MODULE :03

ACOUSTICS

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Outlines:

- Absorption
- Absorption co-efficient
- Determination of Absorption co-efficient

Absorption

- The property of a surface by which the sound energy is converted into another form of energy.
- Absorption coefficient a= sound energy absorbed by the surface/ total energy incident on the surface
- A unit area of a open window transmits all the sound it absorbs.
- unit for measuring “a” is OPW or Sabine.
- Ex: curtains, sofas, carpets, wools, foam etc

13.13 SOUND ABSORPTION COEFFICIENT

A portion of the sound which is incident on a wall is reflected, a portion is absorbed (transformed into heat) and the remaining portion is transmitted through the wall to the other side as shown in Fig. 13.18. Different surfaces absorb sound to different extents. Absorption coefficient, α describes the effectiveness of a surface in absorbing sound energy.

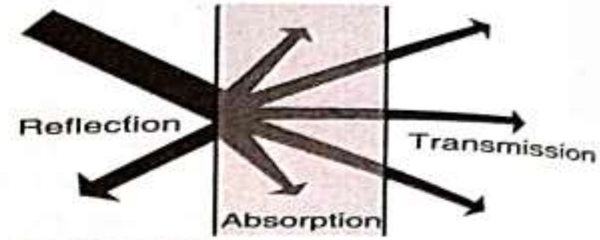

Fig. 13.18: Sound Absorption.

Def: Coefficient of absorption of a material is the ratio of sound energy absorbed by its surface to that of the total sound energy incident on the surface.

$$\text{Coefficient of absorption,} \quad \alpha = \frac{\text{Sound energy absorbed by the surface}}{\text{Total sound energy incident on the surface}} \quad ...(13.14)$$

In order to compare the relative efficiency of different absorbing surfaces, it is essential to select a standard in terms of which all surfaces can be described. A unit area of open window is selected as the standard, *ideal absorber of sound*. The entire sound incident on an open window is fully transmitted and none is reflected.

The unit of absorption is the open window unit (O.W.U.), ***sabin*** termed after the scientist who established it. Table 13.3 lists the absorption coefficients of various materials.

Def: Open window unit (O.W.U.) is $1 m^2$ sabin amount of sound absorbed by one square metre area of fully open window.

Table 13.3: *Absorption coefficients of some materials*

Material	Absorption coefficient per m^2 at 500 Hz
Open window	1.00
Ventilators	0.10 to 0.50
Stage curtain	0.20
Curtains in heavy folds	0.40 to 0.75
Carpet	0.40
Audience (One adult in upholstered seat)	0.46
Fibrous plaster, Straw board	0.30
Perforated compressed fibre board	0.55
Wood-wool board	0.20
Concrete	0.17
Marble	0.01

The value of absorption coefficient of a material depends on its nature and the frequency of sound. The greater the frequency the larger is the value of 'α' for the same material. Therefore, the values of 'α' for a material are determined for a wide range of frequencies. Generally, value of α at 500 Hz is used in acoustic designs.

√ If a material has the value of "α" as 0.5, it means that 50% of the incident sound energy will be absorbed per unit area. If the material has a surface area of $S\ m^2$, then the total absorption provided by that material is

$$a = \alpha \cdot S \quad \text{sabins} \qquad \text{...(13.15)}$$

If there are different materials in a hall, then the total sound absorption by the different materials is given by

$$A = a_1 + a_2 + a_3 + \ldots\ldots$$

$$A = \alpha_1 S_1 + \alpha_2 S_2 + \alpha_3 S_3 + \ldots\ldots \qquad \text{...(13.16)}$$

or

$$A = \sum_{1}^{n} \alpha_n S_n \qquad \text{...(13.17)}$$

where $\alpha_1, \alpha_2, \alpha_3$........ are absorption coefficients of materials with areas S_1, S_2, S_3,..... √

13.14 DETERMINATION OF ABSORPTION COEFFICIENT

There are two methods which are used for the measurement of absorption coefficients of acoustic materials.

Method 1: One of the methods is based on the determination of reverberation times of a room without any material and with the material under test. If T_1 is the reverberation time of in the empty room, then

$$T_1 = \frac{0.161\,V}{\sum_{1}^{n} a_n S_n} = \frac{0.161\,V}{A} \quad \text{(See Eq. 13.24)}$$

where $A = \Sigma\alpha_n S_n$ denotes the absorption due to the walls, flooring and ceiling of the empty room.

Then a certain amount of absorbing material of area S and absorption coefficient α' is added in the room and again the reverberation time is measured. Let it be T_2.

$$T_2 = \frac{0.161\,V}{A + a'S}$$

Then

$$\frac{1}{T_2} - \frac{1}{T_1} = \frac{\alpha' S}{0.161\,V}$$

$$\therefore \quad \alpha' = \frac{0.161\,V}{S}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] \qquad \text{...(13.18)}$$

Knowing the quantities on the right hand side of the Eq. (13.18) the absorption coefficient α' of the material under test can be calculated.

Method 2: The above method cannot be used if the absorbing material is already fixed to the walls and ceiling in the room. The method adopted for such cases, consists in finding the reverberation times for two sources of differing emitting powers.

Let the powers of the two sources be P_1 and P_2 respectively. The steady state energy densities of the sources will be

$$E_1 = \frac{4P_1}{vA} \text{ and } E_2 = \frac{4P_2}{vA}$$

Let T_1 and T_2 be the respective times of decay of energy density to the inaudibility level E_o. Then,

$$E_o = \frac{4P_1}{\upsilon A} e^{-\alpha T_1}$$

and
$$E_o = \frac{4P_2}{\upsilon A} e^{-\alpha T_2}$$

or
$$\frac{P_2}{P_1} = e^{\alpha(T_2 - T_1)}$$

$\therefore$
$$\alpha = \frac{\log_e P_2 - \log_e P_1}{(T_2 - T_2)}$$

But
$$\alpha = \frac{\upsilon A}{4V} \quad \therefore \quad \frac{\log_e P_2 - \log_e P_1}{(T_2 - T_1)} = \frac{\upsilon A}{4V}$$

$$A = \frac{4V \log_e (P_2/P_1)}{\upsilon (T_2 - T_1)}$$

$$\alpha S = \frac{4V \log_e (P_2/P_1)}{\upsilon (T_2 - T_1)}$$

$$\alpha = \frac{4V \log_e (P_2/P_1)}{\upsilon S (T_2 - T_1)} \quad ...(13.19)$$

Knowing the quantities on the right hand side of the above equation, we can calculate the absorption coefficient of the material fixed in the room.

Thanks