Environmental Engineering

Lec.4 Noise Pollution 4th year

Sound Insulation

**Airborne Sound**: Sound or noise radiated directly from a source, such as a loudspeaker or machine, into the surrounding air.

**Structure-borne Sound**: Sound which reaches the receiver after travelling from the source via a building or machine structure; structure-borne sound travels very efficiently in building, and is more difficult to predict than airborne sound.

**Sound Insulation**: The reduction or attenuation of airborne sound by a solid partition between source and receiver; this may be a building partition (e.g. a floor, wall or ceiling), a screen or barrier or an acoustic enclosure.

**4.1 Sound insulation by partitions**

Sound can be transmitted into a room by some or all of the methods shown in Fig.1

1. Airborne sound in the source room excites the separating partition into vibration which directly radiates the sound into the receiving room. The amount of attenuation will depend upon the frequency of sound, the mass, fixing conditions and thus the resonant frequencies of the partition.
2. Airborne sound in the source room may excite walls other than the separating one into vibration. The energy is then transmitted through the structure and re-radiated by some other partition into the receiving room.
3. Any wall other than the separating one may be excited. The sound is transmitted to the separating wall and the re-radiated by it.
4. Sound energy from the separating partition is radiated into the receiving room by some other wall.

Source Room

Receiving Room

(1)

(2)

(3)

(4)

 Fig.1

**4.2 Sound insulation by composite partitions**

The sound reduction of a partition measured in dB will depend upon the proportion of sound energy transmitted.

 Where t= is the transmission coefficient (the ratio of sound energy transmitted by a partition, or across a boundary, to the sound energy incident upon the partition or the boundary,

where ω= angular velocity (radians/sec) = 2πf

 m= mass of the partition /unit area

 When calculating the sound insulation of a partition consisting of more than one part ( e.g. a 115 mm brick wall with a door) it is first necessary to find the transmission coefficient of each. From this, the average transmission coefficient may be calculated using this formula:

tav × S= t1×S1+ t2×S2+…..

where tav=average transmission coefficient

 S= total area of the partition, m2

 t1 , t2, ….= transmission coefficients of each section.

 S1 , S2,…= area of each part, m2

**4.3 The sound insulation depend on mass**

 The insulation from a single partition is approximately

Rav= 10+14.5 log m

Where Rav= average sound reduction in dB

 m = mass/ unit area in kg/m2

**4.4 The sound insulation by the use of absorbents**

**Sound absorption:** 1) the process whereby sound energy is converted into heat, leading to a reduction in sound pressure level. 2) the property of a material which allows it to absorb sound energy like the porous materials

 **Sound absorption coefficient**: a measure of the effectiveness of material as sound absorbers, it is the ratio of the sound energy absorbed or transmitted (not reflected) by a surface to the total sound energy incident upon that surface, the value of the coefficient varies from **0** (for very poor absorbers and good reflectors) to **1** (for very good absorbers and poor reflectors).

 **Reverberation time**: the time required for the steady sound pressure level in an enclosed space to decay by 60dB, measured from the moment the sound source is switched off.

The table below indicates [mean sound absorption coefficient](https://www.engineeringtoolbox.com/accoustic-sound-absorption-d_68.html)  - *αm* - and [reverberation time](https://www.engineeringtoolbox.com/reverberation-time-d_724.html) - *t* - for some typical rooms.

| **Room Characteristics** | **Very Soft** | **Soft** | **Normal** | **Hard** | **Very Hard** |
| --- | --- | --- | --- | --- | --- |
| [Reverberation time](https://www.engineeringtoolbox.com/reverberation-time-d_724.html)*- t-* | 0.2 < *t* < 0.25 | 0.4 < *t* < 0.5 | 0.9 < *t* < 1.1 | 1.8 < *t* < 2.2 | 2.5 < *t* < 4.5 |
| Typical Room | Radio and TV studio | RestaurantTheaterLecture hall | OfficeLibraryFlat | HospitalChurch | Large churchFactory |
| [Mean sound absorption coefficient](https://www.engineeringtoolbox.com/accoustic-sound-absorption-d_68.html) - *αm-* | 0.40 | 0.25 | 0.15 | 0.10 | 0.05 |

The [mean sound absorption coefficient](https://www.engineeringtoolbox.com/accoustic-sound-absorption-d_68.html) should be calculated when more accurate values are needed.

Sabine’s formula:

, where V= volume of room in m3, A= absorption area in m2

the improvement that can be achieved by the use of absorbent materials in dB= 10 log (A+a)/A

where A= number of m2 of absorption originally and equal S×*αm*

 a= number of m2 of absorption added

**4.5 Attenuation in ducts**

Noise from ventilator fans or from other rooms can easily be transmitted by means of ducts. By lining the duct with absorbent attenuation per meter, R1, is obtained, given approximately by:

Where P = perimeter of the duct in m

 S= cross-sectional area in m2

 α= absorption coefficient

**4.6 Grill attenuation**

 Reduction of sound at the opening in dependent upon the area of the grille and the total sound absorption within the room.

where A= absorption area in m2

 S= cross-sectional area of the grill in m2