MR 513 Session 48 12/9/15

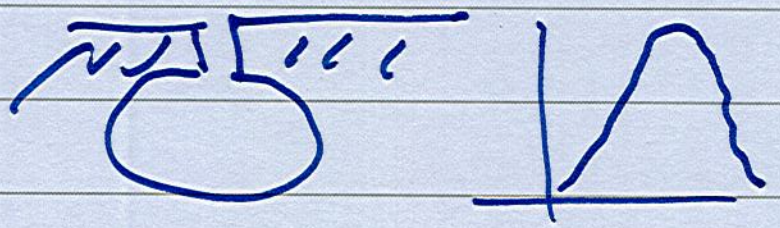
Air Absorption

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

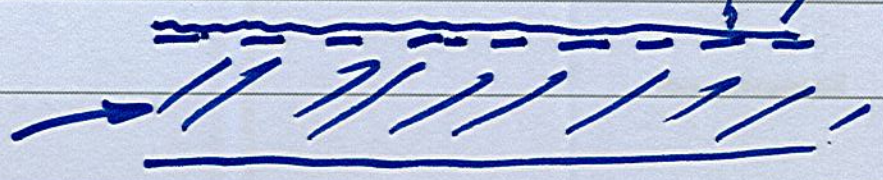
$4mV$: f^2

Absorbing Material

- porous
- panel
- cavity

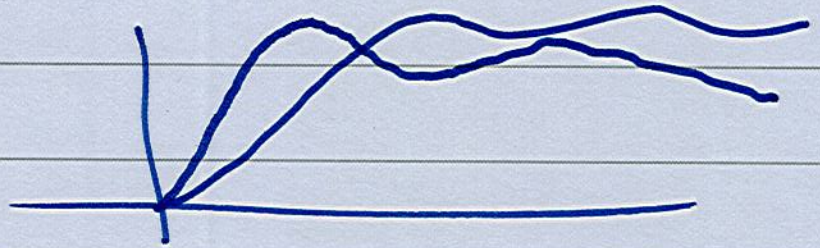


perforated panels



permeable fabric - decorative O(cm) treatment

Porous layer



often used in concert halls to prevent flutter echo.

(iv) People & Furniture

- objects absorb sound

- for various objects - calculate a total absorption area

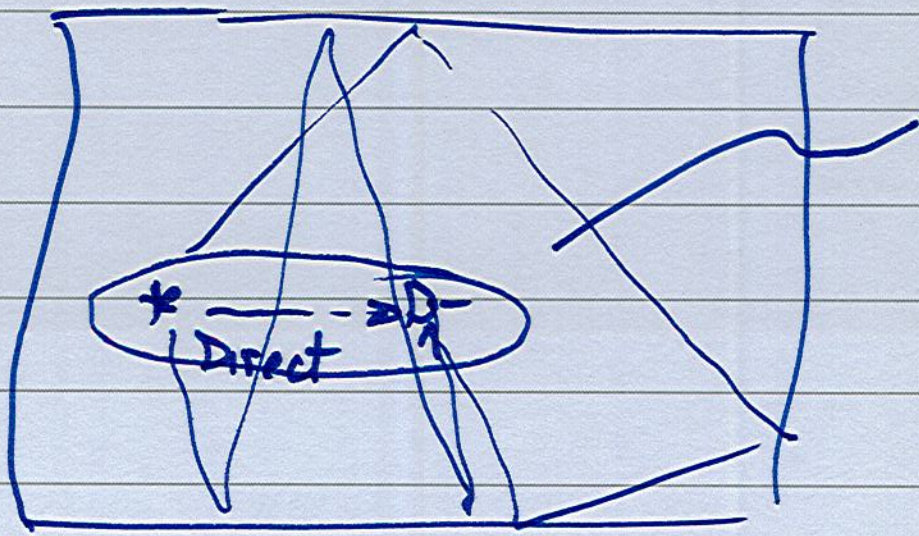
e.g. 1 person $1\ m^2$ absorption area at 1 kHz.

Total Absorption in a space

$$\underline{\underline{A}} = \underbrace{\sum_i S_i \bar{\alpha}_i}_{\text{surface absorption}} + \underbrace{\sum_i A_i}_{\text{absorption areas for individual elements}}$$

6.6. Direct & Reverberant Sound Fields

- consider the spatial variation of sound due to the direct field



reverberant field

Direct Field - omnidirectional source

Direct MSP

$$p^2_{d_{rms}} = \frac{\rho_0 c \Pi_s}{4\pi r^2}$$

sound radiation from a monopole.

Reverberant MSP

$$p^2_{r_{rms}} = \rho_0 c \Pi_s \frac{4}{A}$$

$$\left(p_{rms}^2\right)_{total} = \rho_0 c \overline{\Pi_s} \left(\frac{1}{4\pi r^2} + \frac{4}{A} \right)$$

↑ direct ↑ reverberant

Assuming
- incoherent addition of direct & reverberant fields

- r is the distance from the source to receiver

Ratio of The Remnberant to Direct MSP's

$$\frac{16\pi r^2}{A}$$

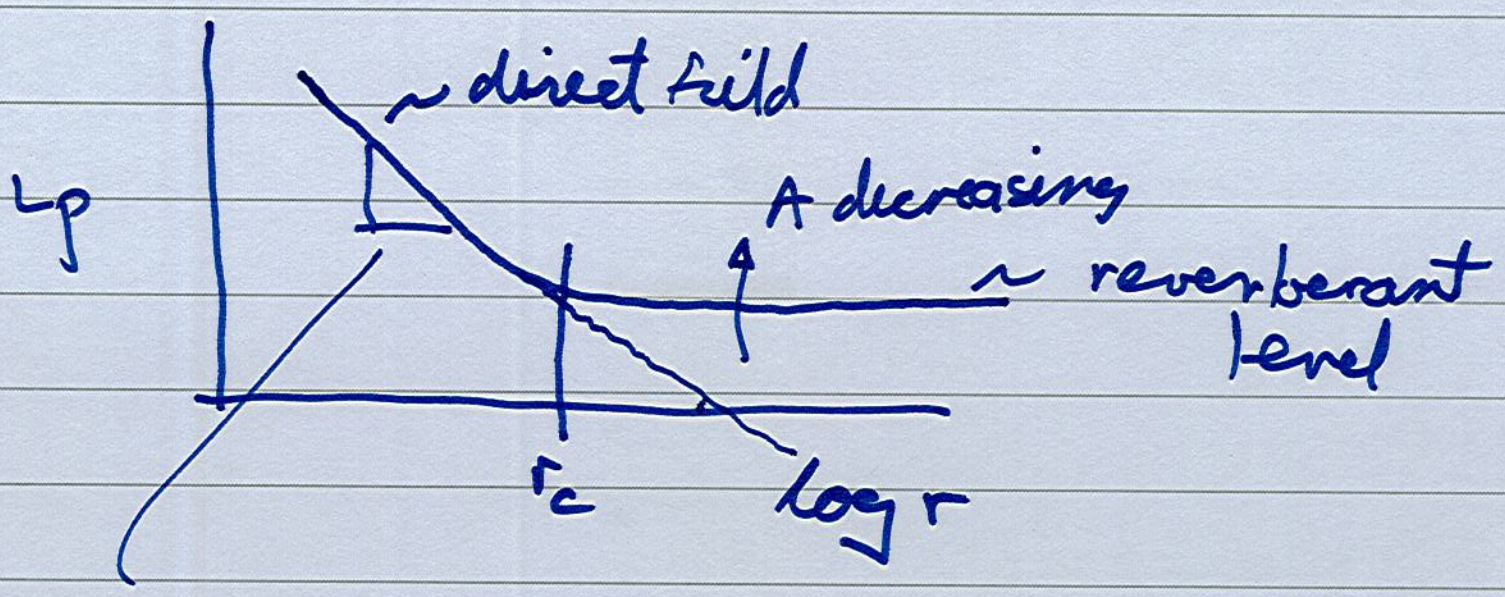
critical radius r_c when

$$\frac{16\pi r_c^2}{A} = 1$$

$$r_c = \sqrt{\frac{A}{16\pi}}$$

r_c - marks the transition from Direct to Reverberant sound fields

- if in direct field
  - no benefit to adding absorption to room surfaces.
- only a benefit when reverberant field dominates



6dB doubling (simple source)

cocktail party effect

Example: large dining area with little absorption

5m x 20m x 40m

$T = 3\ s \rightarrow 0.161 \frac{V}{A}$

$S = 2200\ m^2$ $\quad A = 215\ m^2$

$\bar{a} \simeq 0.1$

100 people (speakers) each one 100 μW sound power.

Reverberant Sound Level

$$10 \log_{10}\left(\frac{\rho c \overline{\Pi_s}}{p_{ref}^2}\frac{4}{A}\right) = 83 \text{ dB re } 20\mu Pa$$

$\overline{\Pi_s}$ ~ $100 \times 100\mu W$

$\simeq$

Direct Level

$$10 \log_{10} \frac{\rho c \overline{\Pi_s}}{4\pi r^2 p_{ref}^2} = 75 \text{ dB re } 20\mu Pa$$

$\overline{\Pi_s}$ ~ single speaker $100\mu W$

$\simeq$

Signal to noise ratio - 8 dB

$\simeq$

SNR = - 8 dB

→ 40 % sentence intelligibility

Try to improve intelligibility by adding abs.

Surface Area = 2200 m^2 currently $\bar{a} = 0.1$

increase $\bar{a} \rightarrow 0.5$

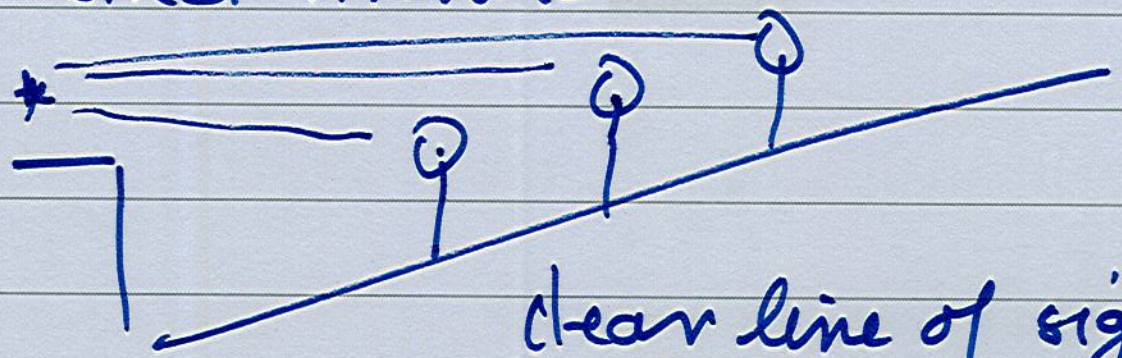
$A \rightarrow 1100\ m^2$

Reverberant level → 76 dB

SNR = - 1 dB → 92 % sentence intelligibility

6.7 Acoustical Factors in ~~Arch~~ Architectural Design

(a) Direct Arrivals



clear line of sight from stage to audience members.

- direct field delivers directional information

(b) Reverberation
- enhance level
- appropriate balance between direct & reverberant fields depending on function of room.

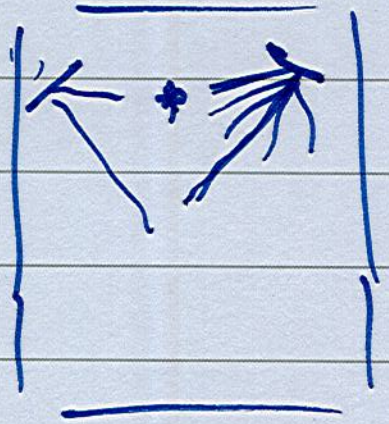
(c) Warmth - balance between low & high freq reverberation

"warm" - low freq rev time > high freq reverberation

d) intimacy - early reflections

10 ms → 100 ms

- should be evenly distributed early reflections
- should come from sides (lateral reflections)

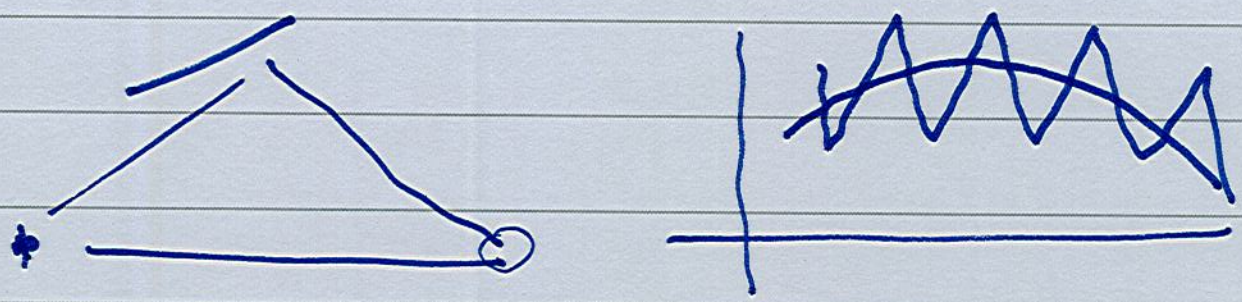


QRD's

Christchurch Town Hall in New Zealand.

- overhead reflections are "bad"

  - cause "discoloration"



harshness due to interference