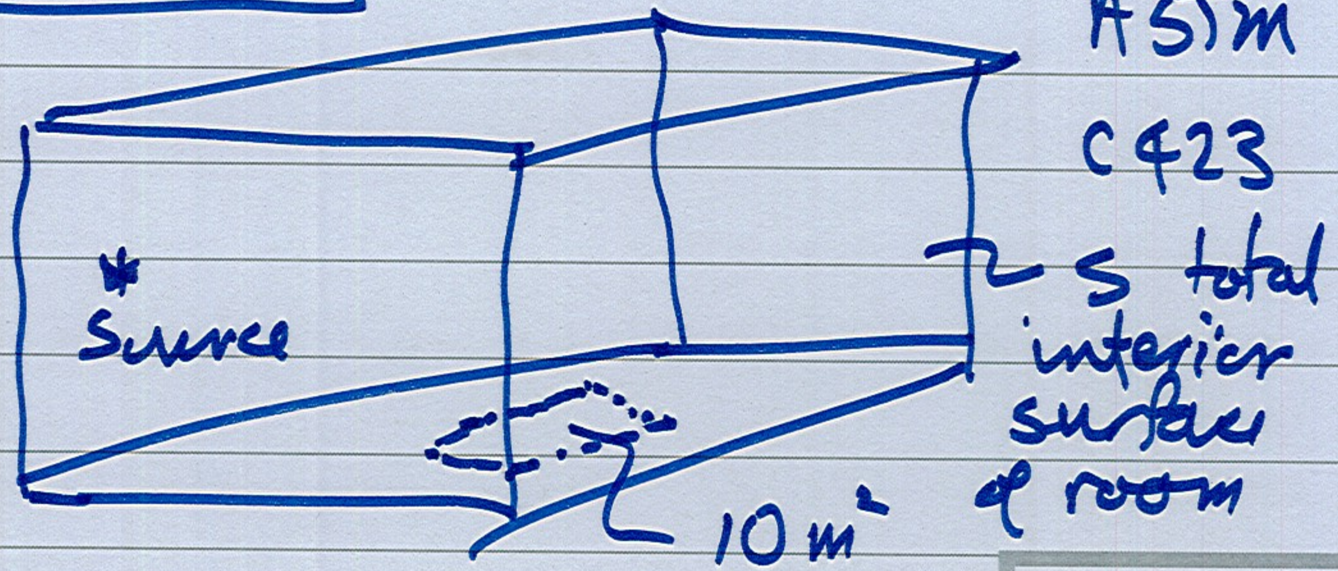
Room Acoustics

- Energy Acoustics
  - transient - response
- Reverberation Time

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

Measure Absorption in a Reverberation Room

ASTM C423



(i) Measure the rev time of the empty chamber

$$T_0 = 0.161 \frac{V}{S\bar{a}_0}$$

$\bar{a}_0$ ~ average abs coeff of bare walls

2 – Measure the rev time with the sample in place

Sample area S_e

Total Absorption

$$(S - S_e)\bar{a}_0 + S_e \bar{a}_e$$

Assume bare walls + surface are all the same

$$T_e = 0.161 \frac{V}{(S - S_e)\bar{a}_0 + S_e \bar{a}_e}$$

$$a_e = 0.161 \frac{V}{S_e T_e} - \frac{(S - S_e)}{S_e} \bar{a}_0$$

$$\bar{a}_0 = \frac{0.161 V}{S T_0}$$

$$a_e = \bar{a}_0 + 0.161 \frac{V}{S_e} \left(\frac{1}{T_e} - \frac{1}{T_0} \right)$$

T_e: sample in place

T_0: empty room

a_e = Sabine absorption coefficient
(random incidence absorption coefficient)

a_e is tabulated for many materials — Table
Table 12.5.1

function of frequency

use a_e's in combination
with source sound powers
to establish steady-state
sound levels in a space

- development of rev time formula has ignored air absorption

As a plane wave travels in air

$P \propto P_0 e^{-\alpha x}$ exponential decay with distance

$x = ct$

$$P_r^2(t) \simeq P_r^2(0)\, e^{-2\alpha c t}$$

exponential decay with time

$$2\alpha = m$$

Provides addition abs.

Decay

$$P_r^2(t) = P_r^2(0)\, e^{-\left[\frac{A}{4V} + m\right] ct}$$

Rev time

$$T = \frac{0.161\, V}{A + 4mV}$$

$20 \le h \le 70$

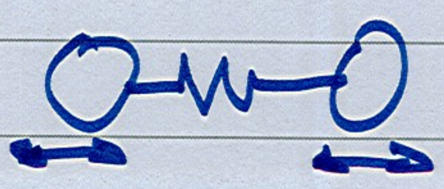
$$m = 5.5 \times 10^{-4} \left(\frac{50}{h}\right)\left(\frac{f}{1000}\right)^{1.7}$$

h= relative humidity in percent

m   air absorption coefficient

- classical
  - viscous effects
  - thermal effects
    - heat conduction
- molecular abs process

O_2



N_2

m = increases with frequency

- air absorption can be neglected at low frequencies (depending on propagation distance)
    - neglect in small spaces

Air absorption can control the rev time at 4 kHz and above

Rev Time formula

- works for spaces with relativly low absorption

  $\bar{a}$ is relatively small

when the abs is high &
when spaces are non-proportional

Norris - Eyring

Millington - Sette

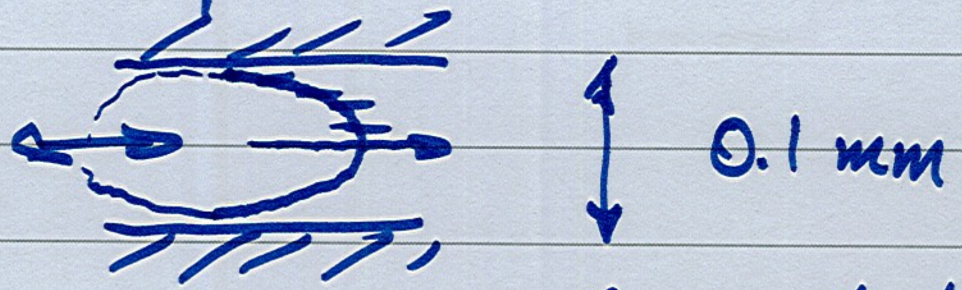
6.5 Absorbing Material

Acoustic Environment can be controlled by adding or removing absorbing elements

4 major types of absorbent

(i) Porous Materials — Thinsulate™
- acoustic tiles, glass fiber, foams, curtains, carpets

- sound - produces oscillatory flow in pores within the material



- viscothermal dissipation of energy

Absorption increases with freq