete slab (Knudsen, N.Y. 1950 Pg. 257)

FLOOR CONSTRUCTION ON CONCRETE SLAB	IMPACT REDUCTION (dB)	COMMENTS
Bare concrete	0	Bad
Asphalt tile	0	"
Asphalt felt	2	"
Rubber tile	7	Better
Heavy carpet	10	Good
Linoleum on felt	12	"
Asphalt-saturated fibreboard	12	"
Wood floor on sleepers	19	Very quiet
Cork tile	20	" "
Wood floor on sleepers and rock wool	20	" "

Cavity Walls

To avoid large weight single leaf solid wall, a double leaf wall with an air gap in between may be used. This gives an average insulation value which is greater than the insulation offered by the wall of the same weight built solid. (Fig. 1.13 Pg. 21).
The double walls used in cavity walls should be isolated from each other with only flexible links to tie them together. Sometimes an absorptive infill may be used in the cavity to increase the sound transmission loss. (See Fig. 2.15 Pg.58). In table 2.3 insulation values and types of walls appropriate for broadcasting studio design are given.

Floor Finishes

The impact noise reduction on the floor depends on the nature of the impact and the floor surface.

Examples of impact noise reductions for various floor finishes compared to bare concrete slab is given in table 2.4.

Floating Floor

The amount of impact energy getting into the floor may not be properly . isolated by resilients surfaces such as cork, carpet or rubber. It becomes necessary to adopt a floating floor construction which not only improves impact noise reduction but also increases transmission loss for air-borne sound.

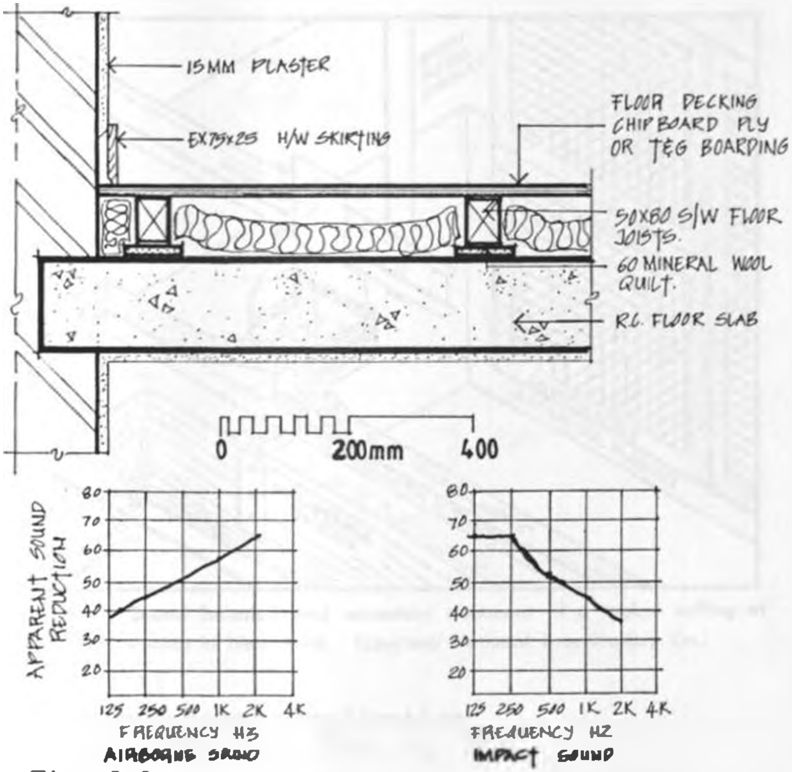


Fig. 2.9
Intermidiate floating floor construction
(Templeton, London 1986 Pg. 74).

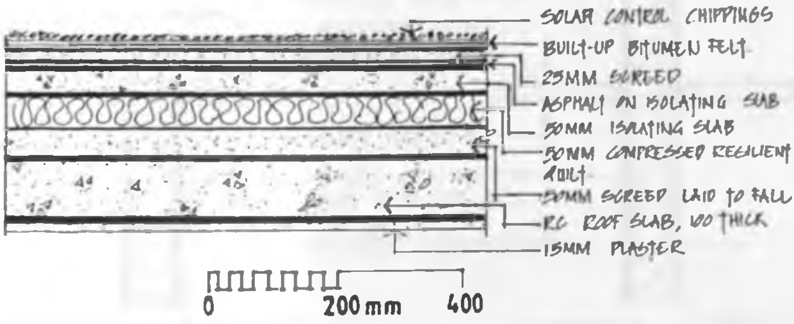


Fig. 2.10
Sound Proof Flat Poof Detail
(Pich, London 1982 Pg. 64).

A floating floor rests on the structural floor but it is separated from it by resilient supports. The resilient supports must withstand compression and must have a long life span. Examples of such supports include; rubber, fibreboard, felt, wood-wool and mineral wool blankets. Fig. 2.9 gives an example of an intermidiate floating floor constructio capable of providing both impact and air-borne sound insulation values depicted in the shown graphs.

2:4:5 Roofs

In construction of studios, roofs must also be treated as sound isolating devices. A quiet loft is necessary where catwalks and ducts may produce unwanted squeaking.

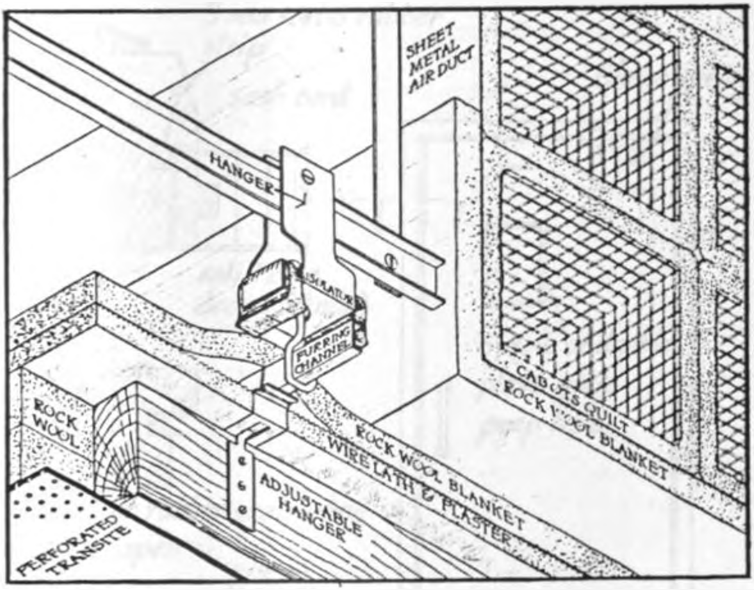
Sound control techniques in duct passages and rooflights should be taken into account to isolate the interior from the exterior.

Sometimes a double structure roof is used in studios to increase sound insulation from aircraft noise. Fig. 2.10 illustrates the details of a sound proof roof construction.

2:4:6 Ceiling

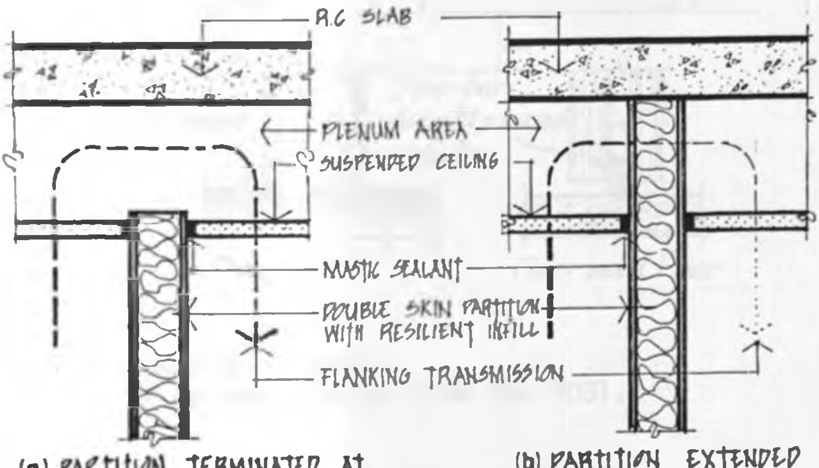
Suspended Ceilings

Many suspended ceilings are either porous or perforated in order to increase the absorption qualities. However, this correspondingly reduces the insulation properties of these ceilings to very low values.



Sound isolation and acoustical treatment of a typical ceiling at NBC studios in New York. (Courtesy National Broadcasting Co.)

Fig. 2.11
Resilient Hanger application
(Knudsen New York 1950, Pg. 267).



(a) PARTITION TERMINATED AT SUSPENDED CEILING HEIGHT

(b) PARTITION EXTENDED TO SLAB

Fig. 2.12
Flanking Transmission
(Detail by author)

If good isolation against impact sound is to be obtained, the ceiling should be rigidly connected on to the undersi structure from which it is hung. Resilient clips may prov convinient means of attaining good isolation between the c and the structure.

Fig. 2.11 depicts a typical application of a resilient ha used for isolating the ceiling from the structural slab.

Suspended ceilings are usually used in studios where ceili should provide favourable sound absorption and diffusion.

Ceiling Shape

Concave surfaces and barreled ceilings should be avoided. ceiling should not be parallel to the floor to avoid unwan flutter echoes.

Partitions

Suspended ceilings have a frequent cause for flanking trans at the wall head if the partition is not built up to the s slab. Fig. 2. 12 illustrates the construction details of t partition walls. Figure (a) shows how ceiling flanking oc to a partition wall being terminated at the suspendeded ce height while Fig. (b) shows how ceiling flanking can be re by extending the partition to slab level.

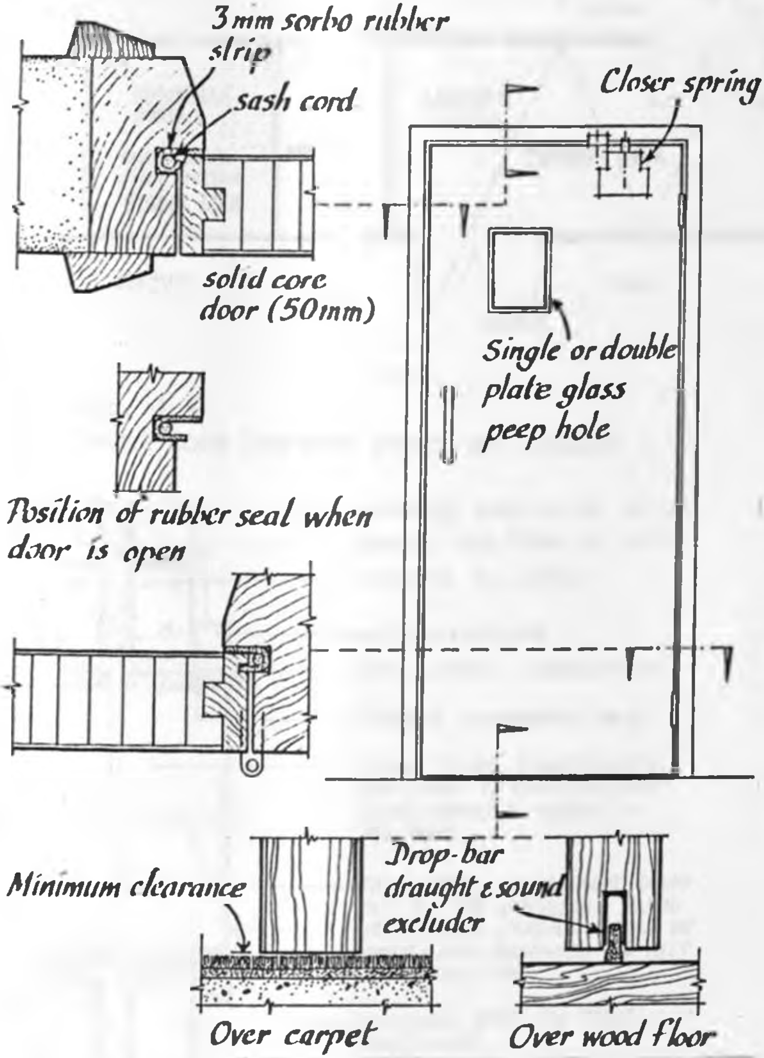


Fig. 2.13
Typical studio door detail
(Parkin & Humphreys London 1969 Pg. 203).

2:4:7 Door

If the wall has an opening, the net insulation value of that wall will be determined by the wall and the opening acting in combination.

The sound transmission loss of a door depends on its mass per unit area and construction. Studio doors must be constructed to achieve transmission loss of the order of 40 dB or more. To achieve this amount of transmission loss at all frequencies, doors should be heavy and made airtight when closed by providing seals around their entire perimeter. The details of a typical studio door are shown Fig. 2.13.

Sound Locks

When doors periodically stand open, they provide no barrier to noise transmission. Sound locks (lobbies) with a set of two doors are provided in studios to reduce direct sound transmission when one door is open.

The lobby is acoustically lined with absorbent materials and the doors made as heavy as practicable. With both doors closed, overall average insulation of upto 45 dB[8] can be achieved.

Staggering of doors will help to reduce direct sound transmission when both doors are open. Such a staggered arrangement of doors in a sound lobby is illustrated in Fig. 2.14.

8-Moore, London 1978, Pg. 84.

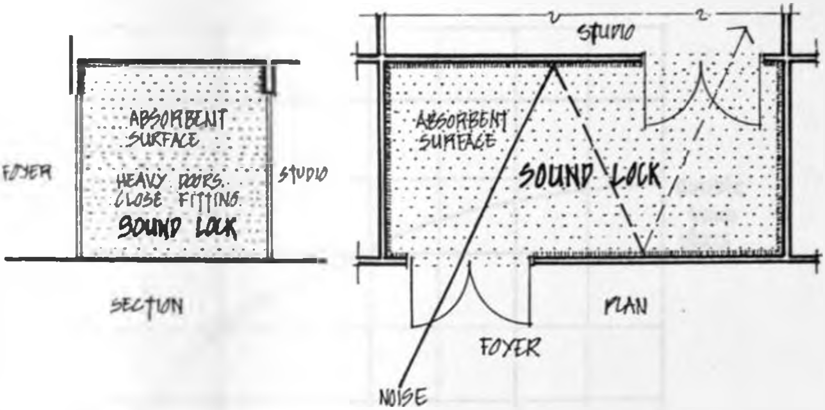


Fig. 2.14
Sound lock between Foyer and Studio

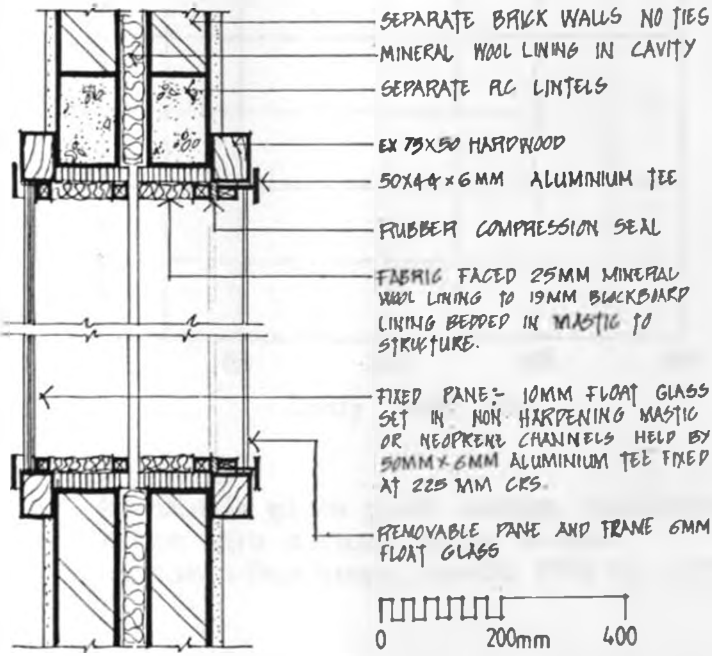


Fig. 2.15
Studio Observation Window Detail
(Templeton, London 1986 Pg. 105).

2:4:8 Windows

Windows like doors provide a similar weak path in defence against air-borne sound transmission.

Observation windows

Observation windows form visual link between control rooms and studios.

The average insulation provided by observation windows should be up to 40 dB or more. To attain this reduction, the following must be incorporated in the window design.

(i) Double or triple glass plates spaced 200mm between them.

(ii) Airtight seal around the entire perimeter.

(iii) The periphery of the space between the panes should be lined with sound absorbing material.

It is advisable to have different glass plate thicknesses and to tilt one glass plate in respect to the other in order to suppress high transmission of certain resonant frequencies. Fig. 2.15 shows a typical studio observation window with two glass plates and an air cavity between them.

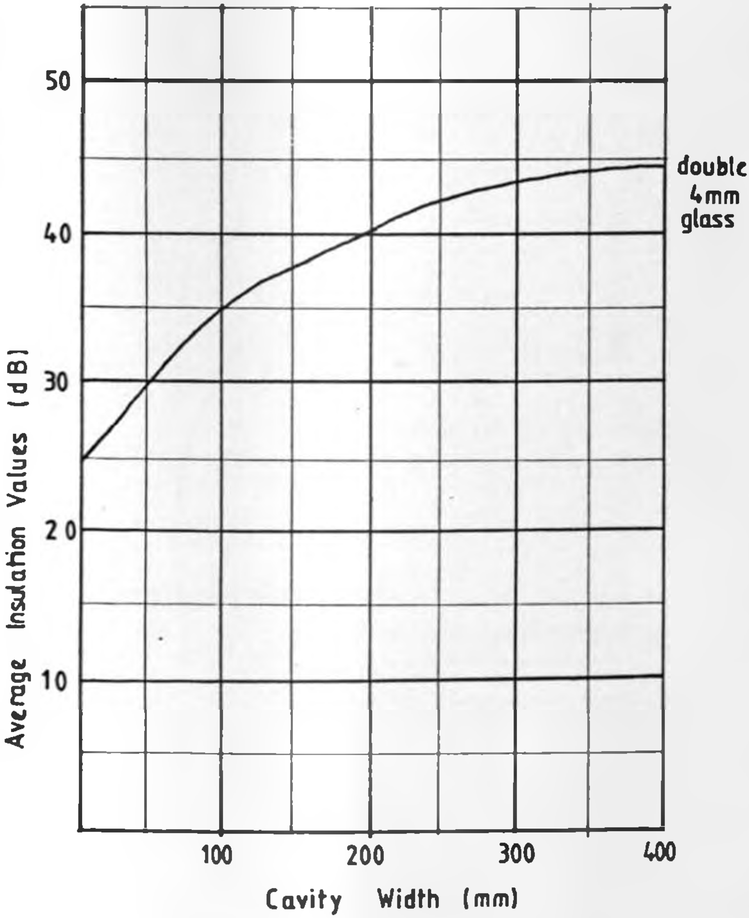


Fig. 2.16
4mm Double glass plate average insulation values with various cavity widths (Parkin & Humphreys, London 1969 Pg. 217).

<u>Cavity Width</u>

Fig. 2.16 shows an example of how average insulation values of a double 4 mm glass window varies with the width between them. The presence of absorbent lining in the cavity may improve the insulation by about 2 to 4 dB.

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2:5:0 LIGHTING AND VENTILATION

In both broadcasting and television studios, artificial lighting and mechanical ventilations are used since natural means are not possible due to high acoustics demands.

These systems may significantly alter the interior acoustic environment in studios by producing and transmitting noise unless considerable care is taken. The architect should be familiar with the internal noise sources and transmissions by these systems.

2:5:1 Air Conditioning and Mechanical Ventilation

Most noise problems in air conditioning and mechanical ventilation can be solved at the design stage. Noise may originate from mechanical equipment such as fans and from air flow in the ducts and grills.

The choice of air conditioning system as well as the location and construction of the plant room and duct work should be considered with careful attention being paid to sound insulation measures. (See Fig.2.18 Pg.61). If these issues are resolved properly, its possible to greatly lower down all the noise originating from these systems to very low levels.

2:5:2 Ventilation Noise Control

The ventilation services contain potential sources of noise which can be identified and sound insulation measures taken.

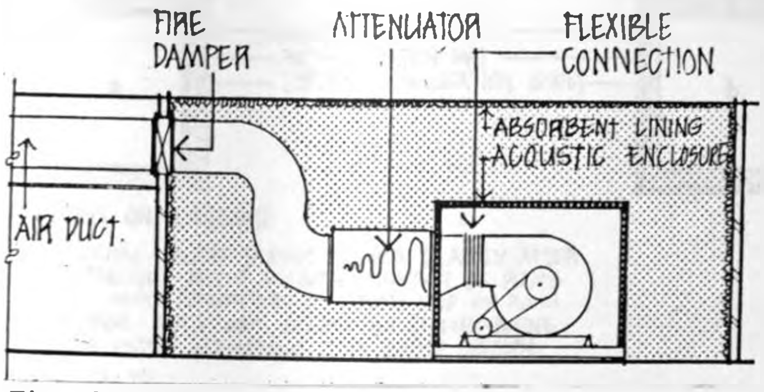

Fig. 2.17 Acoustic Enclosure to noisy items of plan within plantroom (Templeton, London 1986 Pg 136)

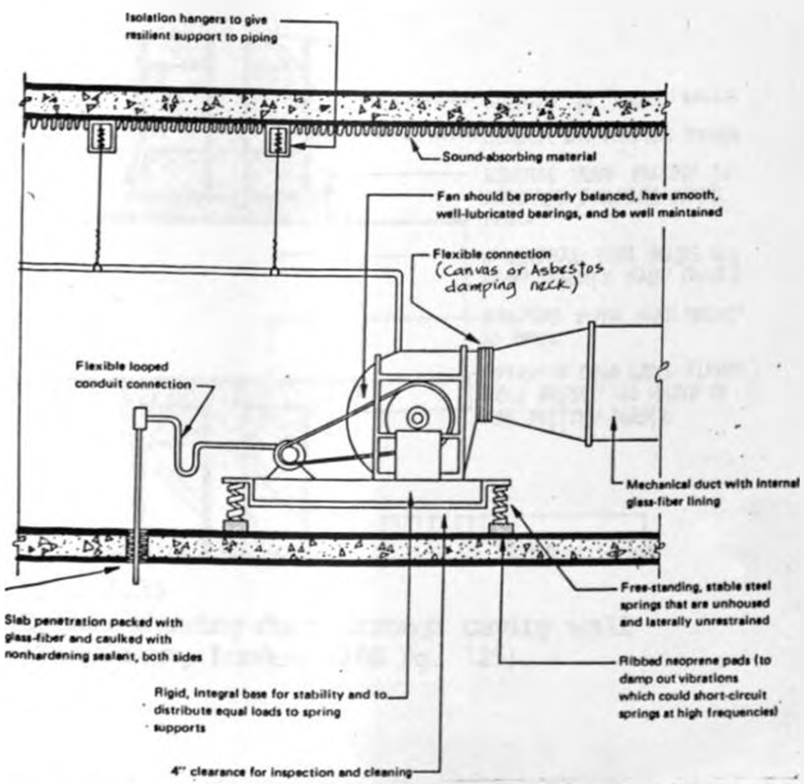

Fig. 2.18 Mechanical System Noise and Vibration Isolation (Egan, New York 1972 Pg. 126).

Planning

The architect should always use this as the first defence against both air-borne and impact sound transmission. The machine room should be located as far as possible from noise-sensitive areas. Any noise sensitive spaces like studios should not be located adjacent to noisy spaces served by the same air conditioning system.

Plant Room

It is essential to have substantial plant room enclosure to ensure good sound isolation. Separation of the plant room structure from the rest of the building can enhance sound isolation.

Acoustic enclosures to noisy items of plant within plant room may be done to ensure substantial isolation as shown in Fig. 2.17.

Vibration Isolation

A ventilation plant causes both noise and vibrations. These vibrations may be transmitted to the structure if vibration isolation is not considered.

The ventilation plant must be mounted on resilient pads and the duct work should be isolated from the plant equipment by using canvas or asbestos damping necks as shown in Fig. 2.18.

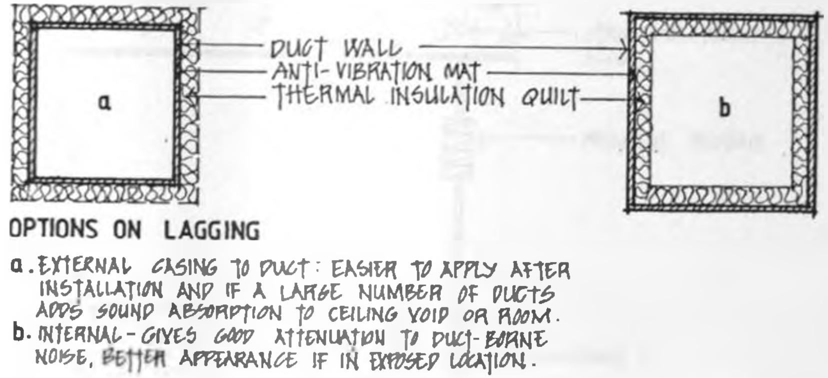

Fig. 2.19
Ductwork linings (Templeton, London 1986 Pg. 127).

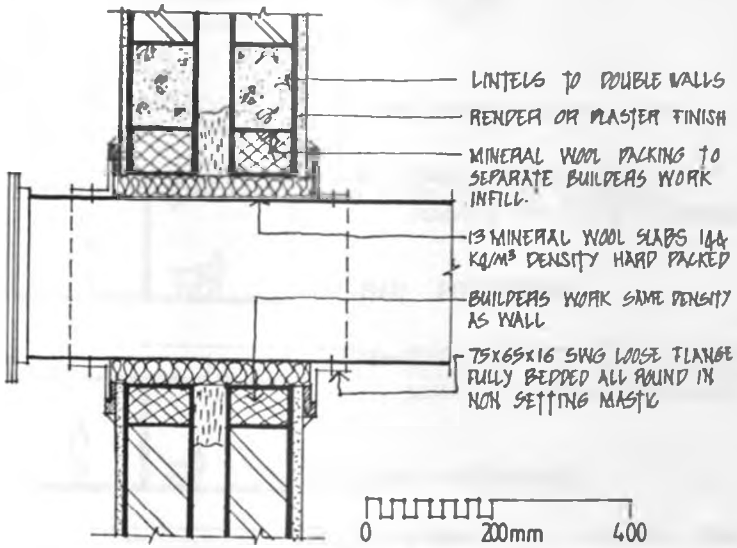

Fig. 2.20
Detail showing duct through cavity wall (Templeton, London 1986 Pg. 125).

In order to reduce the transmitted vibrations, the natural frequency of the resilient mounting must be higher than the plants driving frequency.

<u>Duct Treatment</u>

The speed of air flow in a duct can lead to noise generation. This noise can be transmitted from room to room if the ducts are not acoustically treated to attenuate this noise.

Air-borne sound can be prevented from travelling through the duct by lining it with sound absorbent materials as shown in Fig. 2.19. Duct lining material is placed at both ends of the duct to prevent noise from entering the duct system and to prevent cross-talk noise from being transmitted through the duct.

Ducts passing through walls must be well positioned with sound absorbing materials to prevent any vibration transmission to the walls. Example of such positioning is given in Fig. 2.20.

The ducts must also be resiliently supported with isolation hangers to reduce any vibration transmission to the structure from which it is suspended. Fig. 2.21 gives a duct suspension detail from a concrete ceiling.

Ventilation ducts arrangement in a space must be done in a way that prevents direct sound transmission. Fig. 2.22 oitlines three different ductwork arrangement; bad, good and best positions with respect to flanking sound insulation.

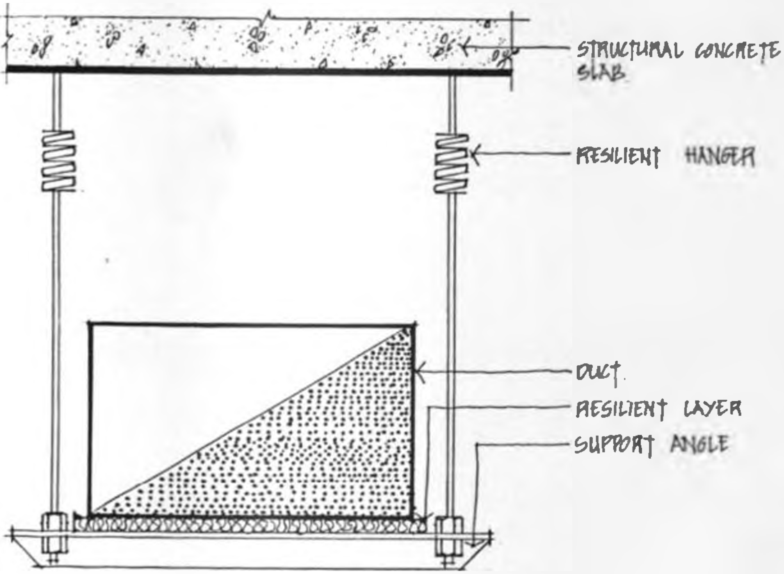

Fig. 2,21
Duct suspension detail (Templeton, London, 1986 Pg. 125).

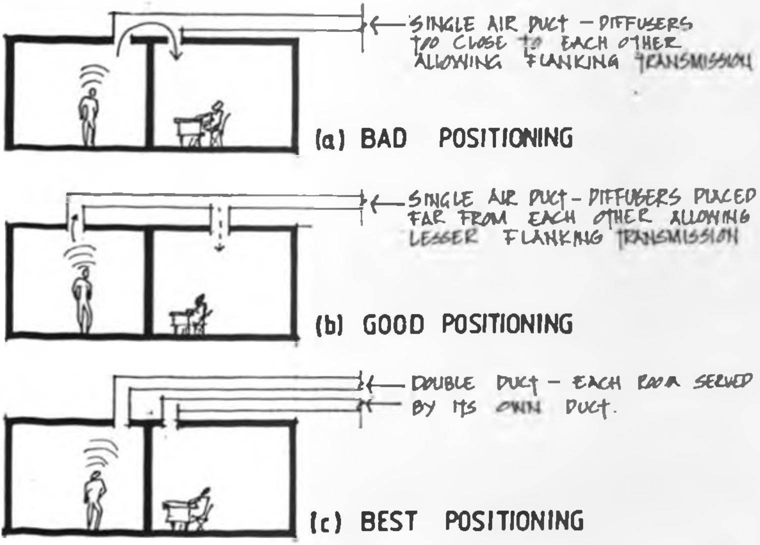

Fig. 2.22 Flanking transmissions in Duct Arrangements (Furrer, London, 1964, Pg. 178).

Fans

The fans as the chief air distributors in an air-conditioned space can present some noise problems. The noise sources may originate from:-

(i) The rotation action of the impeller blade
(ii) Turbulent flow of air across the fan blades
(iii) Motors, bearings and belts

The noise produced can be attenuated by good instalation, choice of equipment, vibration isolation as well as good maintenance.

Fans can also be silenced by enclosing them and by equiping them with intake and exhaust silencers.

2:5:3 Lighting and Noise

The inductive control gear for discharge lighting like flouresoent tubes can produce unpleasant humming sound. This sound may be amplified by ceilings and walls to cause poor sound production.

Incardescent lamps are however silent and the filament may produce a bit of noise only before failing.

The noise level can be kept low by use of good lighting choice. Attachement of the luminare with a firm fitting during installation may help to keep the noise level produced by the lighting to a low value.

PART TWO

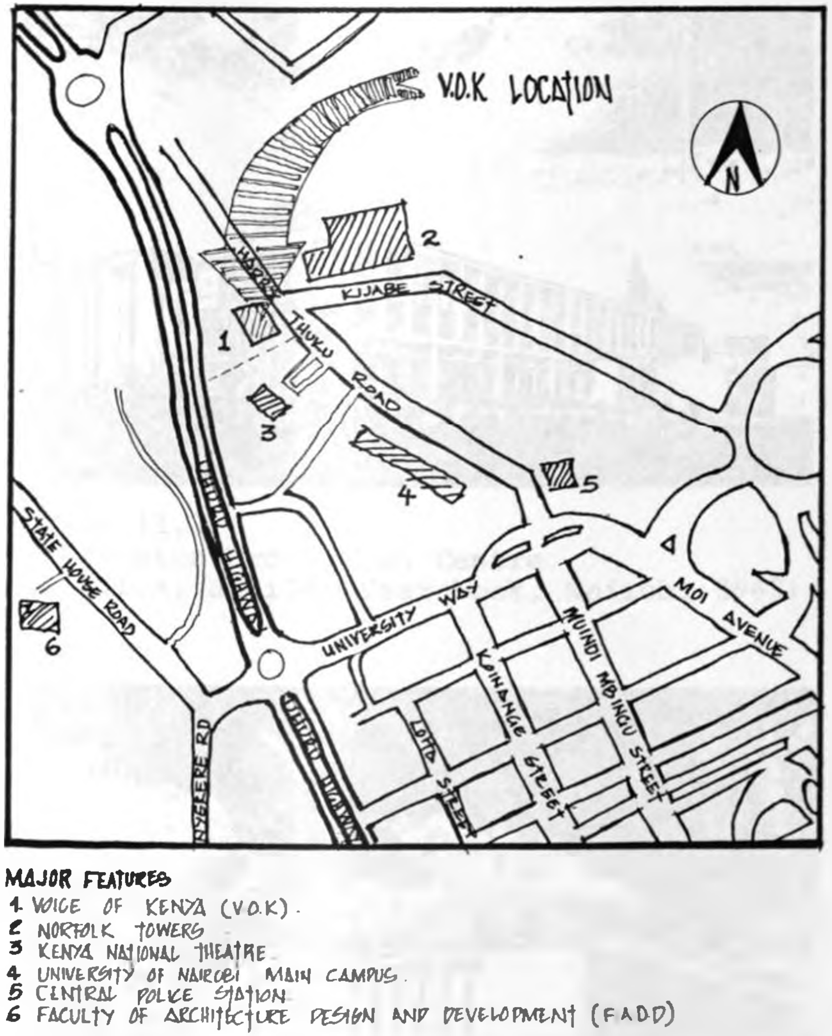

Fig. 11.1 - Location Map.

INTRODUCTION

This part constitutes of case studies conducted on two different types of studio spaces. An investigation into the integration of both technical and architectural elements has been instigated in the resultant studio space. The planning, layout, materials, surface finishes, internal geometry and design of service systems have been taken to evaluate their contribution to the overall acoustic environment in these studios.

The case studies were conducted in the National radio and television broadcasting centre - The Voice of Kenya (V.O.K.). The V.O.K., built in early 1960's, houses both radio and television studios. It serves as a good example to a general scene of studio designs in a developing country like Kenya despite the disadvantage of being located in the Nairobi C.B.D.

Location

The V.O.K. is located off Harry Thuku road (Fig. II.I). Immediate neighbourhood is diversified in character; hotels, apartments, shops and theatres coustitute of the current physical developments around the centre. The centre is also sandwiched between the busy Uhuru Highway and Harry Thuku road.

Organisation Set Up

The complex was designed and executed in two sections which were integrated through a connection building link and a covered walk way.

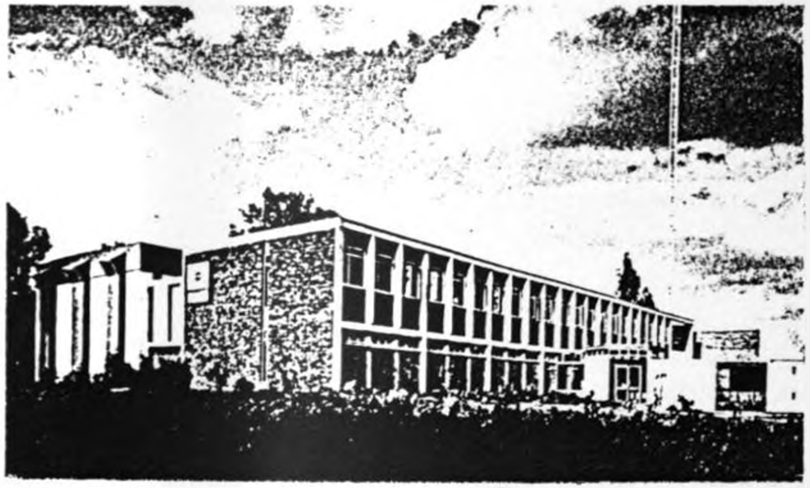

Plate 11.1
Television Production Centre
(E.A.I.A. Jubilee Year book, Nairobi 1963).

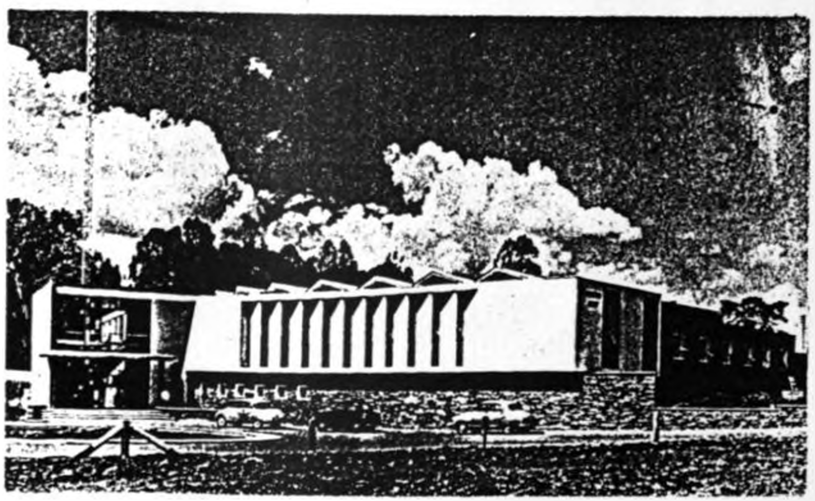

Plate 11.1
Radio Broadcast Centre
(E.A.I.A. Jubilee Year book, Nairobi 1963).

The two sections are:-

(i) The T.V. production centre (Plate II.I)

(ii) The Radio broadcast centre (Plate II.2)

Both sections have associated technical and non technical spaces.

Television Production Section

The Television production section consists of four main elements:-

(i) A two storey wing lying in a North South orientation with offices.

(ii) A Central section - artificially lit and ventilated for equipment, control areas, telecine, small studios and first floor production gallery overlooking main studio.

(iii) Connecting link to radio broadcasting section with stores, workshops and garage.

(iv) Main studio space

The main studio space has been considered for case study.

Radio Broadcast Section

The radio broadcast section has been planned on two levels:-

Level I - Sited on this level are; main entrance, reception, staff canteen and a large multipurpose studio.

Level 2 - This level constitutes of a circulation corridor giving access to upper part of the large multi-purpose studio and four studio suites. Access to record library, cardex room, librarian's office, air conditioning plant, offices and engineering section are served by the same circulation corridor.

The large multipurpose radio studio has been evaluated in the ensuing case study.

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Chapter Three

CHAPTER THREE

This chapter addresses itself to the performance of the main television studio to bring out the main design elements and components that were considered during the design. This takes on a more qualitative analysis of the studio design.

Reverberation time calculations based on Eyrings formula and octave bands range of; 125 h_3,250 H_3,500 H_3 , 1000 H_3 and 4000 H_3 (see Table 1.3 on Pg. 9) has been taken as the only quantitative analysis. This creates a deeper understanding on the acoustic performance of the overall studio space. The absorption offered by studio contents like furniture, equipment, scenery etc. has been left out due to variations in studio set ups.

TELEVISION STUDIO

CHAPTER 3

CONTENT OUTLINE

TELEVISION STUDIO.

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3:6:0 CONCLUSION.........................

3;6;1 Sound Isolation

3;6;2 Spatial Use

3:6:3 Room Acoustics

3:6:4 Ventilation

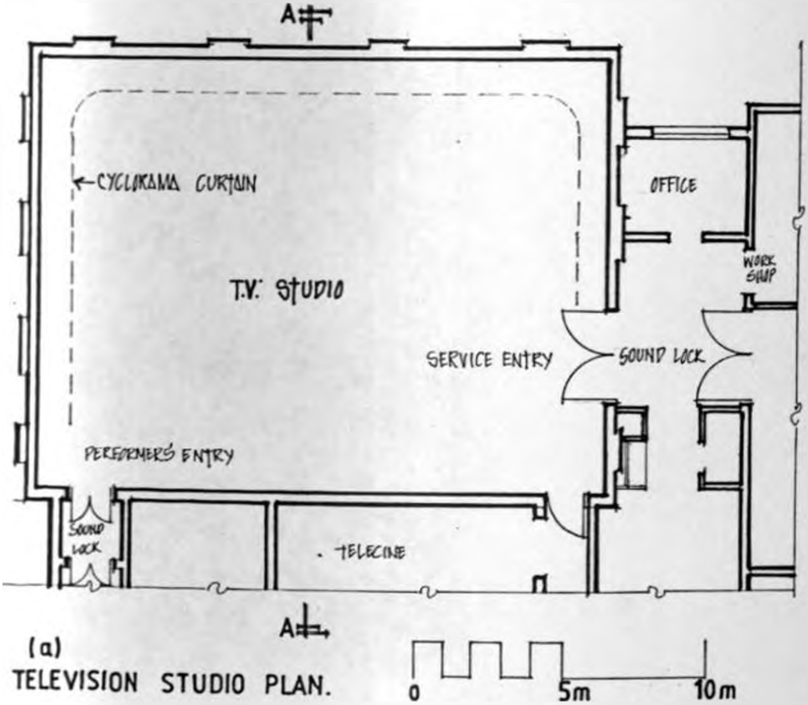
3:6:5 Maintenance

ral purpose studio with no
dio. The studio is rectangular
measures 19.2m by 14.4m. It has
9.7m above the floor is a grid
ing powerful studio lights. A
d on two side walls of the
purpose background. (Fig. 3.2.
windows overlooking the studio
or as shown in Fig. 3.2(b).

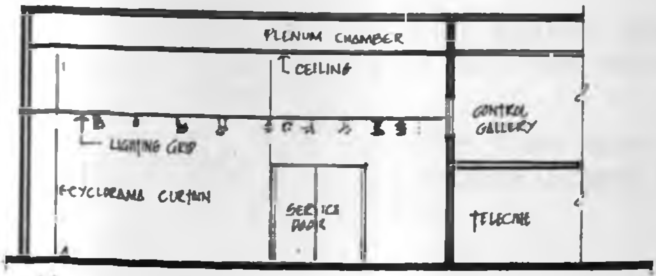
ty of programmes like; interviews,
chats and sometimes for news

ation the small test drama
ceiling height for spot lights
ams. As far as large cast drama
concerned, this studio offers
ending large scenery alterations.

spacing is very neat, flatted by
in the studio could be described
of a more realistic situation.



(a)
TELEVISION STUDIO PLAN.



(b)
SECTION A-A

Fig. 3,1
The Main Television Studio
(Measured Drawing by Author).

3:1:0 STUDIO ANALYSIS

3;1;1 General Description

The main television studio is a general purpose studio with no provision for any audience participation. The studio is rectangular in plan and its internal dimensions measure 19.2m by 14.4m. It has a floor to ceiling height of 7.0m. 4.7m above the floor is a grid of steel scaffold poles from which hang powerful studio lights. A cyclorama screen covers the three of the four side walls of the studio to give an appropriate general prupose background, (Fig. 3.1). A production gallery with observation windows overlooking the studio is positioned 3m above the studio floor as shown in Fig. 3.1(b).

3:1:2 Spatial Utility

The studio caters for a diverse variety of programmes like; interviews, drama, conferences, variety music for choirs and sometimes for news reading.

The studio offers sufficient accommodation for small cast drama though its double volume offers insufficient height for spot lights which appear too close to the performers. As far as large cast drama and better stage set programmes are concerned, this studio offers very little technical innovation concerning large scenery alterations.

General adaptability of any audience seating is very much limited by space. The presence of some audience in the studio could be desirable in some programmes to give an impact of a more realistic situation.

Plate 3.1
Sound lobby showing performers' entrance.
Note:

- The rubber seal gasket along the door edge and the threshold molding.
- The hole on the door that can drastically reduce sound insulation to the studio.

This could even help to elevate the moods of the performers. It is therefore justifiable to say that the studio fails to meet diverse needs for the modern times.

3:1:3 Physical Acoustic Response

Two sound lobbies with sound proof doors give an access to the studio. The interior wall surface comprises of memberane absorbers, resonant absorbents and panel absorbents. Membrane and panel absorbents are good absorbers at low and medium frequencies while resonant absorbents have selective absorption. The ceiling is treated with resonant absorbents while the floor remains acoustically untreated to aid the camera movements.

A quick look at the studio shows some efforts to have a wide frequency range of sound absorption. The acoustic treatment looks well responded to. However, the parallel walls discredits this to a great extent because unwanted flatter echoes remain unsuppressed.

Plate 3.1 shows the main entrance lobby to the studio. However, due to lack of proper maintenance, the doors have deteriorated to no longer offer much sound proofing.

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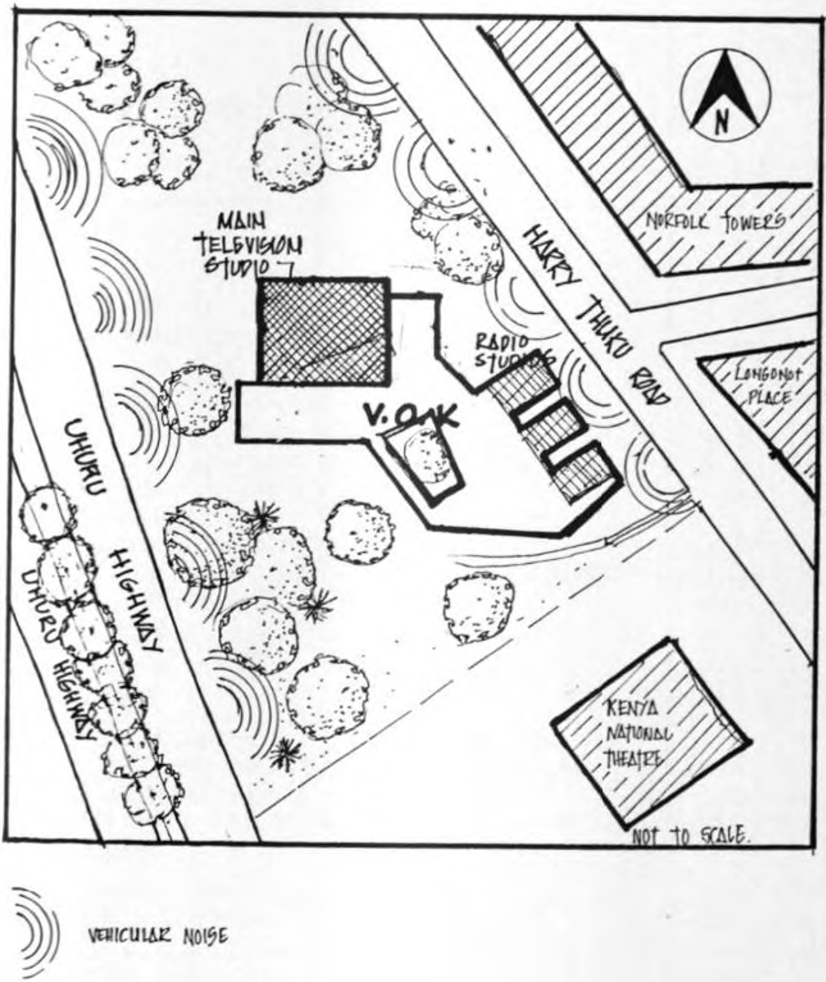

Fig. 3.2
External Noise Sources.

3:2:0 SOUND ISOLATION

3:2:1 Site Selection

The heavy traffic flow along Uhuru Highway remain the main external noise source. From the site location, the architect seems to have overlooked the possibility of future increase in background noise levels. Harry Thuku road on the other side has less traffic though this might increase in time causing more external noise. The site selection was therefore not well considered as far as noise levels are concerned.

3:2:2 Internal Planning

The studio is partly protected from Uhuru Highway traffic noise by the two storey wing lying in a north south orientation on one side and by the connecting link to the broadcasting section on the other side of Harry Thuku road. However, the other two faces remain exposed to any exterior noise since no buffer spaces are provided (Fig. 3.2).

Internal planning of this studio took little application of noise attenuation by other elements of design. A practical case is that one is able to hear traffic noise from the studio once the studio doors are left ajar.

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3:3:0 ROOM ACOUSTICS

3:3:1 Reverberation Time Calculations

Reverberation time in a studio governs its acoustic environment. A certain amount of reverberation enriches and enhances sounds thus conveying an impression of vitality and spaciousness. It also boosts the performers mood and may help to produce better performances.

The reverberation time calculations for the main television studio is carried out below. Eyrings formular for reverberation time calculations is used instead of the Sabines formular to attain better results.

Studio Particulars

Size: 19.2m long x 14.4m wide x 7m high

Volume: $1935.36m^3$

Total Surface area(s) = 1301.36
(This includes cyclorama and lighting components).

Optimum Reverberation time: 0.50 sec. approximately
(This is obtained from Fig. 2.3 (Pg. 41) which gives Recommended Reverberation time for broadcast and Television studios).

TABLE 3.1

REVERBERATION TIME CALCULATIONS FOR TELEVISION STUDIO BY EYRING'S FORMULA

(DATA COLLECTION BY AUTHOR)

ITEM, POSITION & DESCRIPTION	AREA (m^2) VOLUME (m^3) OR NUMBER	FREQUENCY (Hz) ABSORPTION COEFFICIENT (α) & ABSORPTION UNITS (Sabins)												α SOURCE
		125 Hz		250 Hz		500 Hz		1000 Hz		2000 Hz		4000 Hz		
		α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	
FLOOR														
— 6MM VINYL RUBBER SHEET ON SOLID FLOOR	276·48	0·02	5·53	0·04	11·06	0·05	13·82	0·05	13·82	0·1	27·65	0·05	13·82	9
CEILING														
— PERFORATED CELOTEX ACOUSTIC TILES	253·44	0·2	50·69	0·55	139·39	0·6	152·06	0·6	152·06	0·65	164·74	0·8	202·75	9
— METAL AIR VENTILATION GRILLES	23·04	0·15	3·46	0·35	8·06	0·7	16·13	0·85	19·58	0·9	20·74	0·9	20·04	9
WALLS														
— PLYWOOD PANELS ON BATTENS WITH GLASS WOOL IN CAVITIES	162·59	0·3	48·78	0·2	32·52	0·15	24·39	0·1	16·26	0·1	16·26	0·1	16·26	9
— 20MM THICK BLOCK BOARD WALL CABINET DOORS	3·57	0·15	0·54	0·2	0·71	0·1	0·36	0·1	0·36	0·1	0·36	0·1	0·36	9
— SOFT BOARD ON RESONANT PANEL	1·92	0·05	0·10	0·1	0·19	0·15	0·29	0·25	0·48	0·3	0·58	0·3	0·58	9
— TIMBER SKIRTING	12·04	0·15	1·81	0·2	2·41	0·1	1·20	0·1	1·20	0·1	1·20	0·1	1·20	9
— PERFORATED CELOTEX ACOUSTIC TILES	200·96	0·2	40·19	0·55	110·53	0·6	120·58	0·6	120·58	0·65	130·62	0·8	160·77	9
— 20% SLOTTED HARDBOARD ON MINERAL WOOL ON SOLID BACKING	42·51	0·35	14·88	0·7	29·76	0·9	38·26	0·9	38·26	0·95	40·38	0·9	38·26	9
— METAL AIR VENTILATION GRILLES	11·5	0·15	1·73	0·35	4·02	0·7	8·05	0·86	9·78	0·9	10·35	0·9	10·35	9
WINDOWS														
— 6MM THICK PLATE GLASS ON OBSERVATION WINDOW	21·48	0·3	6·44	0·3	6·44	0·2	4·30	0·1	2·15	0·05	1·07	0·05	1·07	10
DOORS														
— 20% SLOTTED HARDBOARD ON MINERAL WOOL ON SOLID DOOR	9	0·35	3·15	0·7	6·3	0·9	8·10	0·9	8·10	0·95	8·55	0·9	8·10	9
— PLYWOOD PANELS ON GLASS WOOL ON SOLID FLUSH DOOR	2·94	0·3	0·88	0·2	0·59	0·15	0·44	0·1	0·29	0·1	0·29	0·1	0·29	9
— SHEET METAL FACING ON DOOR	1·83	0·06	0·11	0·05	0·09	0·07	0·13	0·15	0·27	0·13	0·24	0·17	0·31	11
— 6MM GLASS PLATE VISION PANEL	0·06	0·3	0·02	0·3	0·02	0·2	0·01	0·1	0·01	0·05	NIL	0·05	NIL	9
OTHERS														
— METAL GRID WORK & SPOTLIGHTS (ESTIMATED)	75	0·06	4·5	0·05	3·75	0·07	5·25	0·15	11·25	0·13	9·75	0·17	12·75	9
— CYCLORAMA CURTAIN	203	0·03	6·09	0·04	8·12	0·1	20·3	0·15	30·45	0·2	40·6	0·15	30·45	9
TOTAL PERMANENT ABSORPTION	1301·36		188·90		363·96		413·67		424·90		473·38		518·06	
— $\alpha = \left(\frac{\Sigma S_1\alpha_1 + S_2\alpha_2 + \cdots + S_n\alpha_n}{S}\right)$		0·15	0·	0·28		0·32		0·33		0·36		0·40		
— LOGe (1−α)		0·163		0·33		0·385		0·4		0·45		0·51		
— AIR ABSORPTION	1935·36		NIL		NIL		NIL		5·81		13·53		38·71	9

ITEM POSITION & DESCRIPTION	AREA VOLUME OR NUMBER	FREQUENCY (Hz) ABSORPTION COEFFICIENT (α) & ABSORPTION UNITS (Sabins)												(α) SOURCE
		125 Hz		250 Hz		500 Hz		1000 Hz		2000 Hz		4000 Hz		
		α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	
REVERBERATION TIME BY EYRINGS FORMULA (Seconds) R.T $= \frac{0.16V}{S[-\log_e(1-\bar{\alpha})]+(xV)}$		1.46		0.72		0.62		0.6		0.54		0.50		

α SOURCES

9 — PARKIN & HUMPHREYS. LONDON 1969 Pg 310-313
10 — TEMPLETON. LONDON 1986 Pg 200-201
11 EGAN, NEWYORK 1972 Pg 32-34

"IT SHOULD BE REMEMBERED THAT THE CALCULATED VALUES FOR THE FREQUENCIES 62 - 125 Hz ARE LIABLE TO BE RATHER INACCURATE THAN THOSE FOR OTHER FREQUENCIES BECAUSE THE LOW-FREQUENCY SOUND IS RARELY SO COMPLETELY DIFFUSE IN THE ROOM AND BECAUSE UNPREDICTABLE VARIATIONS IN ABSORPTION COEFFICIENT ARE MORE LIKELY AT THESE FREQUENCIES"
—(PARKIN & HUMPHREYS LONDON 1969 Pg 129)

3:3:2 Reverberation Time Evaluation

The reverberation time for middle and high frequency sounds seem to agree with the volume/reverberation time graph (Fig. 2.3 Pg. 41). which gives recommended reverberation times for broadcasting and television studios.

However, low frequency sounds have more reverberation partly due to improper diffusion and absorption variation. This would greatly affect recording of musical performances with low frequency instruments and bass singers. This can tend to mask original sounds at higher frequencies by emphasis of low frequency sounds.

Reverberation time at low frequency may be improved by use of more membrane panel absorbers and cavity resonators (see Fig. 1.17, 1.18 Pg. 26). There should also be an attempt to increase sound diffusion by variation of material surfaces.

3:3:3 Internal Surface Shapes

The studio, being rectangular in plan, has parallel walls. This is quite undesirable due to creation of flutter echoes between these parallel walls. These echoes may be picked by the microphone affecting the original sound and thus minimizing its intelligibility.

3:3:4 Material Selection and Placement

A general outlook across the studio reveals a well considered case in both material selection and placement.

As a reverberation time consideration at all frequencies, low, medium and high frequency sound absorbent materials have been extensively used in the studio. With reference to table 2.1, perforated celotex acoustic tiles give a good crossection of absorption from low, medium to high frequency sounds.

The placement of more delicate absorbent on the upper wall and ceiling and placement of the less delicate ones within participants reach depicts a well considered case to protect the materials from damage. The variation of material placement shows an attempt to increase sound diffusion in the studio as well.

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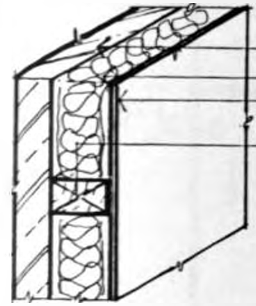

Fig. 3.3
Plywood Panel
(Sketched and drawn by Author)

Fig. 3.4
Slotted Hardboard Panel
(Sketched and drawn by Author)

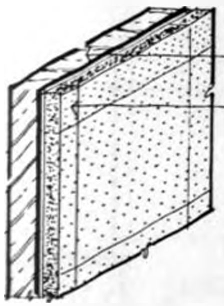

Fig. 3.5
Acoustic tile on Solid Wall
(Sketched and drawn by Author).

3:4:0 CONSTRUCTION

The studio adapts discontinous construction technique by separating the internal walls from the external walls. Suspended ceiling from the roof structure adds to this kind of construction (See Fig. 1.14 Pg. 22).

3:4:1 Wall Finishes

Three main acoustic wall finishes are used. These are:-

(i) Plywood panels on battens with mineral wool in cavities (Fig. 3.3).

(ii) Slotted hardboard on mineral wool on solid wall (Fig. 3.4).

(iii) Peforated acoustic tiles glued on the solid wall (Fig. 3.5).

3:4:2 Floor

A 6mm thick vinyl rubber floor finish is used on the entire floor area. This floor is generally smooth and offers very little sound absorption. Its main purpose is to provide a smooth surface for ease of camera movement (See plate 3.6 Pg. 82).

3:4:3 Ceiling

The ceiling, made out of perforated celotex acoustic tiles, is suspended from the main roof structure.

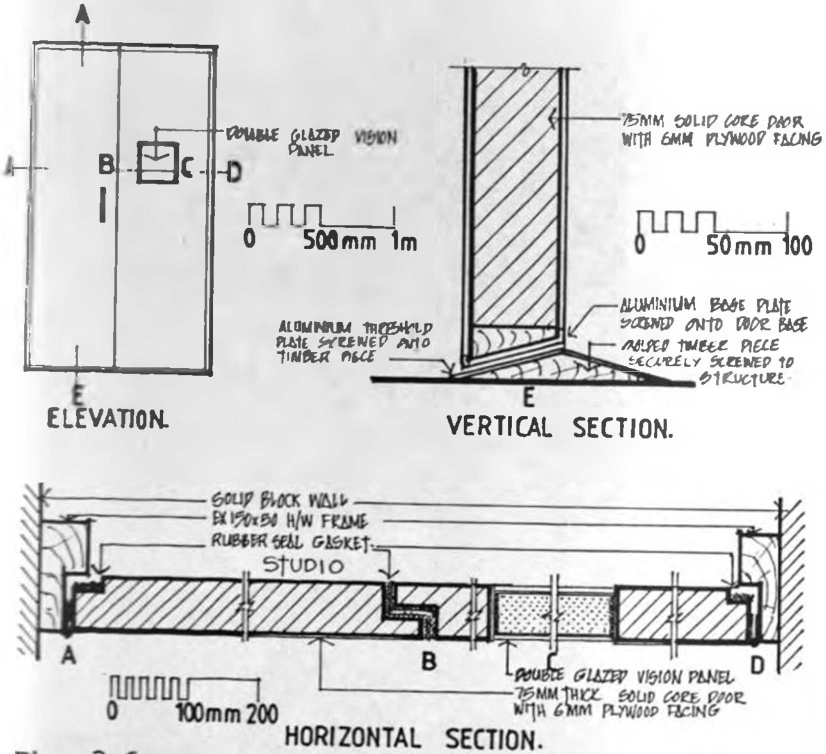

Fig. 3.6
Performers' Entrance Door Detail
(Sketched and drawing by Author).

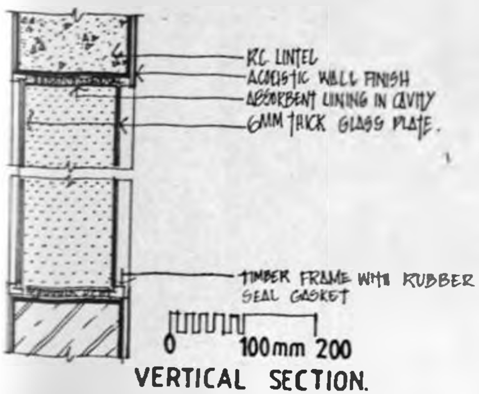

Fig. 3.7
Typical Section through observation window.
(Sketched and drawn by Author)

A grid of steel scaffold poles from which hang the studio lights lies below the ceiling at 4.8m above the floor level.

3:4:4 Doors and Observation Windows

Heavy sound proof doors with sound lobbies are provided. The observation windows have double plate glass with absorbent lining between the cavity. Both doors and observation windows are lined with rubber gaskets to make them air tight. Fig. 3.6 shows the entrance door details while Fig. 3.7 shows the observation window detail. Plate 3.2 captures the control gallery observation windows as well as the studio luminares.

Plate 3.2
Studio Interior showing Control Gallery Observation windows, studio luminares and the lighting steel scaffold grid. Also note the variation of acoustic materials on the walls.

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Plate 3.3
Note:

- Ventilation grille for air inflow
- Piano as a scenery item
- Acoustic treated on the wall
- The vinyl rubber floor

Plate 3.4
Studio luminares hanging from steel scaffolds. Note the cyclorama curtain at the background.

3:5:0 MECHANICAL SERVICES

3:5:1 Mechanical Ventilation

The studio is artificially ventilated not only to give comfort to the performers, but to get rid of considerable heat emitted by both equipment and the powerful studio lighting.

The large U-shaped reinforced concrete columns carrying the roof act as air inlet ducts as well as the structure. Air is extracted by four 1200 mm diameter fans through ceiling vents into a 1500 mm plenum chamber which also acts as a low frequency absorber. Each area is then naturally ventillated to the outside. In plate 3.3 the ventilation grille for air inflow can be seen.

3:5:2 Lighting

The studio comprises of powerful lights which are used only during performaces. These lights can be lowered, raised or moved along the lighting grid below the ceiling.

Fluorescent bulbs fixed on the side walls are used to provide lighting when the studio is out of normal operation.

Plate 3.4 shows the powerful studio luminares hanging from steel scaffolds. The cyclorama screen is seen in the background.

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Plate 3.5
Part of studio set ready for a programme.
Note the Absorbent nature of the furniture used.

Plate 3.6
Television cameras used in the studio
Note:

- The smooth floor finish to aid the camera movement.
- Also note the plywood panel absorbers

3:6:0 CONCLUSION

3:6:1 Sound Isolation

The studio location is only partly protected from the Uhuru Highway and Harry Thuku road traffic noise sources. Though not an appropriate site, the noise from these two sources can be attenuated by use of sound barriers built close to the road. (See Fig. 1.6 pg.15).

3:6:2 Spatial Use

Makeshift audience participation can be conviniently incorporated in the studio to give better performances for audience participation programmes.

3:6:3 Room Acoustics

Reverberation time at low frequencies can be lowered by studio contents like scenery, equipment performers, etc. However, there is a need to use panel and selective resonant absorbers for better low frequency absorption.

Variation in wall surface to provide more sound diffusion could also be of great assistance in distributing sound and hence lowering the reverberation time.

Acoustically, this studio's performance can be termed as appropriate for drama and speech.

Plate 3.5 and 3.6 show some studio equipment that can vary the reverberation time in the studio.

Plate 3.7
Performers' entrance sound lock
Note the mutilated acoustic tiles.

3:6:4 Ventilation

The type of air conditioning system used in this studio is not appropriate to get rid of all the heat created by the studio lighting. The performers usually complain of unfavourable high temperatures when performing.

A better air conditioning system and especially one with chilled water should serve conviniently in such a studio.

3:6:5 Maintenance

The acoustic maintenance in the studio seems to have deteriorated. The rubber seals in doors are wearing out due to age. The doors are no longer air tight when closed, thus forming weak sound insulation links.

The absorbent materials are neglected as seen in the entrance lobby in plate 3.7. This should not be allowed to happen in order to maintain a good acoustic environment.

If left to deteriorate, the background sound levels would rise greatly affecting the original sound thus minimizing intelligibility and good sound production.

Chapter Four

CHAPTER FOUR

In this chapter, the large central broadcasting studio has been evaluated to attain a general understanding of its acoustic performance. Architectural elements and components considered in its design have been outlined to ascertain their contribution to the acoustic performance.

Reverberation time for the octave band range from 125 H_3 to 4000 h_3 has been calculated using Eyrings formula and then acoustic evaluation is made to give a more clear analysis of the studio's interior acoustic environment.

BROADCASTING STUDIO

CHAPTER CONTENT

BROADCASTING STUDIO

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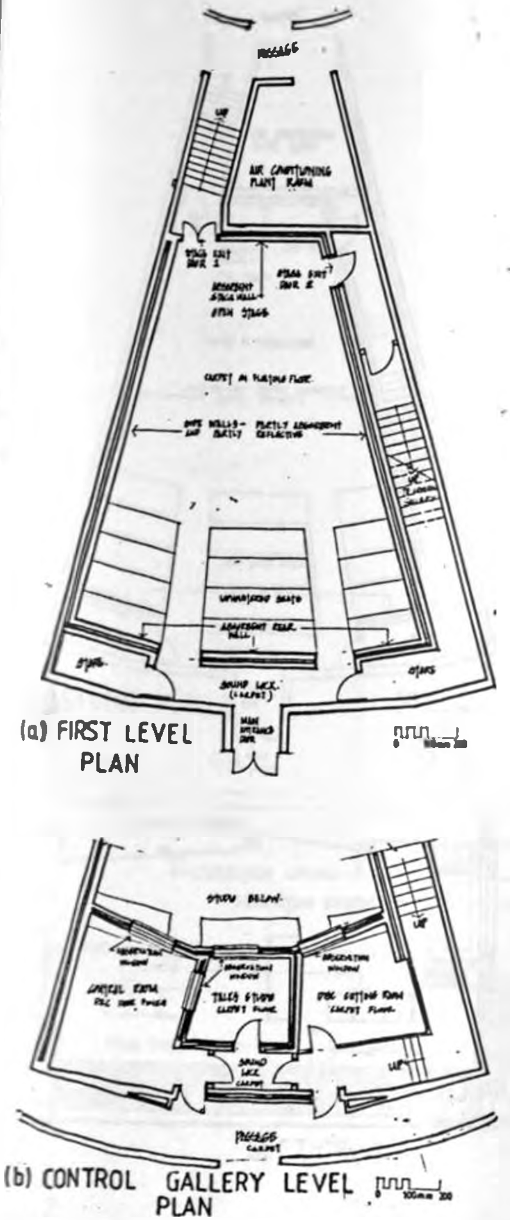


Fig. 4.1
Central Studio Plan
(Measured drawing by Author).

4:1:0 STUDIO ANALYSIS

4:1:1 General Description

The large central broadcasting studio is a general purpose studio. The studio is wedge shaped in plan and it was designed for live shows with a permanent audience provision for sixty people. The studio has a volume of 424.5 m^3 with an average ceiling height of 5.3 m above the studio floor. Part of the audience seating area has control gallery cantilevering out giving a clear ceiling height of only 2.5 m.

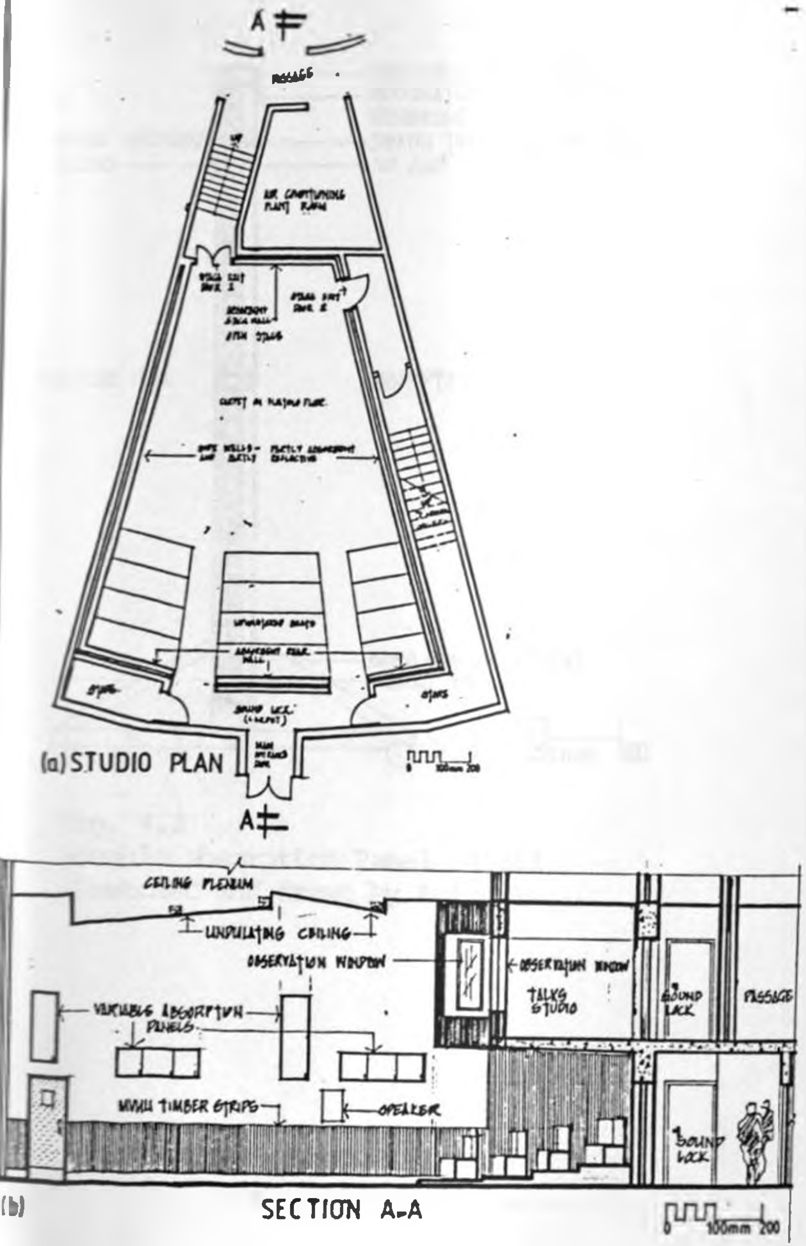
The studio is accessible from both lower and upper level floors. The lower level entrance, serves as the main entrance to the studio while the other two accesses in the upper level are used as emergency exits. These two accesses can also be used by performers as their entry and exit to the studio.

On the upper level is the studio's production gallery comprising of a control room, a talks studio and a disc cutting room all with observation window towards the studio. The control room serves both the main studio and the talks studio (Fig. 4.1b).

4:1:2 Spatial Utility

This studio, though not very oftenly used accommodates various performances such as; drama, concerts, variety shows, bands, ochestras and choirs.

Sufficient accommodation for both audience and performers is well taken care of. The front part of the studio used as a stage gives enough space



. 4.2
dio plan and section showing Acoustic
erials (measured drawing by Author).

for both instruments and performers. This type of stage offers flexibility particularly with reference to adaptability.

Lack of backstage and audience facilities such a foyers and public toilets is the greatest drawback in this studio. The studio space is limited to such facilities therefore becoming unquestionably insufficient for public utility.

4:1:3 Physical Acoustic Response

The main entrance to the studio offers no sound lock. Double doors with rubber gaskets are used at the 1.5 m wide opening. This leads to an acoustically lined lobby which has two 1.2 m wide doorless openings. The lobby never serves any significant measures on sound insulation since the single door used at the entrance may not provide adequate sound insulation or may be periodically open thus allowing unwanted sound into the studio (Fig. 4.2 a).

As one gets into the studio, the well pronounced non-parallel surfaces depict a clear achievement in suppressing undesired flutter echoes. On a closer look at the interior, distribution of materials on different planes to promote sound diffusion never goes unnoticed. The interior walls have been lined with panel absorbents, porous absorbents and pannel absorbers. Part of the wall bearing no absorbent materials characterises the side walls. This helps to reflect sound to the audience.

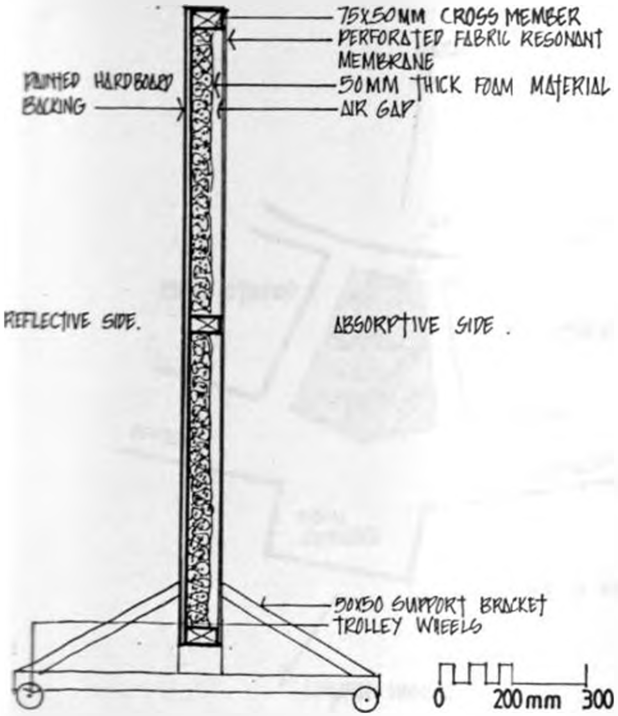


Fig. 4.3
Movable Absorption Panel Detail
(Sketched and drawn by Author).

The ceiling is treated with resonant absorbents while the floor is wholly covered by carpet as a porous absorbent.

The physical look at the studio shows efforts to provide sound absorption at a wide frequency range. However, presence of reflective wall surface and variable absorption panel pronounce the ability of studio's performance in both speech and music. Variable absorption is necessary to alter the reverberation time which should be less for speed than for music. Plate 4.1 (Pg.94) clearly shows the variable absorption panels in both open and closed positions. The panel provides sound reflective properties when closed and sound absorptive properties when open. This variation in absorption also provides variation in reverberation time thus making the studio variable for both speech and music.

Movable absorption panels are also provided in the studio to increase the sound absorption. These panels can be clearly seen on plate 4.2 (Pg.95) Fig. 4.3 shows the crossection detail of a typical movable absorption panel used in this studio.

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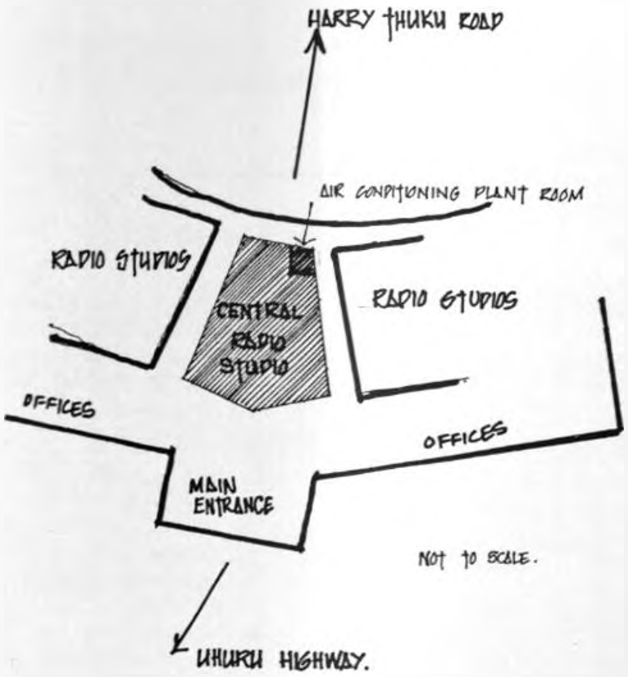

Fig. 4.4
Central Radio Studio Location.

4:2:0 SOUND ISOLATION

4:2:1 Site Selection

Site selection for the entire complex is outlined in chapter 3-(3:2:1) (Pg. 73).

4:2:2 Internal Planning

The studio is centrally located with buffer spaces around it. The buffer spaces comprising of offices and studio suites provide substantial sound insulation from Uhuru Highway and Harry Thuku road traffic noise. (Fig. 4.4).

The location of the studio clearly depicts a well organised internal layout to provide ultimate sound insulation from exterior noise sources.

However, the location of an air conditioning plant behind the stage wall discredits the sound insulation measures taken on planning level. However well the plant room is designed, no assurance can be given against any structure borne sound or vibration being transmitted to the studio.

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4:3:0 ROOM ACOUSTICS

4:3:1 Reverberation Time Calculations

Acoustic design of a studio relies on how dead or line the resultant studio space is acoustically. This is mainly governed by the reverberation time over a wide range of practical frequencies. The reverberation time at all this frequency range should be more or less uniform in order to achieve a better intelligibility of both speech and music.

Reverberation time calculations for the central studio based on Eyrings formula and 125-4000H_3 octave band range is worked out below.

Studio Particulars

Volume: = $424.5m^3$

- Total surface area with variable Absorption Panels open = $396.18m^2$

- With variable Absorption Panel closed = $387.40m^2$

- Optimum Reverberation time (This is obtained from Fig. 2.3 (Pg. 41) which gives Recommended Reverberation time for Broadcast and Television studios). = 0.68 sec. (approx)

TABLE 4.1

REVERBERATION TIME CALCULATIONS FOR RADIO STUDIO BY EYRING'S FORMULA (DATA COLLECTION BY AUTHOR)

ITEM, POSITION & DESCRIPTION	AREA (m^2) VOLUME (m^3) OR NUMBER	FREQUENCY (Hz) ABSORPTION COEFFICIENT (α) & ABSORPTION UNITS (Sabins)												(α) SOURCE
		125 Hz		250 Hz		500 Hz		1000 Hz		2000 Hz		4000 Hz		
		α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	
FLOOR														
— RUBBER BACKED CARPET ON FLOATING TIMBER FLOOR	61·7	0·08	4·94	0·24	14·81	0·57	35·17	0·69	42·57	0·71	43·81	0·73	45·04	14
CEILING														
— PERFORATED CELOTEX ACOUSTIC TILES	56·1	0·2	11·22	0·55	30·86	0·6	33·66	0·6	33·66	0·65	36·47	0·8	44·88	12
— METAL VENTILATION DIFFUSES	1·5	0·1	0·15	0·3	0·45	0·3	0·45	0·1	0·15	0·1	0·15	0·2	0·30	13
— PLASTERED & PAINTED CEILING UNDER CONTROL GALLERY	25·2	0·12	3·02	0·09	2·27	0·07	1·76	0·05	1·26	0·05	1·26	0·04	1·01	16
— TIMBER SLATS ON HESSIAN UNDER CONTROL GALLERY	4·9	0·15	0·74	0·35	1·72	0·75	3·68	0·85	4·17	0·75	3·68	0·4	1·96	12
— FLUORESCENT METAL LUMINAIRES	5·6	0·1	0·56	0·3	1·68	0·3	1·68	0·1	0·56	0·1	0·56	0·2	1·12	13
WALLS														
— PLASTERED & PAINTED BACK WALL	3·1	0·12	0·37	0·09	0·28	0·07	0·22	0·05	0·16	0·05	0·16	0·04	0·124	14
— PLASTERED & PAINTED SIDE WALL	91·54	0·12	10·98	0·09	8·24	0·07	6·41	0·05	4·58	0·05	4·58	0·04	3·66	14
— TIMBER SPLAYS ON HESSIAN AT BACK WALL	17·49	0·15	2·62	0·35	6·12	0·75	13·12	0·85	14·87	0·75	13·12	0·4	7·00	12
— TIMBER SPLAYS ON HESSIAN AT STAGE WALL	21·33	0·15	3·20	0·35	7·47	0·75	16·00	0·85	18·13	0·75	16·00	0·4	8·53	12
— TIMBER SPLAYS ON HESSIAN AT SIDE WALL	36·42	0·15	5·46	0·35	12·75	0·75	27·32	0·85	30·96	0·75	27·32	0·4	14·57	12
— HESSIAN CLOTH ON BACK WALL	17·43	0·07	1·22	0·31	5·40	0·49	8·54	0·75	13·07	0·70	12·20	0·60	10·46	14
— 12MM THICK SOFT BOARD ON SOLID BACKING	1·0	0·05	0·05	0·1	0·10	0·15	0·15	0·25	0·25	0·3	0·30	0·3	0·30	12
— TIMBER SKIRTING	7·56	0·15	3·75	0·2	1·51	0·1	0·76	0·1	0·76	0·1	0·76	0·1	0·76	12
— REAR WALL OPENINGS	5·25	0·30	1·58	0·35	1·84	0·4	2·1	0·43	2·26	0·46	2·42	0·50	2·63	15
WINDOWS														
— 6MM THICK PLATE GLASS ON OBSERVATION WINDOW	6·75	0·3	2·03	0·3	2·03	0·2	1·35	0·1	0·68	0·05	0·34	0·05	0·34	13
DOORS														
— 6MM THICK GLASS PLATE VISION PANEL	0·06	0·3	0·02	0·3	0·02	0·2	0·01	0·1	0·01	0·05	NIL	0·05	NIL	13
— 3MM THICK ALUMINIUM KICK PLATE	0·21	0·1	0·02	0·3	0·06	0·3	0·06	0·1	0·02	0·1	0·02	0·2	0·04	13
— 75MM THICK DOOR WITH ACOUSTIC TILE LINING	1·8	0·2	0·36	0·55	0·99	0·6	1·08	0·6	1·08	0·65	1·17	0·8	1·44	12
— TIMBER SLATS ON HESSIAN ON SOLID 75MM DOOR	2·52	0·15	0·38	0·35	0·88	0·75	1·89	0·85	2·14	0·75	1·89	0·4	1·01	12
TOTAL PERMANENT ABSORPTION	364·46		52·67		99·48		155·41		171·34		166·21		145·17	
VARIABLE ABSORPTION														
— VARIABLE ABSORPTION PANNEL (OPEN)	16·92	0·2	3·38	0·55	9·31	0·6	10·15	0·6	10·15	0·65	11·00	0·8	13·54	12
— VARIABLE ABSORPTION PANNEL (CLOSED)	8·46	0·15	1·27	0·20	1·69	0·1	0·85	0·1	0·85	0·1	0·85	0·1	0·85	12
— UPHOLSTERED SEATS (UNOCCUPIED)	60	0·24	14·40	0·26	15·60	0·27	16·20	0·31	18·60	0·37	22·22	0·38	22·80	13
TOTAL VARIABLE ABSORPTION FOR EMPTY STUDIO WITH VARIABLE ABSORPTION PANEL OPEN	396·18		70·45		124·39		181·76		200·09		199·41		181·51	
TOTAL VARIABLE ABSORPTION FOR EMPTY STUDIO WITH VARIABLE ABSORPTION PANEL CLOSED	387·4		68·34		116·77		172·46		190·79		189·26		168·82	

ITEM POSITION & DESCRIPTION	AREA (m²) VOLUME (m³) OR NUMBER	FREQUENCY (Hz) ABSORPTION COEFFICIENT (α) & ABSORPTION UNITS (Sabins)												(α) SOURCE
		125 Hz		250 Hz		500 Hz		1000 Hz		2000 Hz		4000 Hz		
		α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	α	SABINS	
REVERBERATION TIME CALCULATIONS FOR EMPTY STUDIO WITH OPEN VARIABLE ABSORPTION PANELS														
— $\bar{\alpha} = \left(\frac{\Sigma S\alpha_1 + S_2\alpha_2 + \dots + S_n\alpha_n}{S}\right)$		0·18		0·31		0·46		0·51		0·50		0·46		
— Log e (1−α)		0·2		0·37		0·62		0·72		0·70		0·62		
— AIR ABSORPTION	424·5		NIL		NIL		NIL		1·27		2·97		8·49	12
REVERBERATION TIME BY EYRING'S FORMULA (Seconds)		0·85		0·46		0·28		0·24		0·24		0·28		
REVERBERATION TIME CALCULATIONS FOR EMPTY STUDIO WITH CLOSED VARIABLE ABSORPTION PANELS														
— $\bar{\alpha} = \left(\frac{\Sigma S\alpha_1 + S_2\alpha_2 + \dots + S_n\alpha_n}{S}\right)$		0·18		0·30		0·45		0·49		0·49		0·44		
— Log e (1−α)		0·2		0·86		0·60		0·68		0·68		0·58		
— AIR ABSORPTION	424·5		NIL		NIL		NIL		1·27		2·97		8·49	
REVERBERATION TIME BY EYRING'S FORMULA (Seconds)		0·88		0·49		0·29		0·26		0·25		0·29		

α SOURCES

12 — PARKIN & HUMPHREYS, LONDON 1969 Pg 310-318
13 — TEMPLETON, LONDON 1986 Pg 200-201
14 — EGAN, NEW YORK 1972 Pg 32-34
15 — KNUDSEN NEW YORK 1950 Pg 405-426

Plate 4.1
Use of Sound Reinforcing System
Also note the variable acoustic absorption
Panels in both closed and open position.

4:3:2 Reverberation Time Evaluation

From table 4.1, the reverberation time for the middle and high frequency sounds give more dead acoustic conditions to the studio while lower frequency sounds give a live acoustic atmosphere. This is in contrast with the recommended reverberation time values given in Fig. 2.3 (Pg. 41).

However, during performances, the audience, performers and equipment are bound to increase the sound absorption thus lowering the reverberation time and making the studio's environment more acoustically dead.

Due to the nature of the absorbent acoustic materials used in this studio (Table 4.1), the studio suppresses most acoustic reflections, thus creating a less reverberant environment. The sound therefore produced in the studio may seem weak and faint to the extent of requiring sound reinforcing systems. Plate 4.1 shows the lound speaker system used in this studio to reinforce the sound for better intelligibility In musical performances, low frequency sound producing instruments such as drums would be more enhanced by the reverberant sound since the reverberation time at low frequencies is higher than at mid and high frequency sounds (Table 4.1). Higher frequency sound instruments (e.g. Piano, top note) would remain masked by the low frequency instruments thus making it difficult and tiring for musicians to perform under such acoustic environment.

Plate 4.2
Stage wall with mvuli wood strips on Absorbent material can be seen at the background.
Note the presence of movable absorption panels.

Also note the table top Porosity to reduce Reverberant Sound.

While reverberation time at lower frequencies can be lowered by studio content, there is need to have more reflective surfaces in the studio in order to cater for a diverse acoustic need in both music and speech.

4:3:3 Internal Surface Shape

The studio adopts a wedge shaped internal geometry as shown in Fig.4.1 (Pg. 87). This geometry of non-parallel walls bears the advantage of suppressing most flutter echoes which is a desired acoustic condition in all broadcasting studios.

Stage Wall

The stage wall is treated with absorbent materials and some hard wood strips running vertically as shown in Fig. 4.5 (Pg. 97). Plate 4.2 and 4.6 show the back wall with the conspicuous timber strips. The timber strips help to diffuse sound but the whole surface offers very little sound reflection especially to the audience.

Back Wall

The back wall is treated with absorbent materials to suppress possible sound reflections and hence minimizing the reverberant sound. Details of this back wall showing the use of hesian cloth on mineral wool is illustrated on Fig. 4.6. The wall is also partly treated with timber strips as shown on plate 4.3. The wall provides two doorless openings leading to the acoustically treated sound lock as shown in Fig. 4.2 (Pg.88).

Plate 4.3
Studios Back Wall

Note:

- The Absorbent nature of the hessian cloth used as well as the upholstered seats.
- Also note the timber strips and the variable absorption panel on the left hand side wall.

4:3:4 Material Selection and Placement

Absorbent and reflective materials have been used in this studio. Both the ceiling and the floor have absorbent materials while the wall has both absorbent and reflective surfaces.

Soft absorbent materials have been placed on the ceiling while tougher absorbents are used on the walls where they are likely to suffer damage.

Floor

The studio floor is wholly absorbent to reduce both air and solid borne sound. A 200mm high timber skirting tucks in the carpet and also acts as a duct for broadcast wiring. This can be seen in the floor detail shown in Fig. 4.8. (Pg. 98).

Ceiling

The undulating suspended ceiling is covered with acoustic tiles offering little sound reflections. The ceiling above part of the audience seating is partly absorptive and partly reflective. This helps to reflect sound to the audience thus increasing the reverbera sound in that part of the studio. The undulating ceiling detail is shown in Fig. 4.9 (Pg. 98) while plate 4.5 shows the acoustic tiles on the ceiling as well as the inflow/outflow air diffuser positioned on the ceiling.

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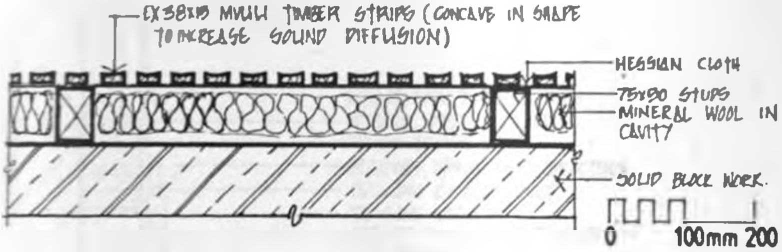

Fig. 4.5
Horizontal wall section showing wood strips on hessian and mineral wool in cavity.
(Sketched and drawn by Author)

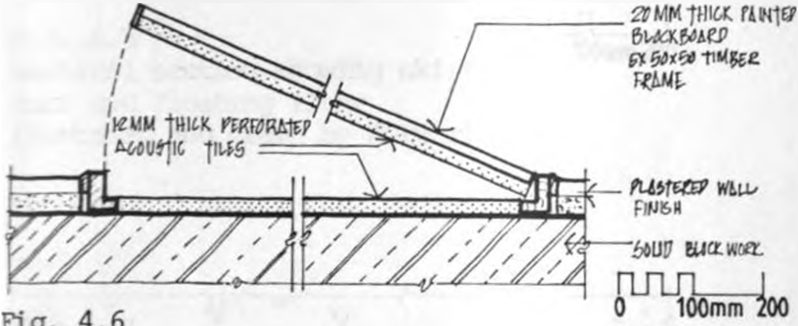

Fig. 4.6
Horizontal wall section through variable absorption panel.
(Sketched and drawn by Author).

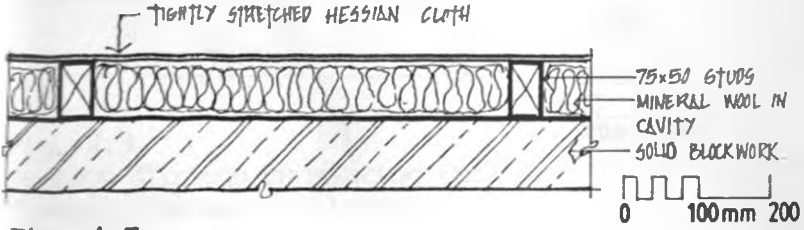

Fig. 4.7
Horizontal wall section through hessian cloth fixing
(Sketched and drawn by Author).

4:4:0 CONSTRUCTION

The studio is constructed with double leaf walls with air cavity between them. The floor is a floating floor construction while the ceiling is suspended from the roof structure. This makes the studio acoustically independent of the main structure - a discontinuous construction phenomenon. (Fig. 1.14 Pg. 22).

4:4:1 Wall Finishes

The main wall finishes in this studio are:-

(i) Ex 35 x 15 mm mvuli wood strips spaced to give 18mm slots, on hessian and mineral wool in air space on solid wall. (Fig. 4.5).

(ii) Hinged variable absorption panels with reflective surface of painted rigid blockboard and an absorbing surface of acoustic tiles (Fig. 4.6).

(iii) Painted hessian cloth stretched over air space with mineral wool (Fig. 4.7).

(iv) Plastered and painted wall surface.

4:4:2 Floor

The studio adopts a floating floor construction. The timber floor board resting on the structural concrete floor covered with a rubber backed carpet laid in separate narrow widths. (Fig. 4.8).

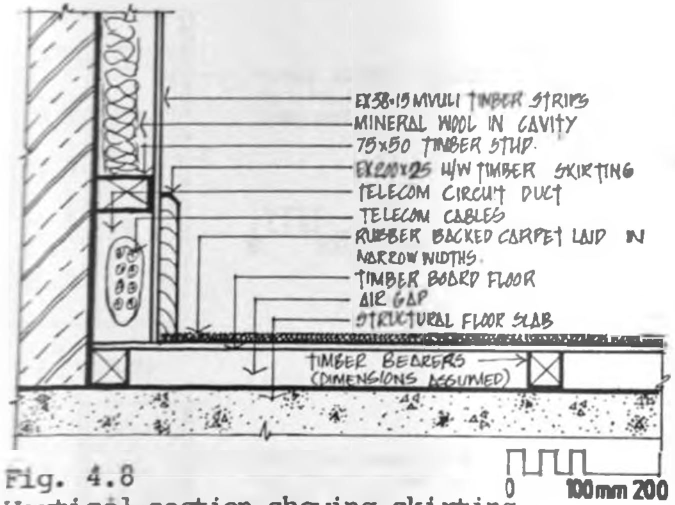

Fig. 4.8
Vertical section showing skirting duct and floating floor
(Sketched and drawn by Author)

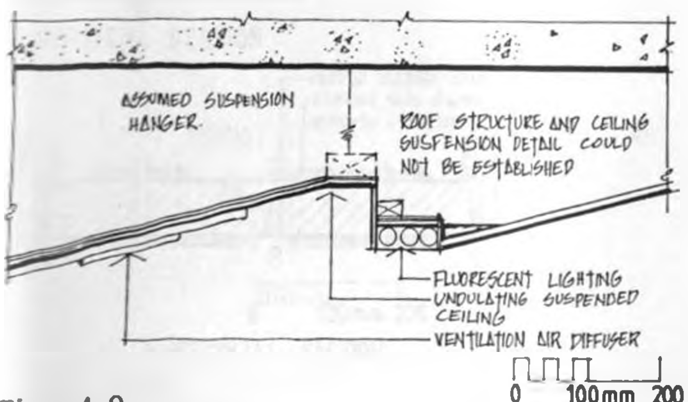

Fig. 4.9
Section through undulating ceiling.
(Details assumed by Author).

4:4:3 Ceiling

The suspended ceiling with undulating surfaces is covered with acoustic tiles. Ventilation air diffusers and fluorescent lights are fixed on the ceiling. (Fig. 4.9).

4:4:4 Doors and Observation Windows

A heavy solid double door with rubber gaskets is used as the main entrance to the studio. The door is padded with foam and leather backing. One of the exit door is lined with acoustic tiles while the other is faced with mvuli wood strips on hesian cloth. (See Figs. 4.10 a,b and c).

The observation windows between the studio and the control gallery (plate 4.4) are formed of three separate scales with the middle one tilting from the other two to give cavities of varying widths. This helps to suppress any resonant frequency in the cavities. The cavities are lined with celotex tiles and a rubber gasket along their entire perimeter. The plate glass is embedded in small cork channels to reduce any vibrations from being transmitted to the wall linings. Fig. 4.11 shows the crossection detail of the observation window in this studio.

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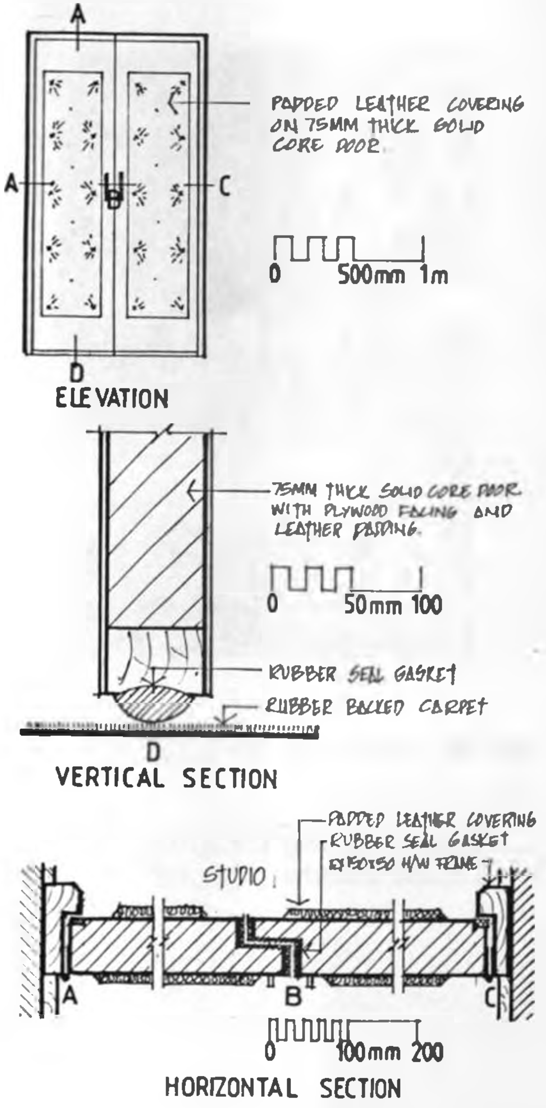


(a) Main Entrance Door

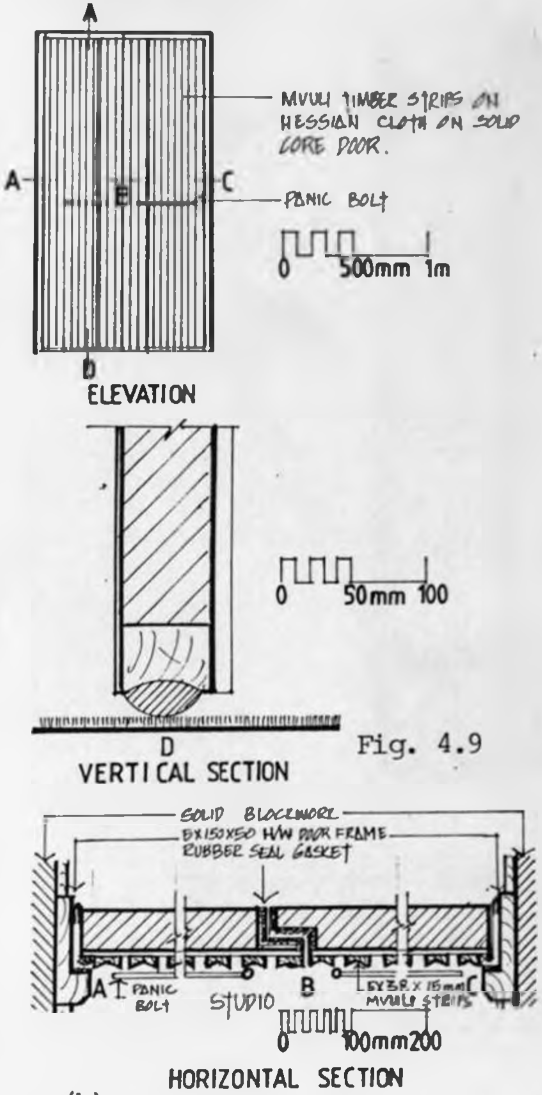
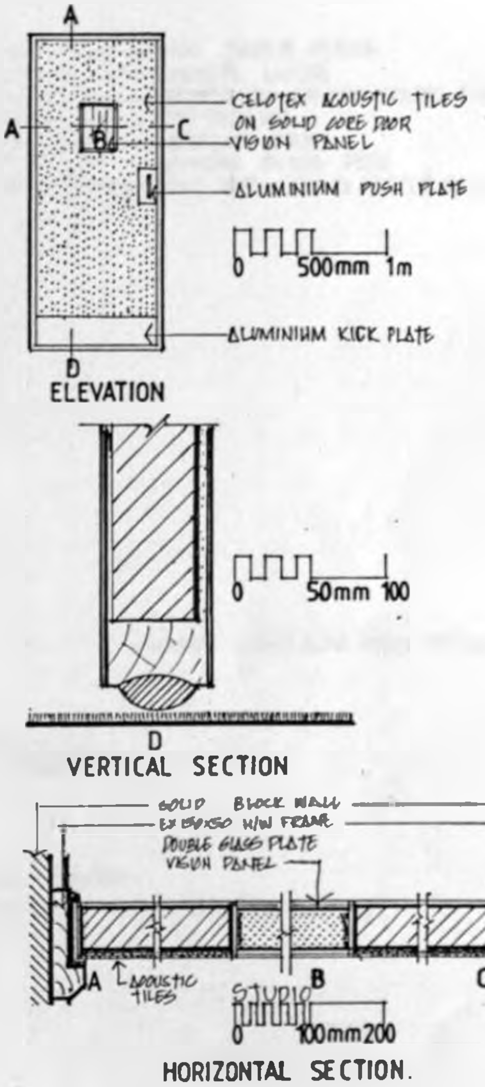


Fig. 4.9

(b)
Stage exit door I



(c) Stage exit door 2

Fig. 4.10
Central Studio door schedule.
(Sketched and drawn by Author).

Plate 4.4
Studio Observation window at the rear wall.
Note:
- The ~~absorbed~~ absorbent rear wall
- The upholstered seats.

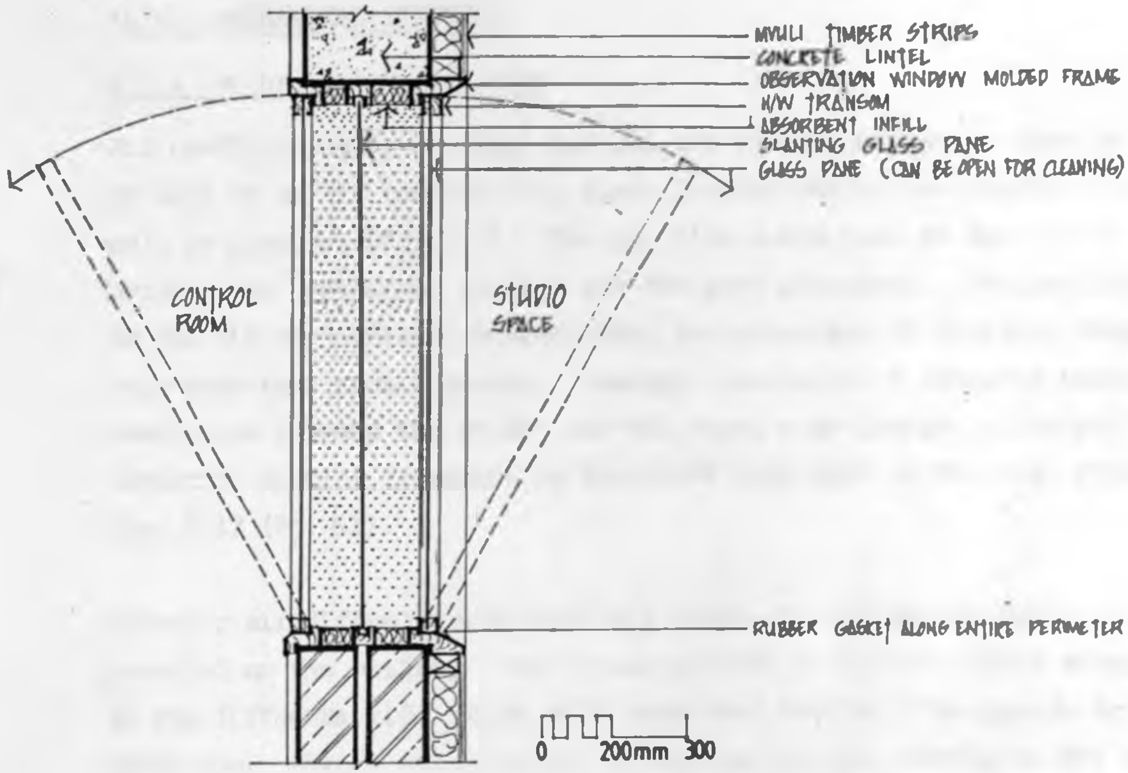


Fig. 4.11
Section through studio observation window.
(Note the tilted glass pane to prevent resonant frequency).
(Sketched and drawn by Author)

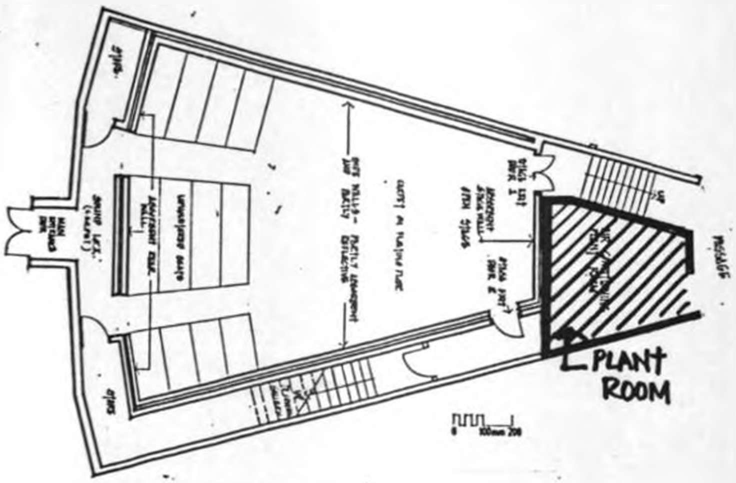


Fig. 4.12
Studio plan showing plant room location

Plate 4.5
Inflow/Outflow air diffuser.

4:5:0 MECHANICAL SERVICES

4:5:1 Mechanical Ventilation

Air conditioning is provided to both the studio and the production gallery by an air conditioning plant located behind the studio stage wall as shown in Fig. 4.12. The air flow ducts pass in the plenum between the suspended ceiling and the roof structure. The proximity of the air conditioning system bears the advantage of avoiding long duct runs thus reducing cost. However, provision of adequate sound insulation between the studio and the plant room becomes a big problem requiring special treatment to the plant room such as the one shown in Fig. 2.17 (Pg. 61).

Circular air diffusers with both air inlet and air return ducts are provided on the ceiling. The movements made by a paper strip attached to the diffusers side (Plate 4.5) show that the air flow speeds are quite low. Faster air movement is required in this studio to get rid of heat and foul air especially during a performance. In an attempt to increase the air speeds, the noisy electric fans such as the one in place 4.7 are being used in this studio. These fans have noise problems and should not be used in studios since this noise could be picked up by the microphones thus masking the recorded sound.

4:5:2 Lighting

The studio is lit through fluorescent bulbs placed on the ceiling. These lamps have low heat output but have the acoustic drawbacks

However, the studio lighting lacks the adaptability of controlling the stage especially during musical performances. The lighting system needs some modification of grid hanging spot lights that can be controlled in various ways to achieve desired lighting effects in a performance (Plate 3.2 Pg. 80 gives examples of various spot lights).

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4:6:0 CONCLUSION

4:6:1 Sound Isolation

The studio is well located with buffer spaces around it. However, the lack of proper sound lock can be improved by fitting two doors at the sound lobby to increase sound insulation measures.

4:6:2 Spatial Use

The studio is well utilized with large stage area which can accommodate about fifteen performers. The studio can be well adapted for various performances due to the flexibility of the stage area.

However, backstage and public facilities cannot be accommodated in the studio without affecting the existing studio.

4:6:3 Room Acoustics

Middle and high frequency reverberation time need to be slightly adjusted to attain an acoustic environment of the studio being neither too dead nor too lively. A suggestion to make the stage wall more reflective by using reflective wall finishes such as plaster or block-board could attain this condition. There should also be an attempt to increase the surface of the varible absorption panels in order to adjust the reverberation time depending on the type of performance.

Plate 4.6
Photo showing the nature of the stage wall.
Note the hard wood timber strips.

Plate 4.7
Studio's Control Room.
Note:

- The fan used to increase the air speed in the room.
- The P.V.C. tiled floor and acoustic material linings on the walls.
- The mixer system used for production.
- The intercom link wires.

4:6:4 Air Conditioning

Air diffusers used in the entire studio have slow air speeds. However, this seems inadequate since the studio feels uncomfortable even with only a few people inside.

The suggestion here is to increase the air flow speeds and the number of inflow/outflow air diffusers as well. This may require adequate noise insulation precautions such as the use of silencers in the diffusers and proper duct treatment such as the one shown in Fig. 2.19 (Pg. 62).

4:6:5 Maintenance

General maintenance of the studio neglects the performance of some acoustic materials. Acoustic tiles especially at the lobby have been bridged over with paint, closing their perforations and thus reducing their absorption performance. To avoid this bridging spray painting method should be used on such surfaces instead of brush painting method.

The fluorescent bulbs replacement should be done in the entire studio at the same time and not fixing only the failing bulbs. This may help to minimize humming sounds made by faulty bulbs.

PART THREE

Chapter Five

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

The preceding chapters portray the role of both architectural elements and components in an area where acoustics is of prime consideration. A lucid outline of certain specific design principles has been expounded upon both in construction and planning to bring out an overall picture of a successful acoustic design.

This chapter concludes and recommends some theoritical and practical requirements already outline in the preceding chapters which are most significant in this study.

CHAPTER FIVE

CONTENT OUTLINE

CONCLUSION AND RECOMMENDATIONS

5:1:0 CONCLUSION.. 107
5:1:1 Sound Theory
5:1:2 Design Consideration
5:1:3 Variety

5:2:0 RECOMMENDATIONS.................................. 109
5:2:1 Location
5:2:2 Design
5:2:3 Execution
5:2:4 Maintenance

5:1:0 CONCLUSION

In order to handle any acoustic design, the architect should understand the sound theory, acoustic design elements and functional requirements of the space.

5:1:1 Sound Theory

Fundamental knowledge of sound theory constitutes an important foundation for the approach of acoustic design. This clearly highlights the behaviour of sound both outdoors and in an enclosed space.

Basic formulae outlined in this study are necessary in order to achieve both a qualitative and quantitative understanding of sound behaviour.

5:1:2 Design Consideration

Basically, good acoustic design commences with the choice of a site whose background sound levels are low. This is then enhanced by the planning and layout of particular activities to attain a separation of noisy spaces from quiet spaces.

The choice of materials, placement and construction technique in studios plays a very important role in the overall acoustic design. All these should be accompanied by carefully designed acoustic details and good workmanship.

Due to high sound insulation requirements, studio spaces require artificial ventilation and lighting. These systems should be selected and incorporated in studio with maximum precaution to preserve the high insulation standards existing in the studio.

To fully realise a studio whose acoustic performance is good, the architect needs to work hand in hand with the client, engineers, acousticians and a competent contractor right from the inception stage to the completion of the project.

5:1:3 Variety

A variety of studios exist whose functional and technical requirements remain diversified both in nature and character. However, all studios have one thing in common - That the sound produced in such a space is picked up by a microphone and is thus subject to the same peculiarities as in the case of somebody listening with one ear.

For the purpose of this study, reference to television and broadcasting studios have been outlined. These are expounded upon to serve as a typical example among other studios whose design criteria fall along the same basic design path.

The presentation of scale and accommodational aspect of particular performance remain a diverse item relying wholly on the studio. A studio should therefore be designed to cater for specific performance, presumably coping up with substantial requirements for modern times.

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5:2:0 RECOMMENDATIONS

In the light of the deductions suggested in the conclusion, the architect's role in an area of prime acoustic design is unfolded.

The architct bears various responsibilities of converting the scientific theory and analysis into a detailed and practicable architectural solutions.

5:2:1 Location

The criteria for site selection and location should be predominantly controlled by surrounding sound levels. The sound pressure levels should be low enough to provide appropriate outdoor acoustic environment.

The design team should search for an appropriate site rather than adopting a site which is set aside without taking the noise levels into consideration.

With proper site location, the studios can be conviniently incorporated in the building set up.

If difficulties arise in getting an acoustically convinient site, sound insulation measures should be taken seriously. This should include appropriate construction, election of sound barrier walls and the appropriate location of the studios with buffer spaces between them and the noise sources.

5:2:2 Design

The design of any studio space should be done by a design team clearly giving a distinction of the activities to be accommodated in the studio.

The integration of other design elements and services should be chosen and implemented carefully without disrupting the desired acoustic environment. The need for the architect to design and supervise the execution of all acoustic details is of prime importance.

The design of studios should be directed to particular activity rather than designing for a wide spectrum of activities.

5:2:3 Execution

In Kenya, the 'Jua Kali' domestic technology is being extensively used throughout the country. Almost all craftsmen used in our local building industry are descendants of this evolving technology. This serves quite well with most of the local construction needs but may be of disastrous effect to an area of specialised construction requirement such as studio construction. Construction of studios require a competent contractor whose past experience on such studios is established.

The design team has to keep close supervision on the project throughout the entire construction period. This would ensure excellent execution and workmanship in the overall project.

5:2:4 Maintenance

Consultation should not only be carried out until the completion of the project. Periodically, the client needs to consult the design team in order to carry out surveys to ascertain any essential areas requiring maintenance.

Epilogue

Epilogue

EPILOGUE

The study cites architecture as an evolution from scientific demand to provide appropriate and feasible solution to an outstanding acoustic field.

The architect is seen to possess the prime objective of propelling the cumulative and challenging responsibility into one target - Achieving a practical solution to the desired studio space.

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APPENDIX I

Absorption Coefficients

The following table of absorption coefficients is divided into four groups: common building materials (1 to 22), common absorbent materials of non-proprietary kinds (23 to 42), room contents (43 to 49), and proprietary absorbents (50 to 69). Coefficients are given for the three representative frequencies 125, 500 and 2000 Hz at which calculations are commonly made and also for a number of materials at some or all of the frequencies 62, 250, 1000 and 4000 Hz to enable calculations at every octave over a wider range to be made for studio design purposes. In all of the groups except the proprietary materials the values given are those which have been found in practice to be most applicable to average room and auditorium conditions, rather than values based on an isolated test measurement. It must be borne in mind that sound absorption is not an intrinsic property of a material alone. Factors such as thickness, method of mounting and decorative treatment will influence actual absorption, as will the nature (solidity and weight, for example) of the structures in which they are built, particularly at the lowest sound frequencies.

The values for proprietary absorbents are those published by the manufacturers of these materials, and only those which are results of tests by the National Physical Laboratory of Great Britain and the Technical Physics Dept. (T.N.O.) of the Netherlands (which are recognised authorities) have been included.

The values quoted under the heading L.R.C. are the loudness reduction coefficients which give an indication of the performance of the material as a noise-reducing treatment

*Parkin & Humphreys, London 1969
Pg. 309-313.

Appendix

	Frequency Hz							
	62	125	250	500	1000	2000	4000	L.R.C.
COMMON BUILDING MATERIALS								
1. Boarded roof; underside of pitched slate or tile covering		0·15		0·1		0·1		
2. Boarding ('match') about 19 mm thick over air-space against solid wall		0·3		0·1		0·1		
3. Brickwork, plain or painted	0·05	0·05	0·04	0·02	0·04	0·05	0·05	
4. Clinker ('breeze') concrete unplastered	0·1	0·2	0·3	0·6	0·6	0·5	0·5	
5. Concrete, constructional or tooled stone or granolithic	0·05	0·02	0·02	0·02	0·04	0·05	0·05	
6. Cork tiles (thin), wood blocks, linoleum or rubber flooring on solid floor (or wall)	0·05	0·02	0·04	0·05	0·05	0·1	0·05	
7. Cork tiles 25 mm thick on solid backing		0·05	0·1	0·2	0·55	0·6	0·55	0·5
8. Fibreboard (normal soft) 12 mm thick, mounted against solid backing—unpainted	0·05	0·05	0·1	0·15	0·25	0·3	0·3	
9. Ditto, painted	0·05	0·05	0·1	0·1	0·1	0·1	0·15	
10. Fibreboard (normal soft) 12 mm thick mounted over 25 mm air-space on battens against solid backing—unpainted		0·3		0·3		0·3		
11. Ditto, painted		0·3		0·15		0·1		
12. Floor tiles (hard) or 'composition' floor		0·03		0·03		0·05		
13. Glass; windows glazed with up to 4 mm glass		0·3		0·1		0·05		
14. Glass, 6 mm plate windows in large sheets		0·1		0·04		0·02		
15. Glass used as a wall finish (e.g. 'Vitrolite') or glazed tile or polished marble		0·01		0·01		0·02		
Granolithic floor—see 5								
Lath and plaster—see 17								
Linoleum—see 6								
Marble—see 15								
Match-boarding—see 2								
16. Plaster, lime or gypsum on solid backing	0·05	0·03	0·03	0·02	0·03	0·04	0·05	
17. Plaster, lime or gypsum on lath, over air-space against solid backing or on joists or studs including plasterboard	0·1	0·3	0·15	0·1	0·05	0·04	0·05	
18. Plaster or plasterboard suspended ceiling with large air-space above		0·2		0·1		0·04		
19. Plywood or hardboard panels mounted over air-space against solid backing		0·3		0·15		0·1		

	Frequency Hz							
	62	125	250	500	1000	2000	4000	L.R.C.
COMMON BUILDING MATERIALS—*continued*								
20. Ditto with porous absorbent in air-space		0·4		0·15		0·1		
Rubber flooring—see 6								
Stone, polished—see 15								
21. Water—as in swimming-baths		0·01		0·01		0·02		
Windows—see 13 and 14								
Wood-block floor—see 6								
22. Wood boards on joists or battens	0·1	0·15	0·2	0·1	0·1	0·1	0·1	
COMMON ABSORBENT MATERIALS (NON-PROPRIETARY)								
23. Asbestos spray, 25 mm on solid backing—unpainted		0·15		0·5		0·7		
24. Carpet—thin, such as hair cord over thin felt on concrete floor	0·05	0·1	0·15	0·25	0·3	0·3	0·3	0·3
25. Ditto on wood-board floor	0·15	0·2	0·25	0·3	0·3	0·3	0·3	0·3
26. Carpet, pile over thick felt on concrete floor	0·05	0·07	0·25	0·5	0·5	0·6	0·65	0·55
27. Curtain—medium or similar fabric, straight against solid backing	0·05	0·05	0·1	0·15	0·2	0·25	0·3	0·2
28. Curtain medium fabric hung in folds against solid backing		0·05		0·35		0·5		
29. Curtains (dividing), double, canvas	0·03	0·03	0·04	0·1	0·15	0·2	0·15	
30. Felt—hair, 25 mm thick with perforated membrane (viz. muslin) against solid backing		0·1		0·7		0·8		
Mineral or glass wool, 80–190 Kg/m³ density, 25 mm thick blanket or semi-rigid slabs against solid backing:								
31. With no covering, or very porous (scrim or open-weave fabric) or open metal mesh covering	0·08	0·15	0·35	0·7	0·85	0·9	0·9	0·85
32. With 5% perforated hardboard covering	0·05	0·1	0·35	0·85	0·85	0·35	0·15	0·55
33. With 10% perforated or 20% slotted hardboard covering	0·05	0·15	0·3	0·75	0·85	0·75	0·4	0·7
Mineral or glass wool, 80–190 Kg/m³ density, 50 mm thick blanket or mattress mounted over 25 mm air-space against solid backing:								
34. No covering or with very porous (scrim or open-weave fabric) or open metal mesh covering	0·15	0·35	0·7	0·9	0·9	0·95	0·9	0·9
35. Ditto with 10% perforated or 20% slotted hardboard covering	0·15	0·4	0·8	0·9	0·85	0·75	0·4	0·7

	Frequency Hz							
	62	125	250	500	1000	2000	4000	L.R.C.
Common Absorbent Materials (Non-proprietary)—*continued*								
36. Panel (about 5 Kg/m^2) of 3 mm hardboard with bitumen roofing felt stuck to back mounted over 50 mm air-space against solid backing	0·5	0·9	0·45	0·25	0·15	0·1	0·1	
37. Panel (about 4 Kg/m^2) of two layers bitumen roofing felt mounted over 250 mm air-space against solid backing	0·9	0·5	0·3	0·2	0·1	0·1	0·1	
38. Polystyrene (expanded) board 25 mm thick spaced 50 mm from solid backing		0·1	0·25	0·55	0·2	0·1	0·15	0·25
39. Polyurethane flexible foam 50 mm thick on solid backing		0·25	0·5	0·85	0·95	0·9	0·9	0·9
40. Wood-wool slabs 25 mm thick mounted solidly—unplastered		0·1		0·4		0·6		
41. Ditto mounted 25 mm from solid backing		0·15		0·6		0·6		
42. Ditto, plastered and with mineral wool in cavity		0·5		0·2		0·1		
Room Contents								
43. Air. (x) (per cu. m)	nil	nil	nil	nil	0·003	0·007	0·02	
44. Audience seated in fully upholstered seats (per person)	0·15	0·18	0·4	0·46	0·46	0·51	0·46	
45. Audience seated in wood or padded seat (per person)		0·16		0·4		0·44	0·4	
46. Seats (unoccupied), fully upholstered (per seat)		0·12		0·28		0·32	0·37	
47. Seats (unoccupied), wood or padded (per seat)		0·08		0·15		0·18	0·2	
48. Orchestral player with instrument (average)	0·18	0·37	0·8	1·1	1·3	1·2	1·1	
49. Rostrum (portable wood) per m^2 of surface	0·6	0·4	0·1	nil	nil	nil	nil	
Absorbent Materials, Proprietary								
50. 'Burgess' metal perforated tile (type C) against solid backing		0·1	0·3	0·6	0·75	0·8	0·8	0·75
51. 'Echostop' plaster perforated tile over 125 mm air-space		0·45	0·7	0·8	0·8	0·65	0·45	0·7
52. Fibreglass 19 mm plastic filmed acoustic tiles spaced 50 mm from solid backing. (Film 0·038 mm stretched across tiles and stuck at edges only)		0·3	0·45	0·7	0·75	0·85	0·75	0·75
53. 'Frenger' metal perforated (heated) panel with 19 mm bitumen-bonded glass wool behind, over air-space		0·2	0·45	0·65	0·45	0·35	0·25	0·4

	Frequency Hz							
	62	125	250	500	1000	2000	4000	L.R.C.
ABSORBENT MATERIALS, PROPRIETARY—*continued*								
54. 'Gypklith' wood-wool tile, 25 mm thick over 25 mm air-space		0·25	0·45	0·9	0·7	0·55	0·75	0·7
55. 'Gyproc' perforated plaster-board over 25 mm scrim-covered rock-wool		0·15	0·7	0·9	0·7	0·45	0·3	0·6
56. Ditto over 50 mm glass-wool		0·4	0·75	0·85	0·55	0·45	0·3	0·55
57. Ditto over 25 mm air-space (empty)		0·1	0·2	0·4	0·3	0·15	0·2	
58. 'Gyproc' slotted plaster-board tile over 25 mm bitumen-bonded glass-wool		0·15	0·5	0·8	0·6	0·25	0·3	0·5
59. 'Paxfelt' asbestos felt 25 mm thick over 25 mm air-space			0·5	0·55	0·65	0·7	0·75	0·65
60. 'Paxtiles' asbestos tiles 25 mm thick over 25 mm air-space			0·55	0·75	0·85	0·8		
61. 'Perfonit' wood fibre perforated tile 19 mm thick over 25 mm air-space		0·2	0·5	0·7	0·85	0·75	0·65	0·75
62. 'Tentest' Rabbit-Warren perforated hardboard tile with grooved fibre backing 25 mm mounted over 25 mm air-space		0·15	0·5	0·6	0·8	0·75	0·25	0·6
63. 'Thermacoust' wood-wool slab 50 mm thick against solid backing		0·2	0·3	0·8	0·75	0·75	0·75	0·75
64. 'Treetex', 'Decorac' slotted wood-fibre tile 25 mm thick		0·15	0·65	0·75	1·00	0·95	0·7	0·85
65. 'Treetex', 'Slotac' grooved wood-fibre tile 19 mm thick		0·15	0·4	0·55	0·7	0·8	0·7	0·7
66. 'Treetex', 'Treeperac' perforated wood-fibre tile 19 mm thick		0·2	0·55	0·65	0·9	0·8	0·55	0·7
67. 'Unitex' perforated wood-fibre tile 12 mm thick		0·2	0·55	0·6	0·6	0·65	0·8	0·65
68. 'Unitex' perforated wood-fibre tile 19 mm thick		0·25	0·65	0·65	0·7	0·8	0·75	0·7
69. 'W. Cullum' Acoustic Felt, covered with painted and pin-hole perforated muslin—solid backing			0·35	0·75	0·85	0·7	0·65	0·75

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