MODULE :03

ACOUSTICS

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Outlines:

- Numerical discussion on Acoustics

Example 13.1: *Find the total absorption in a hall with a volume of 5000 m^3 for reverberation time of 1.5 s.*

Solution:

$$T = \frac{0.161V}{\sum \alpha S}$$

$$\therefore \quad \sum \alpha S = \frac{0.161 \times 5000\ \text{m}^3}{1.5\text{s}} = 537\ \text{O.W.U.m}^2$$

Example 13.2: *If the reverberation time for an empty hall is 1.5 s and it is found to be 1 s when a curtain cloth of 20 m^2 is suspended at the center of the hall for the dimensions of the hall 10 × 8 × 6 m^3, find the coefficient of absorption of curtain cloth.*

Solution: Absorption of empty hall

$$= \frac{0.161(10 \times 8 \times 6)\text{m}^3}{1.5\text{s}} = 51.52$$

Reverberation time of the hall with curtain is

$$1\text{s} = \frac{0.161(10 \times 8 \times 6)}{51.52 + \alpha(2 \times 20)}$$

The factor 2 in the denominator takes into account the two sides of the curtain.

∴ The coefficient of absorption of curtain cloth

$$\alpha = \frac{77.28 - 51.52}{40} = 0.64$$

Example 13.3: *For a hall has a volume of 1200 m^3 and total absorption of 480 m^2 of open window, find the effect on the reverberation time if audience fill the hall with additional absorption of 480 m^2 of open window?*

Solution: Reverberation time

$$T_1 = \frac{0.161V}{\sum \alpha S} = \frac{0.161 \times 1200\ \text{m}^3}{480\ \text{m}^3} = 0.40\ \text{s}$$

When the audience are present in the hall, the reverberation time is

$$T_2 = \frac{0.161V}{\sum \alpha S} = \frac{0.161 \times 1200\ \text{m}^3}{(480+480)\text{m}^3} = 0.20\ \text{s}.$$

Example 13.4: *A classroom has dimensions 20 × 15 × 5 m^3. The reverberation time is 3.5 sec. Calculate the total absorption of is surfaces and the average absorption coefficient.*

Solution:

$$T = 3.5 = \frac{0.161V}{\sum \alpha S}$$

$$\sum \alpha S = \frac{0.161\,(20 \times 15 \times 5)\text{m}^3}{3.5\ \text{s}} = 69$$

$$\therefore \quad \alpha_{\text{average}} = \frac{69}{2(20 \times 15 + 15 \times 5 + 5 \times 20)} = \frac{69}{950} = 0.07$$

Example 13.5: *For an empty assembly hall of size 20 × 15 × 10 m³. The reverberation time is 3.5 s. Calculate the total absorption of its surfaces and the average absorption coefficient.*

Solution:

$$T = 3.5 = \frac{0.161\,V}{\Sigma \alpha . S}$$

$$\Sigma \alpha S = \frac{0.161\,(20 \times 15 \times 5)\ \text{m}^3}{3.5\ s}$$

$$\therefore \quad \alpha_{average} = \frac{69}{2\,(20 \times 15 + 15 \times 5 \times 20)} = \frac{69}{950} = 0.07$$

Example 13.6: *Continuing the example 13.2, find area of the wall should be covered by the curtain so as to reduce the reverberation time to 2.5s? Given the absorption coefficient of curtain cloth is 0.5.*

Solution: Total absorption of the empty hall

$$A = \frac{0.161V}{T_1}$$

$$= \frac{0.161(20 \times 15 \times 5)}{3.5} = 69 \qquad \ldots(i)$$

Average absorption coefficient

$$a_{av} = \frac{69}{2(20 \times 15 + 15 \times 5 + 5 \times 20)} = 0.07$$

When the walls are covered with curtain cloth of surface area S_1, the reverberation time T_2 becomes

$$T_2 = \frac{0.161\,V}{A + a_m S_1 - a_{av} S_1} \qquad \ldots(ii)$$

where a_m is the absorption coefficient of curtain cloth.

Using (*i*) and (*ii*), we get

$$(a_m - a) = \frac{0.161\,V}{S_1}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

or

$$S_1 = \frac{0.161\,V}{(a_m - a)}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

$$= \frac{0.161(20\times15\times5)\text{m}^3}{0.5-0.07}\left[\frac{1}{3.5}-\frac{1}{2.5}\right]$$

The area of the wall to be covered with curtain

$$S_1 = 140\ \text{m}^2$$

Example 13.7: *A hall of volume of 2265 m^3 with total absorption of 92.9 m^2 of open window. Calculate the effect on reverberation time if an audience fills the hall and the absorption increases by another 92.9 m^2 ?*

Solution: Reverberation time, $T = \dfrac{0.161V}{\sum \alpha S}$

Initial reverberation time, $T_i = \dfrac{0.161\times2265\ \text{m}^3}{92.9\ \text{m}^2} = 3.9\ \text{s.}$

With the audience of the total absorption

$$= 92.9\ \text{m}^2 + 92.9\ \text{m}^2 = 185.8\ \text{m}^2.$$

Final reverberation time $T_f = \dfrac{0.161\times2265\ \text{m}^3}{185.8\ \text{m}^2} = 1.95\ \text{s.}$

Thanks