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Acoustics -Essential requirement for public buildings

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ABSTRACT: *This paper discusses acoustical issues related with the public buildings. Basically acoustics, Room acoustics and acoustics related with the auditorium . also this paper discuss on the Architectural acoustics , basic requirements of architectural acoustics, various defects related to acoustics ,necessary requirements of a good acoustics and various acoustical materials commonly used.*
Keywords: *Architectural acoustics, Frequency, Intensity, Reverberation, Tone.*

1. INTRODUCTION [4]

Acoustics is a science which deals with the sound. Also it is a science which deals with the planning, design and construction of building to achieve the proper acoustical conditions within the building and surrounding of the building. Acoustics is also provided for correcting the defects in building units and components of the structure. Mainly the absorption and dissipation of exterior and interior noise (that is outdoor and indoor noise) and their insulation against sound. Acoustics is a science of sound, which deals with origin, propagation and auditory sensation of sound, and also with design & construction of different building units to set optimum conditions for producing & listening speech, music etc. The knowledge of this science is essential for proper functioning of theaters, auditoriums, hospitals, conference halls, etc. also buildings are becoming increasingly mechanized. Use of A.C, work machines, appliances like: vacuum cleaners, typewriters, etc., noise pattern of building has increased, leading to greater need of noise control.

2. SCOPE OF THE ACOUSTICS

When the acoustic is applied to the building, It produces the optimum conditions for producing and listening to speech, music, actual or recorded music on cinema. The planning, acoustical design and construction of the building mainly provides to minimize the noise level below the permissible level. For this the insulation against the noise is essential. Due to increasing use of the various instruments like radio, motion picture, vehicles like 2 wheeler, 4 wheeler, machineries which produces the noise, for that purpose it is necessary to improve the acoustical conditions of the building by removing the acoustical defects.

3. REQUIREMENTS OF ACOUSTICS

1)[5] The Initial sound should be adequate intensity such that it can be heard throughout the hall.
2)The sound produced should be evenly distributed over the entire area otherwise it will lead to acoustical defects such as formation of echoes, sound foci & dead spots.
3)The design of rooms should include consideration of intelligibility of speech no possibility of distortion & should enhance the tonal quality & total blending of the sound.
4) The sound produced should be clearly heard at all points.
5)There should be no focusing of sound or any dead spots or silence zones in the hall.
6)The sound produced in the auditorium should not persist for long time so as to avoid excessive reverberation.
7)There should not be overlapping of sound waves.
8) The external undesired sound should not enter the hall or auditorium.

When we provide good acoustical conditions in a building, it promotes comfortable living. It increases the efficiency of the workers. So in modern practices of building design and construction It is necessary to give the due importance to the improvement of acoustical conditions and sound insulation so that there should be minimum disturbance due to the noise. This can be achieved by considering the following two aspects. Proper control and remedy of the acoustical defects in building i. e. Acoustics of the building. And Proper control of disturbance due to noise . When we discuss about the Acoustics of the building, it is required to study the following aspects in details.

3.1. Characteristics of the audible sound:

[4]Sound is nothing but the series of alternate compressions and refractions which are produced by vibrating body.

Basically this sound is in the form of waves which transmitted or travels in all directions through an media . the media may be solid, liquid or gaseous. The average speed of the sound is 340 m/sec. This velocity of sound mainly depends upon the nature and temperature of the media through which the sound travels. The velocity of sound in water is 4 times of that in air, about 10 times in wood , 12 times in bricks and 15 times in steel. Here a main observation is that the sound cannot travels through the vacuum and hence it is required to transmit the sound from one place to the another place, some media is essential.

Frequency or pitch : It is defined as the number of cycles or vibrations per second. Greater the no of cycles , the higher will be the pitch. The highest audible sound that has frequency of 2000 cps. While lowest audible sound has frequency of sound below 20 cps.

Intensity of loudness of sound : It is nothing but the flow of sound energy per second through unit area . the unit area being perpendicular to the specified direction. The intensity or loudness is a measure if the quantity of sound which is measured. Measurement of sound: The range of variation of intensity is very large. The loudest and almost painful sound is about 10^{13} times the intensity of sound which is just audible by the human ear. The unit used to compare the two sound levels is 'Bel 'which is logarithm (base 10) of the ratio of two intensity levels. Tone or tone structure: It is the quality of sound which various sounds can be distinguished from one another. Sometimes the two sounds may have the same frequency and intensity , but even they can be distinguished by virtue of their different tones.

3.2 Principles Of Acoustics:

The behavior of the sound plays an important role in acoustical design of the buildings and rooms or in sound insulation. When sound originates from its source, the source may be speech or music. It is transmitted from the source in all directions. When it travels , it strikes on some surface such as wall , ceiling , floor or any other barrier. Some part of the sound may be reflected back , a part of the sound may be absorbed by the surface i. e. the sound may die out in the material or transmitted in part to another side of the barrier when the sound is reflected back and it is not properly controlled . It may creates some acoustical defects like reverberation and echoes.The reflected sound , which remains in the room is represented by Reflection Coefficient and it is most important in acoustical design of the building. The part of the sound may absorbed is represented by Absorption Coefficient. Absorption Coefficient for open window is unity. When the sound waves strikes against the resilient and porous surface , the considerable heat is dissipated and hence absorption is relatively high .

3.3 Acoustical Defects:

Formation of echoes: Echoes mainly produced due to the reflection of sound waves (mainly from the surface of walls , roofs , ceilings etc.) coming from the some sources , reaches to the ear , just when direct sound wave is already heard and thus there is a repetitions that is nothing but echoes. Normally the formation of echoes (happens when the time lag between the two voices or sounds is about 1/17 of a second. And the reflecting surfaces are situated at a distance more than 15 meter. If the reflected surface is curved with smooth surface this problem usually occurs. To minimizes this problem select ion of proper geometry of auditorium and surface and also use the rough and porous material for the interior surface.

Reverberation: Reverberation means the prolonged reflection of sound from wall floor or roof of a hall. It is nothing but persistence of sound after the source of the sound has stopped. When the sound is reflected back (some part of the sound is absorbed) resulting in formation of echoes, but sometimes this reflection of sound does not stop even the sound is died out. The sound reflected back and forth against the walls, ceilings and floors for several times This is mainly when sound in closed spaces successively reflected by the smooth boundaries of the enclosed space. In this condition there is very little or no energy is lost in multiple reflections and the echoes produced having maximum intensity for long time. This is nothing but the reverberation. To minimize this defect use of suitable absorbents or acoustical material .

Reverberation Time: The time gap between the initial direct note & the reflected note up to a minimum audibility level is called as reverberation time. The intensity of sound as received by the listener as shown gradually. When the source emits sound, the waves spread out and the listener is aware of the commencement of sound. When the direct waves reach his ears Subsequently the listener receives sound energy due to reflected waves also. If the note is continuously sounded, the intensity of sound at the listeners ear gradually increases. After some time, a balance is reached between the energy emitted per sound by the source and energy lost or dissipated by walls or other materials. [2]The Value of reverberation time depends on the volume and the are of the room

$t = 0.166\ V/as$ Where t = Reverberation time in seconds.

V = Volume of the room in m2 as = Total absorption of various absorption units in m2 sabins

Sound foci .: In case of concave shaped reflecting interior surface or domed ceiling or an enclosure, depending upon the curvature of these surfaces, there is possibility of meeting the sound rays at appoint called as sound foci and thus it creates the sound of large intensity . these spots of unusual loudness is called sound foci. This defect can be minimized by providing proper geometrical design. Shape of the interior faces including ceiling and also by providing absorbent materials on focusing areas.

Dead Spots: This is mainly due to sound –foci. Due to the high concentration of reflected sound at sound foci, there is deficiency of reflected sound rays at some other points. In this areas low sound intensity may result in unsatisfactory hearing for the audience called as dead spots .This defect can be minimized by providing diffusers , which provides the uniform distribution of sound throughout the auditorium.

Insufficient loudness: In case of theatre or large auditoriums, the speakers voice or music from the stage should be easily audible in all parts of the hall at a uniform intensity of loudness. To achieve this , the sound waves should be properly reflected and uniform ally spread all over the interior part of the auditorium. But due to the lack of sound reflecting flat surfaces near the sound source or stage and excessive absorption of sound in the hall resulting the defect of insufficient loudness. This defect can be minimized by providing hard surface near the stage and absorbent material should be provided as per the requirements. Also the location of the loud-speakers should be adjusted. So that there is no dead spots and sound foci. Also use of adequate no of windows or door openings

3. 4. Architectural Acoustics:

[3]Theatres and other listening environments are carefully designed to balance the amount of reflection and absorption of energy to create an appropriate sound. In India less attention is given to acoustics of the building. Lot of money is invested on construction , but if proper care is not taken related with the acoustics of the building. This may be result in increasing the acoustical defects and the basic purpose is not fulfill ,resulting in loss of money. To overcome this problem the Architectural acoustics is very essential. Basic services related to the acoustics mainly for -

To obtain the quality sound in the building.
To create an environment in which good quality of sound is essential.
To control the sound in the high noise areas by providing proper techniques.
To minimize the sound problems in the existing areas.
To study the different acoustical information related with environmental impact studies.
For that the architects must be well known with-
Fundamental concepts of acoustical theory and concepts
Knowledge of Physics, Chemistry and maths
Knowledge of various requirements related to music theater and construction techniques.
Knowledge of different mechanical equipments which produces the noise.
Operating skill of equipments which are used to measure the sound.
Ability to communicate the technical information.
While designing and building from acoustical point of view the following facts should be considered.
Indoor ambient noise level.
Room size , reverberation time , requirement of acoustical absorption.
Room geometry – reflections , flutters focusing and diffusion
Electronic speech reinforcement.

3.5 Sound Absorbing Materials:

[3]]On striking any surface, sound is either absorbed or reflected. The sound energy absorbed by an absorbing layer is partially converted into heat but mostly transmitted to the other side, unless such transmission is restrained by a backing of an impervious, heavy, barrier. In other words, good sound absorber is an efficient sound transmitter and consequently an inefficient sound insulator. Sound absorbing materials and constructions used in the acoustical design of building or the sound control of noisy rooms can be classified as 1) porous materials 2) panel or membrane absorbers, 3) cavity resonators. 4) Gypsum Boards 5) Blue boards 6)Sound boards 7) Glass fiber insulations 8) Board insulation 9) Duct Boards

4. GUIDELINES FOR DESIGN ACOUSTICS

[4] These are the same basic guidelines depending upon specific requirements.

1) Selection of the site - As far as possible the site for the auditorium is away from the noisy place, like railway track, roads, with heavy traffic, airports, industrial vicinity.

2) Volume - Size of the hall / auditorium should be such that if remains optimum. small halls leads to irregular distribution of sound because of formation of standing waves. Too big halls may also create a weaker intensity &

larger reverberation time which may be a very serious issue.

3) Shape - It is one of the most important parameter to be considered for acoustically correct hall. The reflections are created due to side walls & roof so while designing the halls care should be taken that no formation of echoes in the hall. In phase of parallel walls, splayed side walls are preferred. Curved surface on walls, ceilings or floors produce concentration of sound into particular region & absence of sound in other regions.

4) Use of absorbents – When the construction of hall is completed. Certain errors are found or the hall requires further corrections as far as acoustics are concerned. Hence use of absorbents is essential & it is very common. Reflection of sound from rear wall is of no use. Hence it must be covered with absorbents, also ceiling is covered with absorbents. If the hall height is more then false ceiling is provided in the hall to solve the problem effectively.

5) Reverberation – Reverberation time must be maintained in such a that it does not to short or too long i.e. 0.5 sec. for hall 1.2 sec. for concerts hall & 2 sec. for cinema hall. Proper use of absorbent material, capacity of the audience, presence of open windows furniture, these are the important components which affects the Reverberation time. So before designing any hall the calculated use of such components will be helpful to either increase of decrease the Reverberation time.

6) Echelon Effect – [6] If in the auditorium set of railings, staircase or any regular spacing of reflected surface may produce a musical note due to regular succession of echoes of the original sound to listener. This makes the original sound to appear confused. So to avoid this problem either avoid use of such surface or keep them covered with thick carpets.

5. CONCLUSION

The goal of this paper is to show the importance of the acoustics and acoustical treatments at the time of designing the building. The architects or the designers must be well known with the guidelines before designing any building and this produces the useful results . Also to control the noise , the windows and doors of the various rooms should be kept away from the main traffic . Instead of increasing the thickness of the brick wall for sound reduction ,the cost of structure may increases , to overcome that problem the porous and flexible material if used it will reduce the thickness of the wall. The double glazing windows improves the sound insulation to a considerable degree.

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