AN ANALYSIS OF ACOUSTIC TREATMENT ON RECORDING STUDIO

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Abstract - *A recording studio consist of a live room, control room and an isolation booth. Recording studios are designed around the principles of room acoustics. This will consist of both room treatment (through the use of absorption and diffusion materials on the surface of the room) and soundproofing to prevent sound from leaving the property. For this some common acoustic material used are glass wool, foam panels, fabric coverings, bass traps, fiberglass, gypsum board, plywood, etc. And flooring can be of hardwood, cork, vinyl or carpets. Based on this acoustic treatment, layout is designed with adequate ventilation, storage, door and window placement, lighting and electrical layouts.*

Key Words: **Recording Studio, Acoustics, Soundproofing, Absorption, Diffusion.**

1. INTRODUCTION

A recording studio is a place prepared for sound recording, mixing, and audio production of instrumental or vocal musical performances, spoken words, and other sounds.

Recording studios are carefully designed around the principles of room acoustics to create a set of spaces with the acoustical properties required for recording sound with precision and accuracy. This will consist of both room treatment (through the use of absorption and diffusion materials on the surfaces of the room, and also consideration of the physical dimensions of the room itself in order to make the room respond to sound in a desired way) and soundproofing (also to provide sonic isolation between the rooms) to prevent sound from leaving the property.

1.1 RELATIONSHIP BETWEEN MUSIC AND DESIGN

Music is a powerful means of connecting people. Music and design are part of our society. They are the soul of the place and reflects the society that creates them. Music influences the space. Design and music are connected to each other as both contains the same mixture of rhythm, unity, balance, variety and harmony.

Music and design are the two interrelated fields of art with the similar origin, terms and concepts. It is observed that music and design as tools of communication and cultural heritage of environment always influence each other throughout the ages.

The role of music in the design is elaborated through different literature case studies based on the work of different architects such as Alamillo Bridge in Seville, Spain, 1992 designed by Santiago Calatrava, The Piano House in china designed by the company of Huainan Fangkai Decoration Project Co, Craigieburn Bypass by Cullity Lethlean and Peter Tonkin, Le Corbusier designed a residential complex in Chandigarh, India. Daniel Libeskind, Hans Hollein and Lannis Xenakis.

2. DESIGNING A VOCAL BOOTH

Vocal booths are generally smaller rooms designed to accommodate one or two people, while isolation rooms need to be large enough to accommodate a drum kit, guitar amp and so on. Most vocal booths tend to range from 3′ x 4′ to 4′ x 6′ in size. The walls of the vocal booth are separated from the studio so that they are decoupled. Smaller rooms are best accessed via a door that swings outward from the room. The window is basically used as a means of visual communication.

Provision of windows in the studio should be minimum so as to minimize the transfer of noise. Small rooms tend to get warm very quickly. Therefore, low energy lighting is best. Also, the use of dimmers should be avoided as they often generate electromagnetic fields that can introduce hum and buzz into the recording. The studio rooms must be reasonably air tight and should be ventilated with conditioned air supplied through silenced grilles.

Table -1: Common Studio Requirements

Acoustical	Functional
Insulation	Adequate ventilation and thermal control
Isolation from the surroundings	Access to bathrooms and cabling
Adequate reverberation	Visual contact with the control room
Freedom from acoustical defects	Storage areas
Reasonable diffusion	Equipment maintenance facilities
Isolation for different instruments	Break rooms and private phone areas
Control of bass reverberation	Communication areas (internet access)
Variable absorption	Offices and conference rooms
Moveable gobos (reflecting or absorbing acoustic panels)	Handicapped access

3. ACOUSTIC TREATMENT

There are four primary goals of acoustic treatment are:

(a) To prevent standing waves and acoustic interference from affecting the frequency response of recording studios and vocal booth.

(b) To reduce modal ringing in small rooms and lower the reverb time in larger studios, churches, and auditoriums.

(c) To absorb or diffuse sound in the room to avoid ringing and flutter echoes, and improve stereo imaging.

(d) To keep sound from leaking into or out of a room.

There are two basic types of acoustic treatment - absorbers and diffusors. There are also two types of absorbers. One type controls midrange and high frequency reflections; the other, a bass trap, is mainly for low frequencies. All three types of treatment are usually required before a room is suitable for making music.

The more fibrous materials have more absorption; oppositely the denser materials are less absorption. By using the absorption materials in the studio, it can minimize the reflections while the recording going and it can also prevent the standing waves and flutter echoes. But, the control room is treating to be more diffusive than absorptive with the LEDE (Live End Dead End) concept for the monitoring purpose. By using acoustic treatment we can deaden one half of the room whilst keeping the other half reflective.

Insulation is the process of blocking sound from leaking out from the room. Sound absorbers, mostly of porous materials, are poor sound insulators, while hard materials, used for sound insulation are poor absorbers.

Reverberation time will be affected by the absorption. The lower the reverberation time, it is mean there is more absorption.

Diffusor can be used to reduce reverb or echoes that will be occur in a room that has parallel walls and the flat ceiling. Diffusers are commonly made of wood, plastic, or even polystyrene.

3.1 CUBIC VOLUME AND SHAPE

Cubic volume is equal to floor area multiplied by ceiling height. Reducing this space can make the room unresponsive and excessively loud.
Never cut corners on cubic volume. Low ceilings are a common cause of poor music room acoustics. Use portable risers instead of poured concrete tiers. Concrete dramatically reduces room volume and increases loudness, while the space beneath portable risers, if left open, will not reduce cubic volume.
Untreated parallel walls cause flutter echo. Avoid visual acoustics. These are designs — such as curved walls and domes — that look attractive but in reality are often disastrous to the acoustic environment.

Square or cube-shaped rooms with parallel walls create

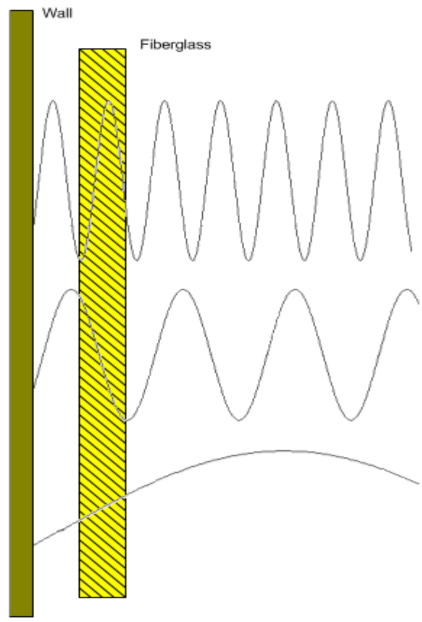

Fig -1: The higher frequencies (top) are absorbed well because their velocity peaks fall within the material thickness. The lower frequency at the bottom does not achieve as much velocity so it's absorbed less.

additive wave lengths, called “standing waves,” that over-emphasize certain frequencies, making them abnormally loud. Creating a rectangular room by varying one dimension 30% or more is a typical solution [2].

3.2 SOUNDPROOFING

Soundproofing is any means of reducing the sound pressure with respect to a specified sound source and receptor. There are several basic approaches to reducing sound: increasing the distance between source and receiver, using noise barriers to reflect or absorb the energy of the sound waves, using damping structures such as sound baffles, or using active anti-noise sound generators.

The process of soundproofing a room is accomplished using a combination of 4 tactics:

Adding Mass

Damping

Decoupling

Filling Air Gaps

3.3 REFLECTION OF SOUND

Reflection of sound waves follow practically the same laws as reflection of light, the angle of incidence being equal to angle of reflection. However, this may not be true in some exceptional cases, hence great caution should be exercised while applying these laws.

The reflected wave fronts from a flat surface are also spherical and their center of curvature is the image of source of sound fig.2 (a).
Sound waves reflected at a convex surface are magnified and are considerably bigger fig.2 (b). They are attenuated and are therefore weaker. Convex surfaces may be used with advantage to spread the sound waves throughout the room.

The sound wave reflected at a concave surface are considerably small fig.2(c). The waves are most condensed and therefore amplified. The concave surfaces maybe provided for the concentration of reflected waves at certain points [1].

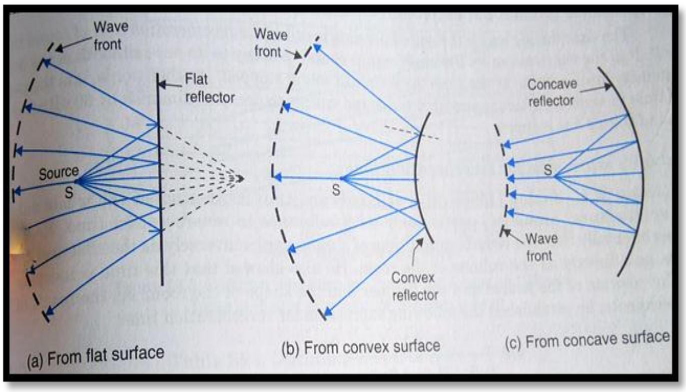

Fig -2: Reflection of sound waves

3.4 WALL INSULATION: VERTICAL BARRIERS

Wall and partitions are the vertical barriers to noise. Their proper design and construction may insulate the sound to the desired level. Wall construction, used for sound insulation, may be of four types –

(a) Rigid homogeneous walls –

A rigid wall consists of stone, brick of concrete masonry construction, well plastered on one or both the sides. The sound insulation offered by these rigid walls depends upon their weight per unit. The sound insulation thus increases with the increases in the thickness of the wall. Because of the logarithmic variation between weight and transmission loss, such a construction (i.e., solid wall) becomes highly uneconomical and bulky after certain limit. The transmission loss (sound insulation) of a one-brick wall is 50 db while that of $1^1/_2$ brick wall is 53.

(b) Partition walls of porous materials –

Porous materials may be rigid or non-rigid. Rigid porous materials (such as porous concrete masonry, cinder concrete etc.), the insulation increases about 10% higher than the non-porous rigid material. However, partition walls of non-rigid porous materials (such as felt, mineral wool etc.) offer very low sound insulation, though they can be used in combination with rigid materials with added advantage.

(c) Double wall partition –

A double wall patition, shown in fig.3, consists of plaster boards on fibre boards or plaster on laths on both the faces, with sound absorbing blanket in between. Staggered wood studs are provided as support, though their number should be a minimum. A double wall construction is thus a partition wall of rigid and non-rigid porous materials.

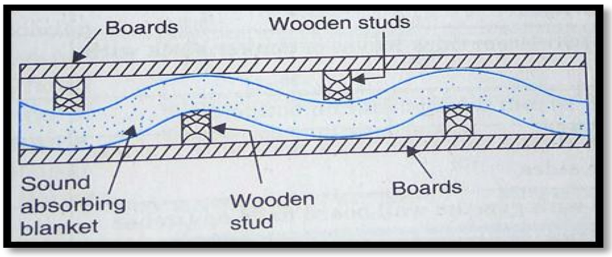

Fig -3: Double wall partition

(d) Cavity wall construction –

This is an ideal construction from the point of view of sound proofing, as shown in fig.4. The gap between the two leafs of the wall may be left air-filled or else filled with some resilient material, like quilt etc., well suspended in the gap. The two faces of the wall may be fixed with celotex or other insulating board. The width of cavity should be at least 5 cm, and the two wall leaves should be tied by use of only light butterfly wall ties [1].

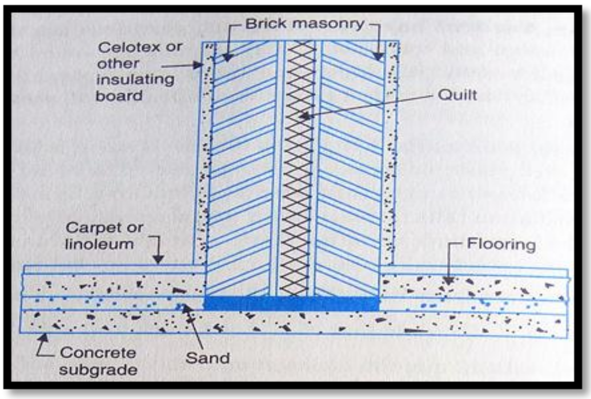

Fig -4: Cavity Wall or Double Wall Construction

4. ACOUSTIC MATERIALS

4.1 Wood Floors, Ceiling, and Walls –

Wood is a light material, so its sound insulation performance is not particularly good. Wood conducts sound better in the longitudinal direction of the grain than perpendicular to it. A dense wooden structure reflects sound, and can easily be made into surfaces that channel sound reflections.

Plywood to separate gypsum and studs and adhere with soundproofing mat. Chip wood (recording room floor) is an ordinary chip wood for flooring.

4.2 Stone, Concrete, Rock, and Brick –

Brickwork provides good insulation against sound, particularly if plastered on one or both sides. Concrete rates as a good insulator of sound; but it will generally transmit impact sound unless it is combined with some other form of insulation or isolation treatment. Moreover, being hard, concrete surfaces also readily reflect the sound.

4.3 Glass –

Glass is a very poor absorber of sound. Most of sound energy impinging on a glass surface is reflected. On the other hand, glass is an excellent insulator of sound. However, the performance of glass as an insulator of sound is limited by the practical consideration of its thickness.

4.4 Reflective panels –

Acoustical reflectors or diffusers are implemented to evenly distribute sound to avoid areas where sound quality is either weak, too excessive or cannot be heard clearly. Acoustic diffusion or sound reflection helps to provide wider sound coverage for speech and music and are often used to improve speech intelligibility and music.

4.5 Vinyl Sound Barrier –

Mass Loaded Vinyl Sound Barrier has smooth finish. This acoustical barrier is made from high-density limp mass barrier material to reduce noise transmission. Vinyl Barrier reduces noise transmission through ceilings, walls, floors, machinery enclosures, and ductwork. Colors: Black, Grey (Reinforced), Tan and Clear (Transparent or Translucent) - Aluminized Mylar / Foil can be added to one side. Acoustical barrier material can be nailed, screwed, stapled or can be reinforced and grommets and hung like a curtain.

4.6 Acoustic Panels –

Acoustic panels are designed to absorb sound. They are typically applied to a ceiling or wall to reduce echoes and reverberation in a room. Asbestos are lightweight, fireproof, inexpensive and durable. Acoustical panels are designed to be porous. The panels are usually mounted below a gap under a concrete ceiling. The lighter and softer material allows sound to pass through the panels and diffuse into the space between the panels and the concrete ceiling.

4.7 Acoustic Ceiling Tiles –

Acoustic ceiling tiles may absorb sound, block sound or scatter sound. Absorptive Ceiling Tiles help to reduce the reverberation reflecting within a space. Sound diffusing ceiling tiles will scatter and disperse sound that strikes the surface. The shape of a typical sound diffuser is not flat. This redirects the sound in a different direction, reducing the sounds intensity without removing the sound like an absorber would.

4.8 Fabric Coverings –

There are different acoustic fabrics used to wrap acoustical panels, cover speakers and amplifiers, or directly mount to a wall to let sound energy into an acoustical panel to absorb mid to high frequency sound, rather than reflecting sound off the surface.

4.9 Lead sheet –

Lead sheet is an exceptionally good sound-insulating material. This acoustic property of the lead sheet is the result of its high superficial weight (weight per unit area of the surface) as well as its natural limpness. This implies that a sound barrier incorporating lead can be lighter and thinner than other sound barriers offering a similar acoustic performance.

Until recently, the main factor limiting the use of lead sheets for noise insulation was the high cost of rolling the lead slab to the required thin sheets. This has now been overcome by the recent development of continuous cast thin-sheet lead.

Thin lead sheets have the advantage that they can easily be cut (with scissors, for example), wrapped or draped around a structure, nailed, or stapled. In addition, thin lead sheets can readily be bonded to other surfaces.

In addition to lead sheets mentioned above, lead materials used for sound insulation also include the following:

(a) Lead/foam sandwich;

(b) Lead-loaded plastic sheet; and

(c) Leaded plastics.

Lead/foam sandwich consists of lead sheet laminated between the polyurethane foam. The lead in this case is usually a single layer (of about 0.4 mm thickness), with foam thickness ranging from 6 mm to 50 mm.

Lead-loaded plastic sheets are usually vinyl or neoprene sheets loaded with powdered lead. This process yields a flexible curtain or blanket, which can be used as a sound barrier. Fabric reinforcement may also be incorporated in the lead-loaded plastic sheet.

4.10 Bonded acoustical cotton (B.A.C.) –

The Most Cost Effective Acoustical Absorbing Material. It is a high-performance acoustical material made from recycled cotton. It is Non-Flammable, Lightweight, and Easy to install and Low cost. It can be used as an acoustic wall panel or hanging baffle. Standard Colors - White, Marble Light Blue, Light Grey, Beige, Graphite, and Black.

4.11 Fabric Panels –

These are decorative cloth wrapped boards designed to capture and convert the unwelcome sound wave reflections inside the studio, and deliver back the sound wave. The panels can be wall or ceiling mounted. Fabric Panels come in 60 colors, they are fire rated, durable, decorative, and portable and combine to produce maximum sound absorption coefficients.

4.12 Tiger Traps –

Tiger Traps are the compliment to the Fabric Panel. These are base traps that can be wrapped in the same color as the Fabric Panels, and recessed into the 4 corners of the live rooms to reduce base frequency reverberations that will gather in the corners of the studio space.

4.13 Bass trap –

Bass trap is a material for absorption, but is specifically designed in order to absorb the low frequency energy and minimize standing waves. The good bass trap is the combination of the hard, soft, thin materials. The back of the trap and the gap between the walls can make it even more effective.

4.14 Fiberglass –

Glass fiber wool is both an excellent thermal insulate as well as sound absorber. Glass fiber wool is extensively used for lining ducts, silencers and acoustic hammers. Glass wool is also widely used for facing in the sound absorbent treatment of hard surfaces, as an absorbent layer behind perforated tiles, and in felted form as a supporting medium for floating floors, etc.

Rigid fiberglass is made of the same material as regular fiberglass, but it is woven and compressed to reduce its size and increase its density. As with all absorbent materials, the thicker it is, the lower in frequency it will absorb to. That is, 703 fiberglass one inch thick absorbs reasonably well down to 500 Hz. When two inches thick, the same material is equally absorbent down to 250 Hz.

Although 703 and 705 fiberglass panels are more effective than foam of the same thickness, they are usually covered with fabric for appearance, and to prevent the glass fibers from escaping into the air. This adds to the expense and difficulty of building and installing them.

4.15 Acoustic Foam –

Acoustic foams are sponge-like materials. It is an open celled foam used for acoustic treatment. It attenuates airborne sound waves by increasing air resistance, thus reducing the amplitude of the waves. Such materials possess the ability to absorb sound energy by changing it into heat. The capacity of acoustic foams to absorb acoustic energy depends primarily on their permeability and thickness of the cellular structure and, to a lesser extent, on the pore size and surface treatment. On the other hand, the rigidity of the foam has very little or no effect on its acoustic performance. Acoustic foam can be made in several different colors, sizes and thickness. Acoustic foam can be attached to walls, ceilings, doors, and other features of a room to control noise levels, vibration, and echoes.

As a general rule, the higher the permeability the greater the sound absorption capacity of a foam. For optimum acoustic performance, the thinner the foam, the lower the permeability has to be.

This requirement has a significant effect on the acoustic performance, particularly at lower frequencies. Other parameters being the same, the smaller the pore size (i.e., the larger the number of pores per unit area), the greater the capability for absorption of sound.

Acoustic foams are especially suitable for the acoustic treatment for middle and high frequencies. For low-frequency applications, on the other hand, acoustic performance of foams can be improved by spacing them away from hard surfaces. Acoustic foams can be made from any "expandable" material. However, the main type of foam used for acoustic applications is the flexible polyurethane foam of open pore structure.

4.16 Gypsum board –

Gypsum board is a typical material used for layering walls, holding insulation fibers, providing a certain amount of damping and as wall surface. It is also used for floors, doors and ceilings treatment.

Gypsum is a natural mineral. The hemihydrate and a hydrate types of gypsum are widely used for the manufacture of acoustic tiles, boards and panels. General building materials based on gypsum are insulating wall-boards, ceiling panels and impregnated wood-wool slabs.

Insulating wall-boards consist of a core of aerated gypsum plaster faced on both sides by mill board. One surface is normally covered with polished aluminium foil (to act as a reflective surface) facing the side of the cavity where the board is attached to timber studding.

4.17 Gasket –

Gaskets/ Cushioning, self-adhesive EPDM / Neoprene blend expanded foam rubber sealing strip. This is ideal for exposed sealing, damping and cushioning. It age resistant and chemically neutral against the most commonly used lacquers and Plastics and resistant to most caustic chemicals, resistant against ozone, moisture and UV radiation. This is good for isolating and 'decoupling' battens attached to walls and ceilings.

4.18 Curtains –

The acoustic curtain material must be thick and highly porous. The thicker the absorption material, the more effective it will be against a longer wavelength (lower frequency) of sound. In order to improve the low and mid frequency sound absorption performance of your acoustical curtain, the material must be pleated. This will cause the fabric to be "gathered," such that it loops in and out (i.e. does not lay flat). The pleating should be as deep as possible in order to expose more sound-absorbing surface, thus increasing effective thickness and improving low frequency sound attenuation. Minimum pleating at 50% fullness is required; 100% fullness is recommended. The drapery will also become more effective at absorbing longer sound wavelengths (lower pitches) if it is spaced several inches from the wall or window.

5. CONCLUSIONS

Music is a powerful means of connecting people. Now-a – days, there is a high demand for music to be produced for film, T.V., advertising, digital and live performances. Recording studios plays an important role as it is used to record singers, instrumental musicians (e.g., electric guitar, piano, saxophone, or ensembles such as orchestras), voice-over artists for advertisements or dialogue replacement in film, television, or animation to record their accompanying musical soundtracks.

They range in size from a small in-home project studio large enough to record a single singer-guitarist, to a large building with space for a full orchestra of 100 or more musicians.

Recording studios are designed according to the principles of room acoustics i.e. absorption, diffusion and soundproofing. For making a room acoustically stable various methods and acoustic material are available for walls, ceiling and flooring treatment.

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