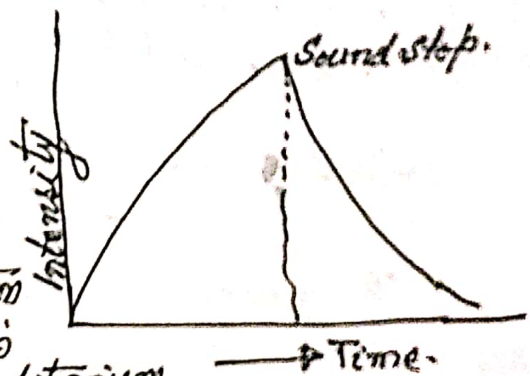
§ 8.10:- Acoustics of Building

According to the Sabine a hall is good for speech and music which have.
(i) The sound heard must be loud in every point of the hall.
(2) The syllable must not ~~contake~~ overlap.
(3) There should be no echoes; ~~to fulfill the de~~

To fulfill the above demands the following conditions are to be secured.

(a) Optimum Reverberation:- when a contineous sound is sounded in a hall it take time to reach its max$^m$ intensities due to reflection and refraction from the object and wall of the ~~hall~~ Hall. Similarly as the sound is stopped, the energy takes some time to reach its min$^m$ audibility. This dying sound is k/a Reverbration. The dying time of sound is k/a Reverbration time. According to Sabine this reverbration time for good auditorium




$$\boxed{T = \frac{0.16V}{A}}$$

Where, V = Volume of hall, A = Total absorption of the sound

(b) Adiquate Loudness:- This can be achived by placing large woodent board near and behind the speeker.

(c) Uniform distribution:- For uniform distribution of the sound the hall should not have curved surface because they focie the sound at some places loudly. A parabolic cuttering is helpfull for this purpose.

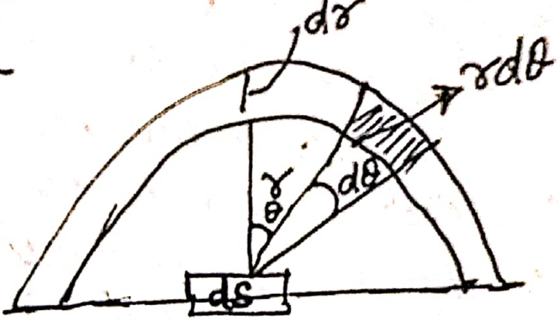
(d) Absence of echelon effect:-
The echelon effect is minimise by using Hair carpet

SABINE'S FORMULA :- Growth and decay of Sound.

Assumptions (1) The distribution of energy is same throughout the room.

(2) There is no interferance between sound wave

(3) The absorption coefficient of the surface is independent of sound intensity.




Let us consider an element ds at a plane of the wall. Let us consider two sphere of radii r and r+dr.

Let us consider a small area $rd\theta \cdot dr$ between the sphere. If the whole figure is rotated by and angle $d\phi$ such that it travels a volume.

$$V = r^2 \sin\theta \, d\theta \, dr \, d\phi.$$

The sound energy in unit solid angle

$$= \frac{E}{4\pi} r^2 \sin\theta \, d\theta \, dr \, d\phi.$$

The energy in solid angle $\frac{ds\cos\theta}{r^2}$

$$= \frac{E}{4\pi} r^2 \sin\theta \, d\theta \, dr \, d\phi \, \frac{ds\cos\theta}{r^2}$$

$$= \frac{E\,ds}{4\pi} \sin\theta\cos\theta \, d\theta \, dr \, d\phi.$$

The energy received by ds in one second.

$$= \frac{E\,ds}{4\pi} \int_0^{\pi/2} \sin\theta\cos\theta \, d\theta \int_0^{V} dr \int_0^{2\pi} d\phi.$$

$$= \frac{E\,ds}{4\pi} \frac{1}{2} \cdot V \cdot 2\pi$$

$$= \frac{E\,ds\,V}{4}$$

If "$\alpha$" is the absorption coefficient of ds then. energy absorbed per second

$$= \frac{E V ds}{4} \text{"}\alpha\text{"}$$

The total energy absorbed by the room per second.

$$= \frac{1}{4} E V \sum a\,ds$$

$$= \frac{1}{4} E V A$$

The rate of energy supply by the source is equal to the sum of rate of energy growth in space and rate of energy absorption by the Hall.

$$P = V \cdot \frac{dE}{dt} + \frac{1}{4} E \cdot AV$$

or, $\frac{dE}{dt} + \alpha E = \frac{4P}{VA}\alpha$

or, $\left(\frac{dE}{dt} + \alpha E\right)e^{\alpha t} = \frac{4P}{VA}\alpha e^{\alpha t}$ or $\frac{d}{dt}\left[E e^{\alpha t}\right] = \frac{4P}{VA}\alpha e^{\alpha t}$

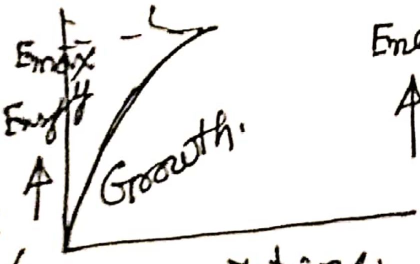
Integrating we get; $E e^{\alpha t} = \frac{4P}{VA} + C$ ——— (A)

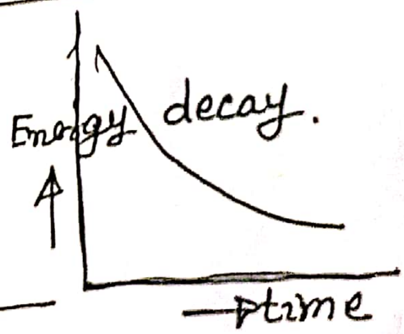
(i) At $t = 0$, $E_0 = 0 \Rightarrow C = -\frac{4P}{VA}$

$\therefore E = \frac{4P}{VA}(1 - e^{-\alpha t}) = E_{max}(1 - e^{-\alpha t})$ ——— (B)

(ii) If source is cut off $P = 0$ at $t = 0$ and $c = E_{max}$ ——— (C)

$\therefore E e^{\alpha t} = E_{max}$




According to Sabine the reverbation time T, is the time during which the steady energy density falls to $10^{-6}$ of it max value.

or, $\frac{E}{E_{max}} = 10^{-6} \Rightarrow 10^{-6} = e^{-\alpha t}$

$\Rightarrow \alpha T = \log_e 10^6 = 6 \log_{10}$

$$T = \frac{6 \times 2.303}{\alpha}$$

$$= \frac{6 \times 2.303 \times 4V}{v A}$$

$$= \frac{6 \times 2.303 \times 4V}{330 \cdot A}$$

$$\therefore \boxed{T = \frac{0.16 V}{A}}$$

Scanned with CamScanner