Acoustical Treatment of Room and Recent Trends in Selection of Acoustic Materials

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***Abstract*-Every room has its unique sound effect and acoustical properties. The acoustic performance of a room depends on various factors such as reverberation time, its sound absorbing quality, the material used in different surfaces and interiors of room etc. By using different materials or by proper treatment of room as per acoustic performance point of view, the acoustic efficiency of room can be improved. In this paper, two major problems are discussed with their possible solutions. First, by adopting different methods of acoustic treatment if the material can't be replaced in room. And second, by placing different materials (including absorbers) at different locations or replacing the surfaces of room by a new acoustic material. These all methods help in improving the acoustic efficiency of a room.**

Keywords: Acoustic material, reflection, absorption, absorber, sound waves.

1. INTRODUCTION

Every room has its special and unique sound effect and acoustical performance. The reasons behind this special effect are reflections and resonance which directly can be connected to dimensions of room and presence of material used for construction of room. Different materials used for construction of room and the content available in room also affect the acoustic performance of environment. The work by Sabine [5] around 1900 firstly introduced the room acoustic. He introduced this concept firstly and derived the reverberation formula which includes room absorption coefficient and hence proved the importance of absorption coefficient as a function of the surface material present in room. Eyring [6] in 1930 presented his paper with some practical problems considering room surfaces. And hence the era of research of improving the room acoustic quality initiated.

Millington [7] and sette [8] introduced the analysis which includes the concept of average absorption coefficient. Fitzroy applied the same theories but also discussed about geometrical aspects of a room. Recently Sezgin Ersoy et al. [1] investigated different materials and found that industrial tea-leaf-fibre waste material can be a good acoustical material because of its sound absorption properties. Kimihiro Sakagami et al. [2] examined the possibility of producing a useful sound absorbing material for acoustical purpose with an MPP (microperforated panel) and a permeable membrane as an alternative. Antonio Tadeu et al. [3], performed sound simulation by using single and double panel walls and demonstrated that size of the panel is important variable in sound insulations. David J. Oldham et al. [4] revealed that sustainable absorbers formed by biomass or recycled materials has considerable potential application in field of acoustic materials with good absorption characteristics at low frequencies. He also suggested that by combining some natural fibers with required properties provides the possibility of such absorbers which can work effectively for all range of frequencies. Several researchers used different waste materials also and then recycled them into the new acoustical materials. A general conclusion was drawn [4] that those natural fibers which have small averaged diameters and can be compacted easily, may be used as substitutes of sound absorbers. Rui Lin Mu et al. [9] used multi layered structure with microperforated panel for sound insulation and elucidated the dependence of sound absorption characteristics on diameter of hole and perforation pitch.

In the following sections different methods of acoustical treatment of materials have been discussed. Some recent trends used in material selection including some new materials for acoustic point of view have also been discussed further.

2. ACOUSTIC TREATMENT OF MATERIALS PRESENT IN ROOM

The acoustic performance of room can be improved either by proper selection of material or if the material can't be replaced then by proper treatment of material used in surfaces and interiors of room. Acoustic treatment of material can be done in four different ways [10]:

- **i.** Absorbers
- **ii.** Diffusors
- **iii.** Resonators
- **iv.** Free standing devices.

Absorbers allow air to enter or pass through the material. They reduces sound by converting friction of sound energy into heat energy. Thick materials provide additional friction and hence more efficient in reducing sound. Diffusors permit more reflection of sound than absorption. Since Diffusors are also capable to change the direction and quality of the reflected sound hence they can be used as the alternative materials. Resonators are most effective at low frequencies. They are primarily rigid or semi-porous panels (such as pegboard) with an enclosed air space, behind which it may contain absorptive materials. The latest, popular and most effective application of material treatment falls in category of free standing devices. Since they are time saving as per their installation point of view and can be used to alter the acoustic properties easily, they are growing now these days rapidly.

3. WHERE THE SOUND ABSORPTION MATERIAL SHOULD BE PLACED WITHIN A ROOM…?

If the sound walls are straight and made of hard material then the sound can be heard most. When the sound is produced by source, most of part of it travels along horizontal, because the remaining part strikes the nearest walls and get absorbed most of it. The absorption of sound can be increased successfully by placing the absorption material at the respective walls, ceiling and floor near the sound source as much as possible. If the acoustic treatment of large sized room i.e. seminar hall, concert hall etc. where many sound sources are located like speakers at different locations then placing of screens in between sound sources help in reducing the range of sound. It not only absorbs the sound but also blocks sometimes. The absorption of sound by screens placed between sound sources depends on the location of sound source and the material used in screen surfaces. As per traditions the canvas is painted on the walls to make it attractive but literally if one is concerned for achieving better acoustics, canvas should be avoided since it has poor absorbing capacity. The paint on the canvas reflects the sound more than as in the normal conditions.

4. EFFECT OF APPLICATION OF NEW ACOUSTIC MATERIALS

In this section effect of broadband absorbers and another material made by recycling tire fluff are discussed when used as acoustic materials in room.

4.1. BROADBAND ABSORBERS

Placing the broadband absorbers only at few edges of the room can increase the acoustical efficiency of room tremendously. Even if we apply the absorber less than 20 percent of the ground surface and walls; and leaving the ceiling completely without applying any absorption material, still it can maximize the efficiency. The room can be made more attractive with few more investment by coloring all the absorbers applied at edges.

Figure 1. Application of mineral wool absorber behind plaster board covers [11]

Application of compact edge absorbers with mineral wool filling behind plaster board panels has been enormous area of interest in research for increasing the acoustical efficiency since it requires minimum budget investigation and these are unnoticeable also when applied at specific places.

4.2. RECYCLING OF TIRE FLUFF TO MAKE A NEW ACOUSTIC MATERIAL

Recycling of waste tire eliminates the problem related to health and environment pollution. If one can use even few of wastage part of it as for upcoming future acoustic materials then it will be a significant contribution in increasing the acoustic performance of a room. Tire contains the steel, rubber and fluff in which steel and rubber are recycled for industrial use whether to recycle the fluff of tire is a complicated piece of work. By mixing the fluff (waste tire textile) with hot melt adhesive and sometimes geotextile films also, the acoustic material is synthesized.

Figure 2. Fluff (as a waste material) obtained from tires.

The epoxy-polyester can be taken as adhesive which further grouped with fluff and then geotextile layer is pasted to the rest of the material. Triturating mesh size has a great impact on contributing the acoustical property of a room. The smaller size of mesh will improve the material cohesion whether larger size refers to high heterogeneity. For achieving higher acoustical efficiency the density range should be within 180-250 kg/m^3. The ratio of fluff to powder made by hot melt adhesive should be in specific ratio as per requirement of acoustical property. Ratio of 1:1 with 5 mm trituration mesh and density of 180 kg/m^3 gives best NRC (noise reduction coefficient) [12]. NRC can be calculated by summing up the values of all the sound absorption coefficients at different frequencies and then dividing it by the total no. of coefficients at different frequencies.

5. RECENT TRENDS IN SELECTION OF ACOUSTIC MATERIALS

In recent few years much research is going on acoustic materials as to develop new materials to enhance acoustic efficiency. Manufacturing of new acoustic materials by use of waste helps in minimizing the cost [13]. Manufacturing of acoustic material from Phase Changing Material (PCM)-Electric Arc Furnace Dust (EAFD) has been found as of great importance. EAFD is a special kind of filler used in polymer matrix and Paraffin is used as PCM because of its higher thermal energy storage capacity. For manufacturing the material the composition of material should be taken as PCM of 10 to 12 %, EAFD of 70 to 72% by weight and remaining are zinc stearate and polymer matrix.

Carpet is one of the most used and cost effective material which minimize the noise in surroundings. Wool carpets can completely replace the sound absorbers since it can reduce most of the noise present in the room such as footsteps, movement of chairs, tables and other elements present in the room [14] [15]. By application of wool carpet on the floor, it can reduce the sound in three ways. First, it reduces the airborne sound such as it eliminates the possibility of reflections on the floor. The sound waves produced by sound source penetrate into the pile rather than reflecting back from the surface. Its porous structure helps in absorbing the sound waves hence improves the acoustical efficiency of a room. Second, it eliminates all surface noise up to maximum limits such as while dropping any element on the surface will not produce any sound unlike the reflective surface does. As much as the thickness of piles will be, more will be the reduction in sound. Presence of wool carpet can reduce the sound by 18-20 dB. The third and the most important it reduce the noise transmission by absorbing wider range of frequencies.

6. CONCLUSIONS

In most of times, the material can't be replaced within a room hence proper treatment is necessary to achieve better acoustical efficiency of the room. Different methods for treating the material of room has been discussed above. Also the location of the absorption material has been discussed for achieving better accuracy. Application of broadband absorbers up to only 20 percent of surface area increases the acoustical efficiency. Recycling of tire fluff with powder at low density leads to best noise reduction coefficient. Several materials such as wool carpets, PCM -EAFD can be used as acoustic materials for interiors to enhance the acoustical properties. Clearly much more research is needed for implementing the solutions for replacement of poor acoustic materials in practical aspects.

6. REFERENCES

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