# PRINSIP AKUSTIK ARSITEKTURAL

SOURCE : MEE

## TEORI BUNYI:

**UMUM:**

**AKUSTIK ARSITEKTURAL : TEKNOLOGI MERANCANG RUANG, STRUKTUR DAN SISTEM MEKANIKAL UNTUK MEMENUHI KEBUTUHAN PENDENGARAN…. BUNYI YG DIINGINKAN DPT DIDENGAR DGN JELAS… BUNYI YG TDK DIINGINKAN/BISING DPT DIHILANGKAN / DIKURANGI**

**STRUKTUR RINGAN PD UMUMNYA MENTRANSMIS BUNYI LEBIH BESAR DARIPADA STRUKTUR BERAT**

# DEFINISI DAN TERJADINYA BUNYI

**BUNYI ADALAH SUATU GELOMBANG FISIK ATAU SUATU GETARAN MEKANIK ATAU SECARA SEDERHANA, SUATU SERI VARIASI TEKANAN PADA SEBUAH MEDIUM ELASTIS.**

**UNTUK BUNYI DIRUANG BEBAS MEDIANYA UDARA, UNTUK STRUKTUR MEDIANYA BISA BETON, BAJA, KAYU, KACA ATAU KOMBINASINYA.**

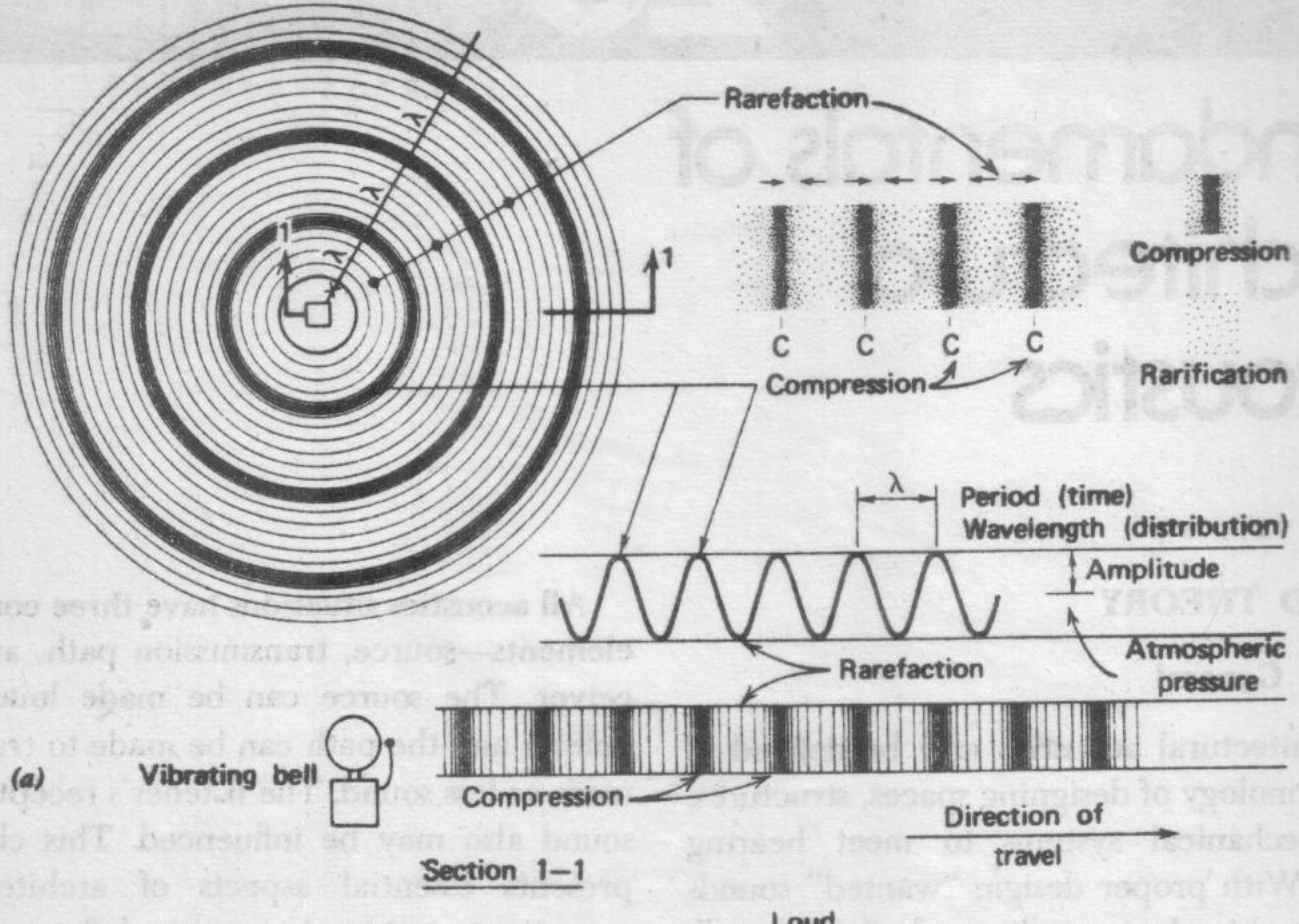
**UNTUK MATERI INI DIBATASI PADA SINYAL YANG DAPAT DIDENGAR (AUDIBLE SIGNAL), TANPA MEMBICARAKAN SUBSONIC DAN SUPERSONIC.. MEMPERHATIKAN PENGHUNI BANGUNAN DAN BUNYI YANG DAPAT DIDETEKSINYA**

**DIASUMSIKAN BUNYI YG DPT DIDETEKSI OLEH PENDENGARAN ANTARA 20 – 20.000 Hz.**

**-→ BUNYI DIPANDANG SEBAGAI VARIASI TEKANAN. DALAM UDARA VARIASI TEKANAN BERBENTUK PEMAMPATAN (KOMPRESI) DAN PENGULURAN (RAREFACTION) SECARA PERIODIK**

**FREKUENSI**

**JUMLAH KEJADIAN SIKLUS KOMPRESI DAN PENJARANGAN DALAM UDARA PADA SATU SATUAN WAKTU ---- 1000 KALI SIKLUS TSB DLM 1 DETIK = 1000 cps [1000 Hz]**


Rarefaction
λ
λ
λ
1
1
Compression
C
C
C
C
Compression
Rarification
λ
Period (time)
Wavelength (distribution)
Amplitude
Atmospheric pressure
Rarefaction
(a)
Vibrating bell
Compression
Direction of travel
Section 1–1
Loud

# KECEPATAN PROPAGASI

BUNYI BERJALAN PADA KECEPATAN YG BERBEDA-BEDA TERGANTUNG PADA MEDIUMNYA. DLM UDARA PD PERMUKAAN LAUT KECEPATAN SUARA 344 m/det.

BUNYI JUGA MERAMBAT PADA STRUKTUR --- KECEPATANNYA PADA MEDIA LAIN (m/det)

KECEPATAN INI BERUBAH DISEBABKAN TEMPERATUR DAN KETINGGIAN (TEKANAN ATMOSFER)

| | |
|---|---|
| UDARA | 344 |
| AIR | 1410 |
| KAYU | 3300 |
| BATA | 3600 |
| BETON | 3700 |
| BAJA | 4900 |
| KACA | 5000 |

# PANJANG GELOMBANG & TIPE PROPAGASI

$\lambda = c / f$

$\lambda$ = PANJANG GELOMBANG (m)

c = KECEPATAN SUARA (m/det)

f = FREKUENSI BUNYI (Hz)

FREKUENSI RENDAH ---- PANJANG GELOMBANG PANJANG

FREKUENSI TINGGI --- PANJANG GELOMBANG PENDEK

# INTENSITAS BUNYI, PROPAGASI MEDAN BEBAS

INTENSITAS BUNYI PADA JARAK TERTENTU DARI SUMBER BUNYI =

$I = P / A$ dimana I = INTENSITAS BUNYI (w/cm$^2$, w/m$^2$)

P = KUAT AKUSTIK (watts)

A = LUAS (cm$^2$ ATAU m$^2$)

BUNYI DIPANCAR SECARA BEBAS KE SEGALA ARAH:

$I = P / 4\pi r^2$ DALAM w/cm$^2$

INTENSITAS PADA JARAK $r_1$ DAN $r_2$ DARI SUMBER =

$I_1 / I_2 = r_2^2 / r_1^2$ ----- (INVERSE SQUARE LAW)

TINGKAT INTENSITAS (INTENSITY LEVEL(IL), db)

LEVEL MENGINDIKASIKAN JUMLAH RELATIF TERHADAP KUANTITAS DASAR

$IL = 10 \log I / Io$ dimana

IL = INTENSITY LEVEL, decibel

I = INTENSITAS, $w / cm^2$

Io = INTENSITAS DASAR, $10^{-16}$ $w/cm^2$, BATAS PENDENGARAN

**SELISIH/BEDA DLM db ANTARA 2 TINGKAT BUNYI DIEKSPRESIKAN :**

$$IL_2 - IL_1 = 10 \log I_2/Io - 10 \log I_1/Io$$

$$= 10 (\log I_2/Io - \log I_1/Io)$$

$$IL = IL_2 - IL_1 = 10 \log I_2/I_1$$

**CONTOH: 2 SUMBER BUNYI MENGHASILKAN TINGKAT INTENSITAS MASING-MASING 50 DAN 60 db, JIKA BERFUNGSI BERSAMAAN BERAPA TKT INTENSITAS TERJADI:**

**CARI $I_1$, $I_2$, JUMLAHKAN $I_1$ & $I_2$, CARI IL KOMBINASI**

**FENOMENA PENDENGARAN**

**TEKANAN SUARA DAN TINGKAT TEKANAN SUARA (SPL)**

**SPL = 10 log $p^2/po^2$ ATAU**

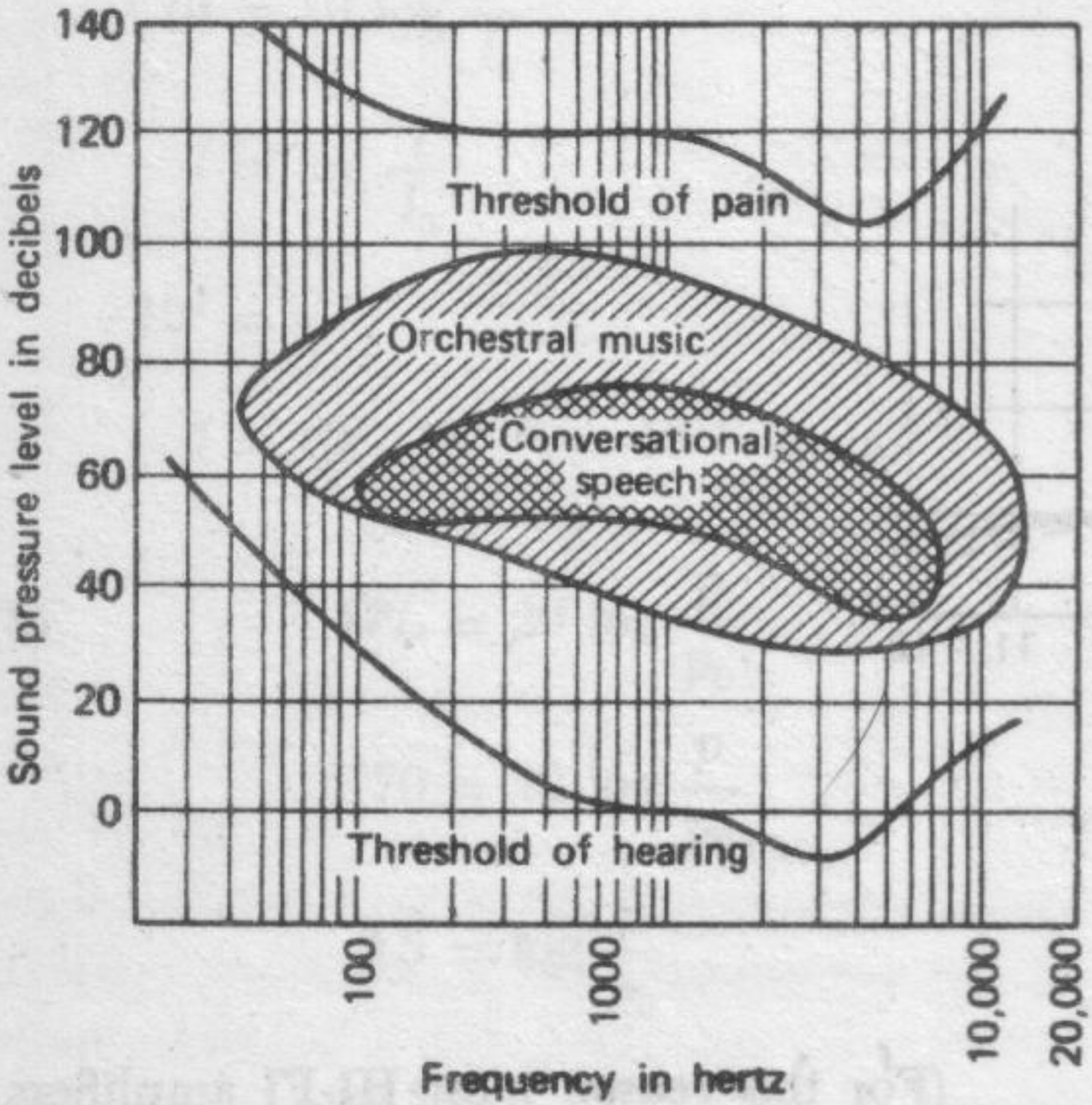
**=20 log p/po**

**SPL = SOUND PRESSURE LEVEL, db**

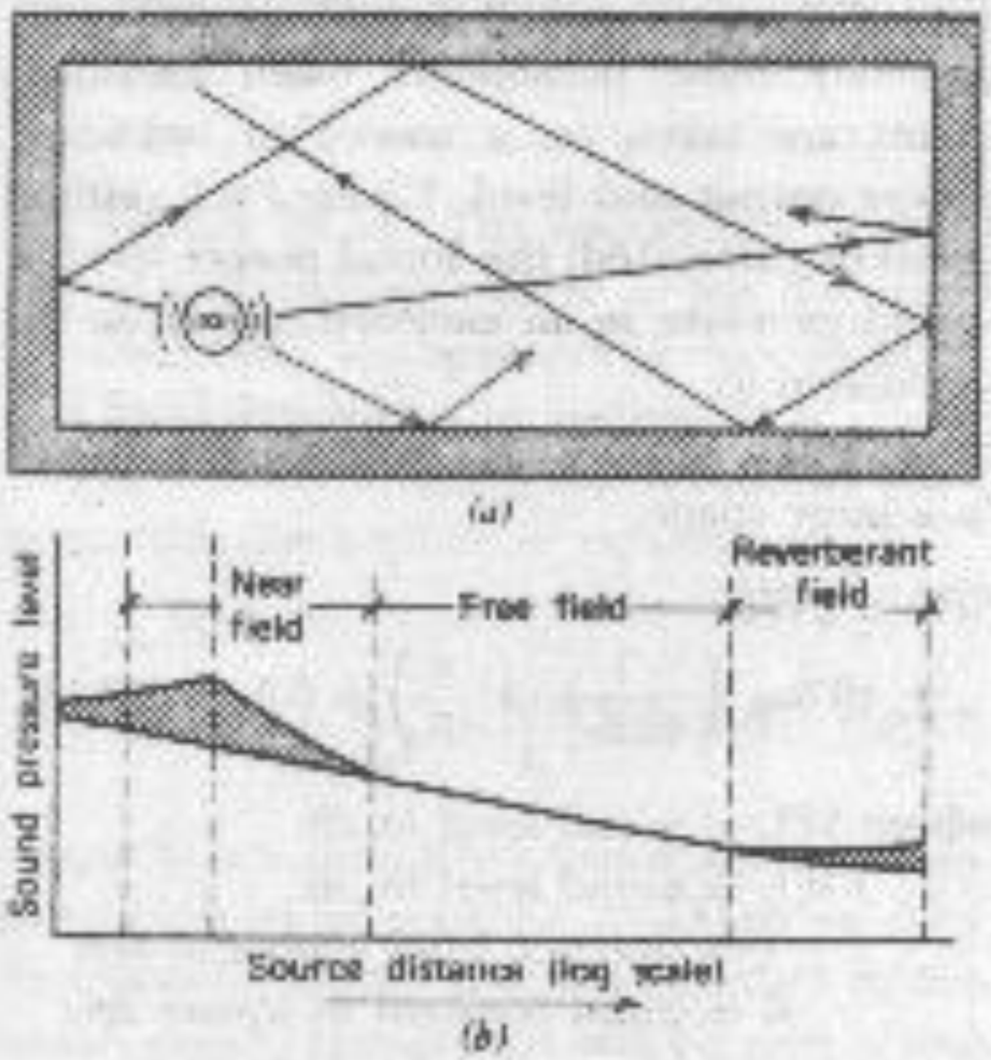
**p = TEKANAN, Pascal ATAU bar**

**Po = TEKANAN REFERENSI , Pascal a/ bar, 2 X $10^{-4}$ µbar**

**LOUDNESS LEVEL, TINGKAT KEKERASAN SUARA**


140
120
100
80
60
40
20
0
Sound pressure level in decibels
Threshold of pain
Orchestral music
Conversational speech
Threshold of hearing
100
1000
10,000
20,000
Frequency in hertz

# MEDAN BUNYI PADA RUANG TERTUTUP



**PWL = 10 log W/Wo**

**PWL=SOUND POWER LEVEL, db**

**W=SOUND POWER OF SOURCE, WATTS**

**Wo=BASE POWER ==$10^{-12}$ w**

# SOUND POWER & PRESSURE LEVELS IN FREE SPACE (OUTDOORS)

SPL = PWL – 20 log r + (Q – 1)

SPL = SOUND PRESSURE LEVEL, db

PWL = EQUIPMENT POWER LEVEL

r = DISTANCE FROM THE SOURCE, IN FEET

Q = DIRECTIVITY FACTOR →

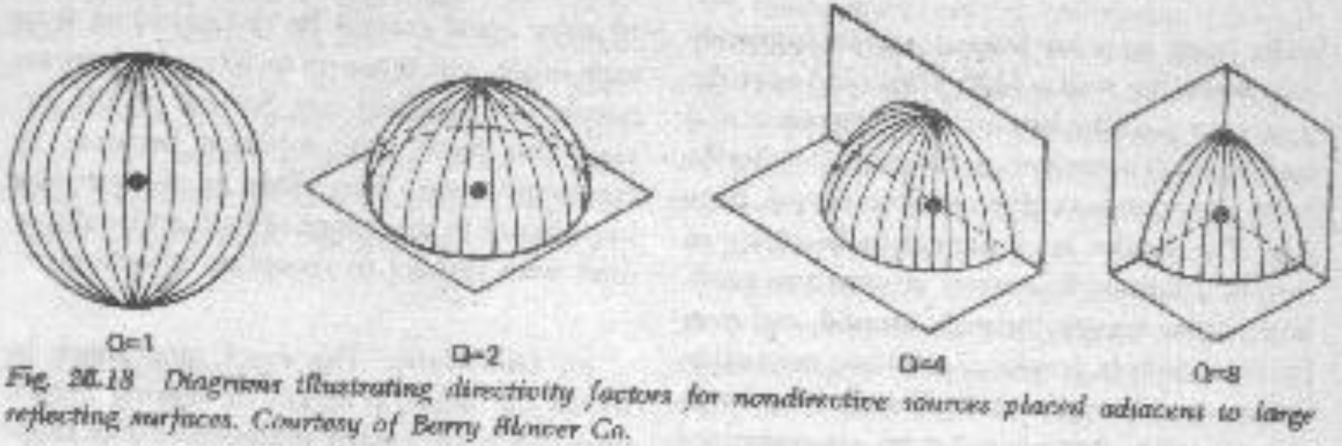


Fig. 26.18 Diagrams illustrating directivity factors for nondirective sources placed adjacent to large reflecting surfaces. Courtesy of Barry Blower Co.

AKUSTIK RUANG

SOUND ABSORPTION

$\alpha = I\alpha / I_i$

$I_i$ = INTENSITY IMPINGING ON THE MATERIAL, $w/cm^2$

$I\alpha$ = INTENSITY ABSORBED BY THE MATERIAL, $w/cm^2$

$\alpha$ = ABSORPTION COEFFICIENT

JIKA $\alpha = 1$, ENERGY DIABSORBSI, PADA OPEN SPACE,

CONTOHNYA $\alpha = 1$ PADA JENDELA TERBUKA

**TOTAL ABSORBSI PADA SUATU PERMUKAAN DIEKSPRESIKAN DALAM SABIN**

**$A = S\alpha$ DIMANA A= TOTAL ABSORPTION, SABINS**

**S = SURFACE AREA, SQUARE FEET**

**$\alpha$ = COEFFICIENT ABSORPTION**

**JIKA TERDIRI DARI BEBERAPA MATERIAL YG BERBEDA $\alpha$-NYA MAKA**

$\Sigma S\alpha = S_1\alpha_1 + S_2\alpha_2 + \ldots + S_n\alpha_n$

# REVERBERASI

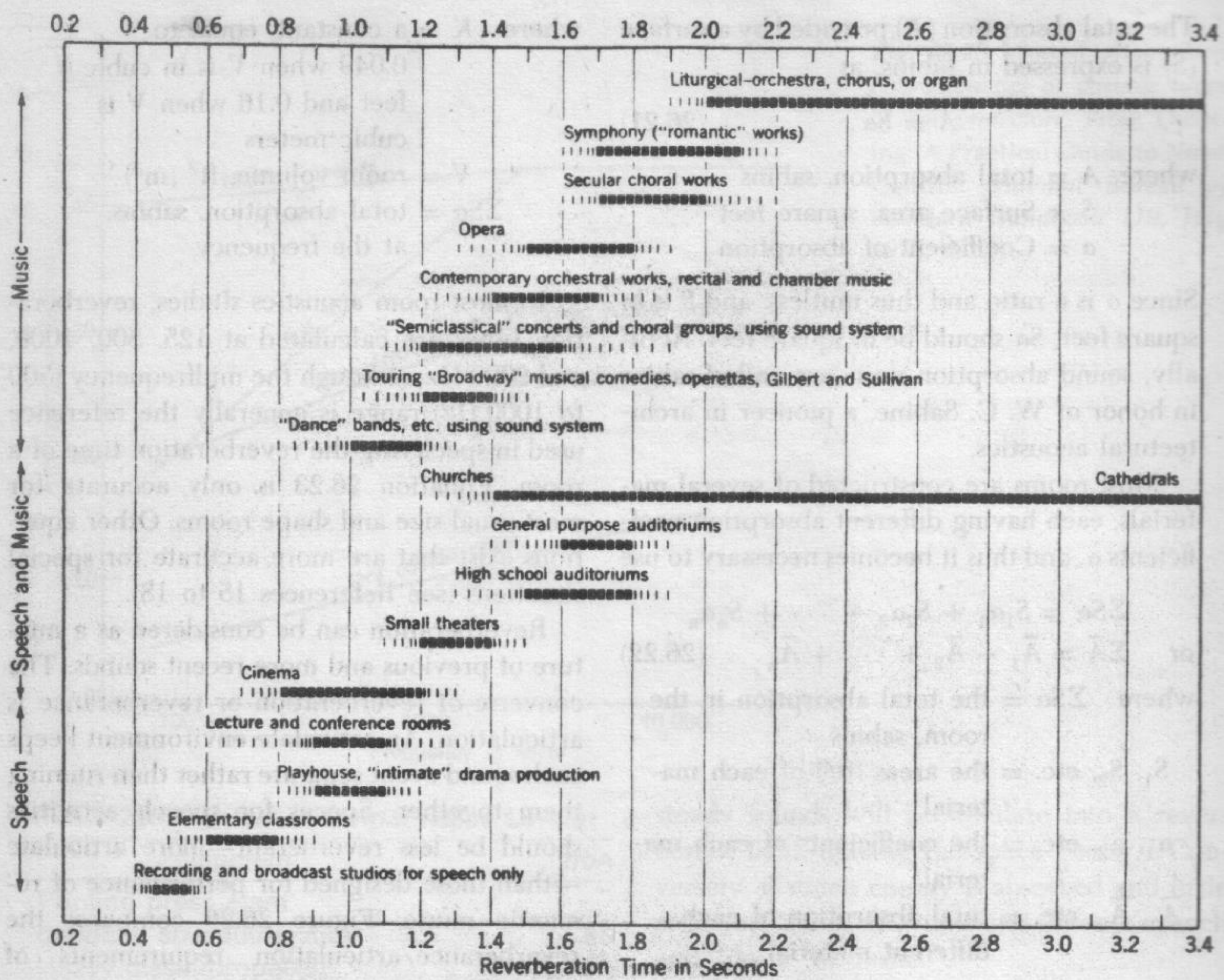
REVERBERASI ADALAH KELANGSUNGAN BUNYI SESUDAH PENYEBAB BUNYI DIHENTIKAN.

WAKTU REVERBERASI (Tg) ADALAH PERIODE YG DIBUTUHKAN UTK MENURUNKAN 60db SOUND LEVEL SESUDAH SUMBER BUNYI BERHENTI BERBUNYI.

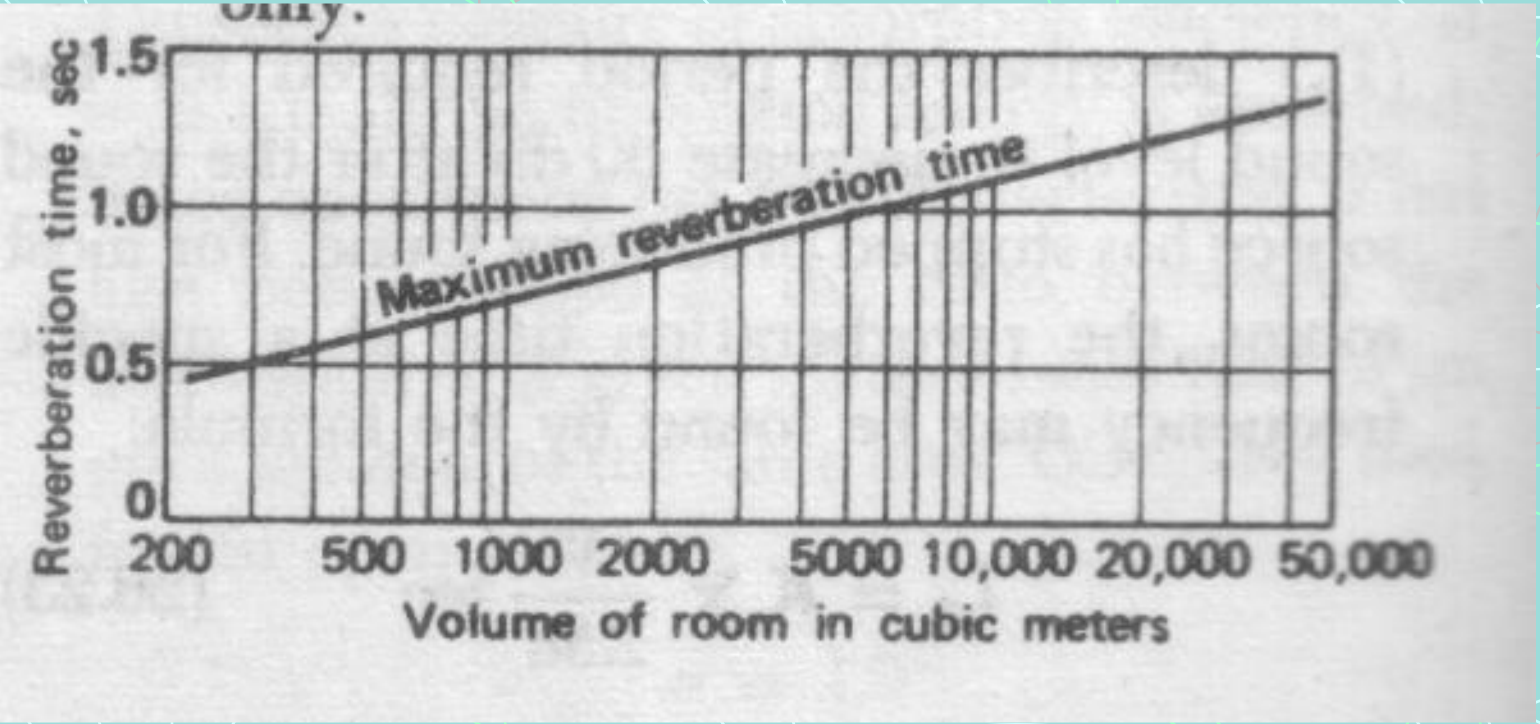
$$Tg = K \times V / \Sigma S \alpha$$

K = KONSTANTA, 0.049 UTK V IN $\text{feet}^3$, 0.16 V IN $m^3$

V = VOLUME RUANG, $\text{feet}^3$ ATAU $m^3$


0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
Music
Speech and Music
Speech
Liturgical–orchestra, chorus, or organ
Symphony ("romantic" works)
Secular choral works
Opera
Contemporary orchestral works, recital and chamber music
"Semiclassical" concerts and choral groups, using sound system
Touring "Broadway" musical comedies, operettas, Gilbert and Sullivan
"Dance" bands, etc. using sound system
Churches
Cathedrals
General purpose auditoriums
High school auditoriums
Small theaters
Cinema
Lecture and conference rooms
Playhouse, "intimate" drama production
Elementary classrooms
Recording and broadcast studios for speech only
Reverberation Time in Seconds

# KRITERIA FOR SPEECH ROOMS



$T = 0.3 \log V/10$ --- T = TIME IN SECONDS

V = ROOM VOLUME IN $m^3$

UTK LECTURE ROOM T = 0.35 – 0.4 DETIK

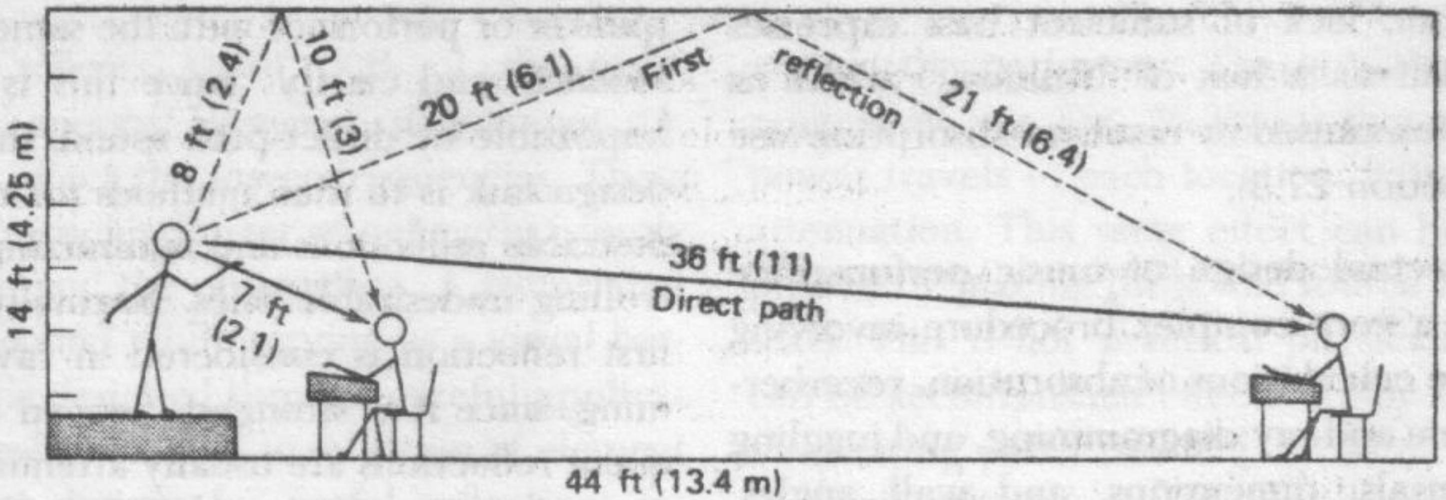
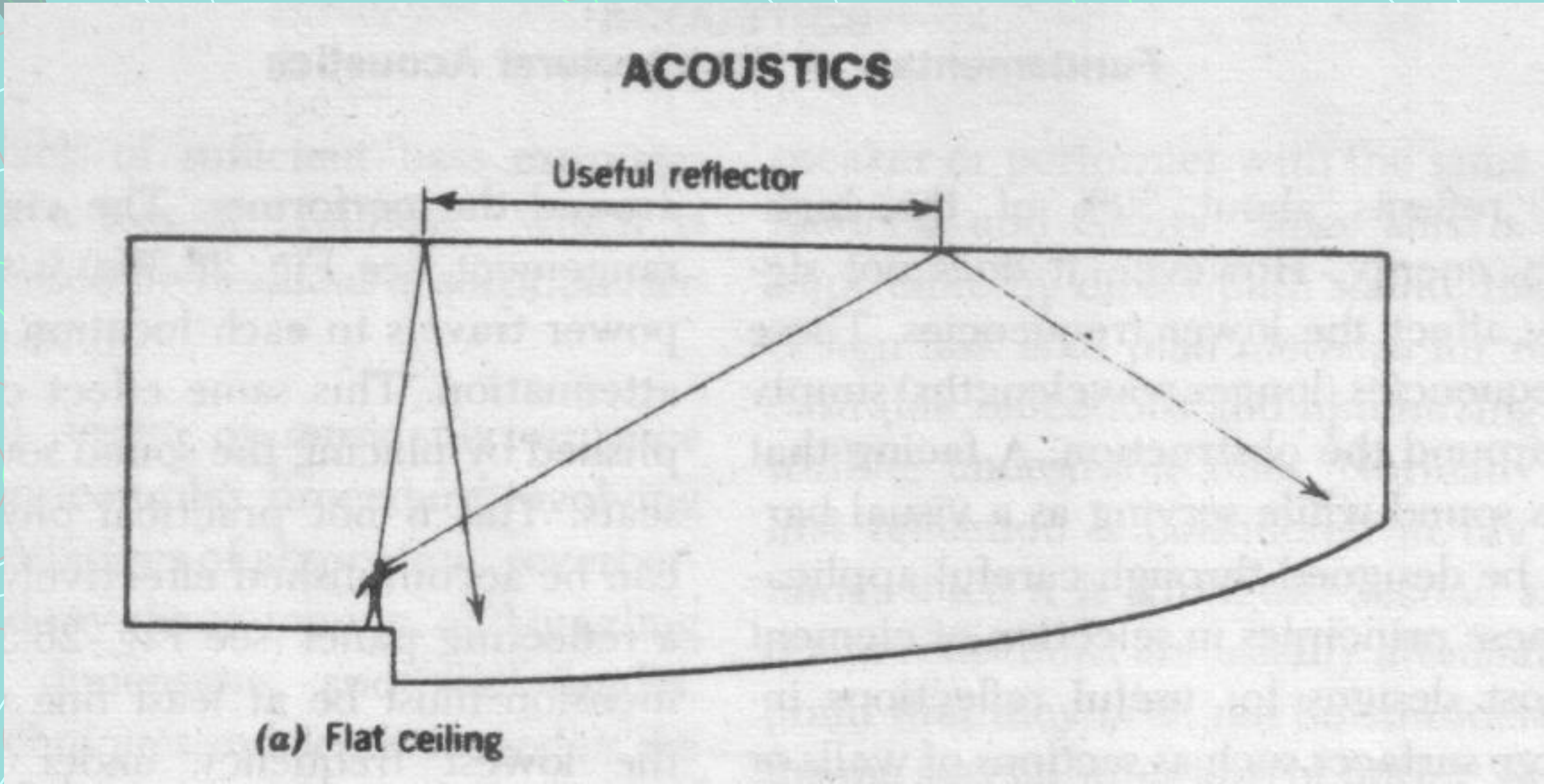


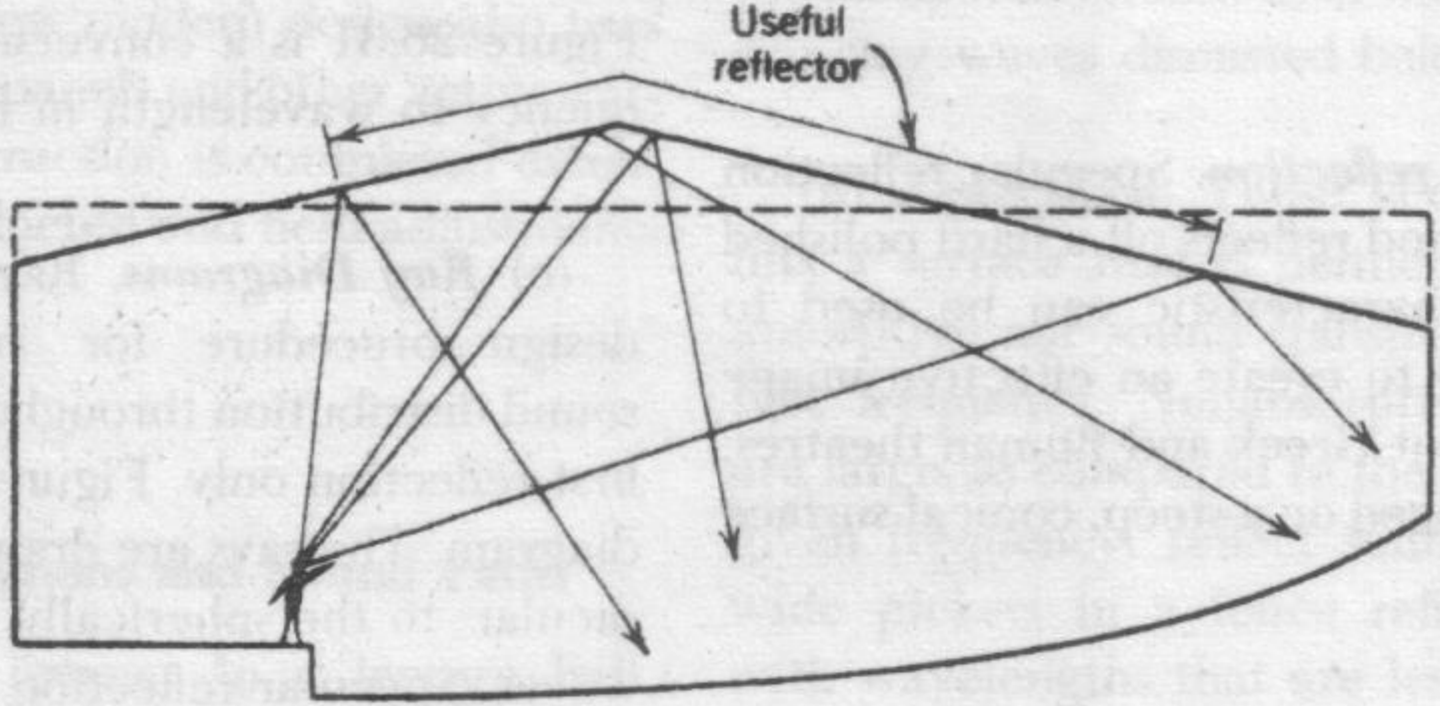
***Fig. 26.29** Sound paths in a typical medium-size lecture room. Note that for both extremes of listener position, the maximum path-length difference between direct and first reflection is 11 ft. Thus signal is reinforced and intelligibility should be excellent if room absorption is provided to limit reverberation time to about ½ sec maximum (see Fig. 26.28). Numbers in parentheses are dimensions in meters.*

# DIAGRAM PANCARAN (RAY DIAGRAMS) DAN JALANNYA BUNYI (SOUND PATH)

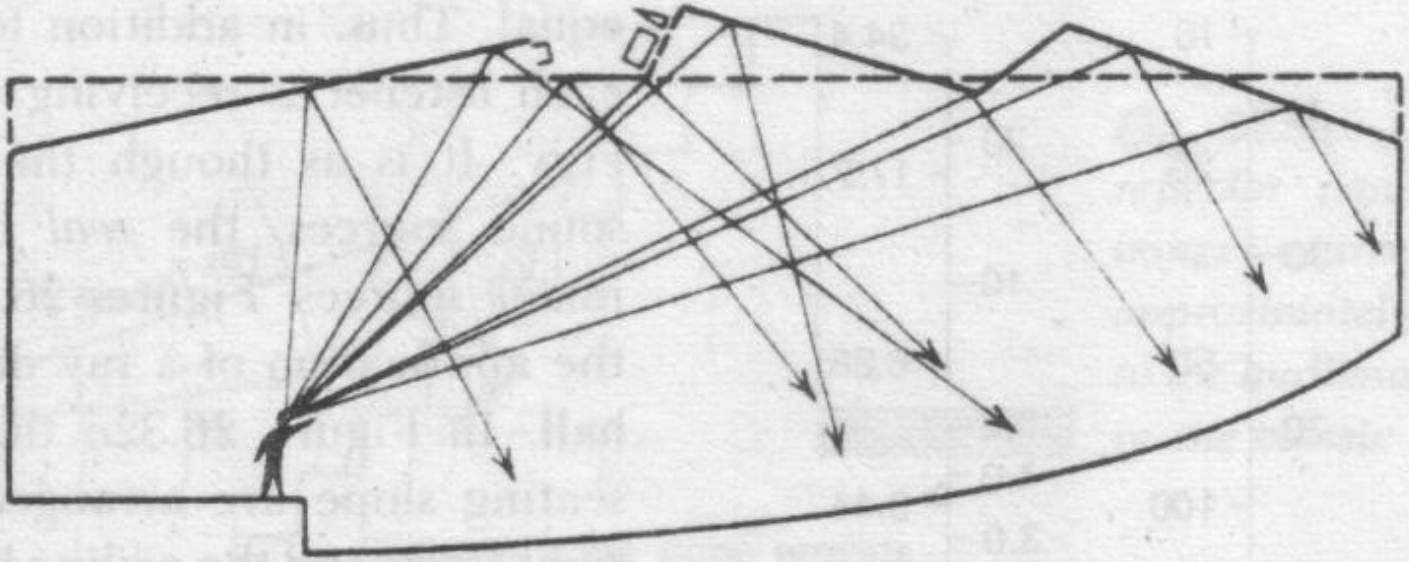
**DIAGRAM PANCARAN ADALAH SUATU PROSEDUR DESAIN UNTUK MENGANALISIS DISTRIBUSI SUARA PANTULAN DALAM RUANGAN, MENGGUNAKAN HANYA PANTULAN AWAL.**



(a) Flat ceiling



(b) Two panel ceiling increases useful reflecting area



(c) Multifaceted ceiling incorporates lights and loudspeakers

*Fig. 26.32 Section through a typical lecture room showing use of ray diagrams.*

## ECHOES.

ECHOES MURNI DISEBABKAN KETIKA BUNYI PANTULAN PADA SUATU INTENSITAS YANG CUKUP MENCAPAI PENDENGAR SEKITAR 0,70 DET ATAU LEBIH SETELAH PENDENGAR MENDENGAR SUARA LANGSUNG

(A CLEAR ECHO IS CAUSED WHEN REFLECTED SOUND AT SUFFICIENT INTENSITY REACHES A LISTENER APPROXIMATELY 70 msec OR MORE AFTER HE HEARS THE DIRECT SOUND)

## FLUTTER

A FLUTTER IS PERCEIVED AS A BUZZING OR CLICKING SOUND, AND IT IS COMPRISED OF REPEATED ECHOES TRAVERSING BACK AND FORTH BETWEEN TWO NONABSORBINGPARALLEL (FLAT OR CONCAVE) SURFACES.

SEBUAH FLUTTER DIANGGAP SEBAGAI SUARA YANG TERDENGAR ATAU BERBUNYI, DAN ITU TERDIRI DARI GEMA YANG BERULANG MELINTASI BOLAK BALIK ANTARA DUA PERMUKAAN PARALEL YANG NON MENYERAP (RATA ATAU CEKUNG) .

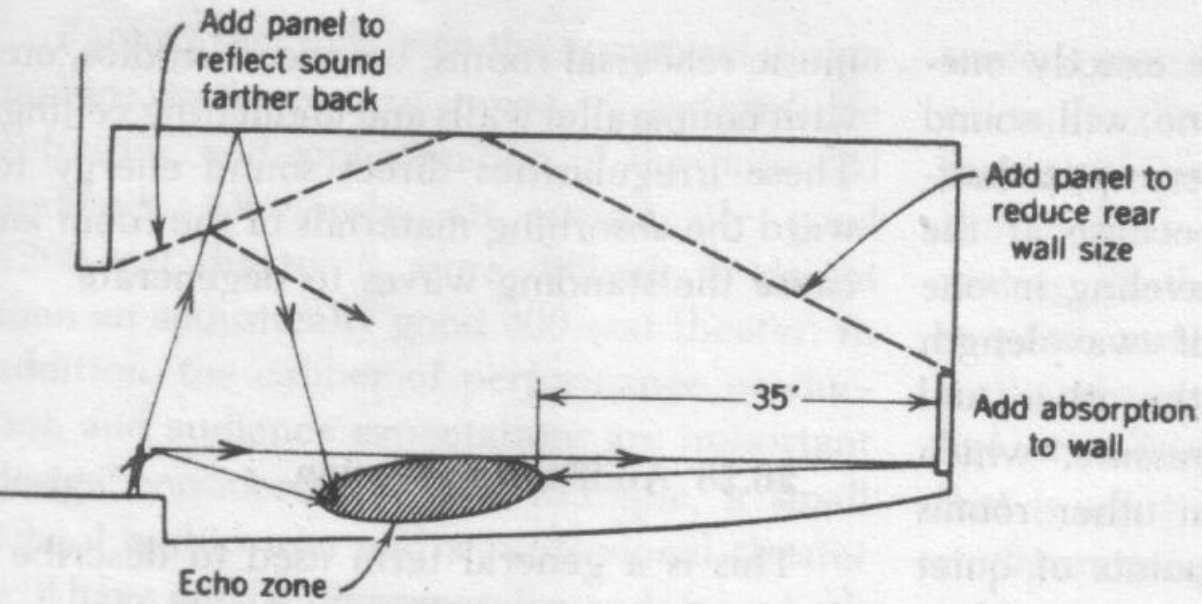
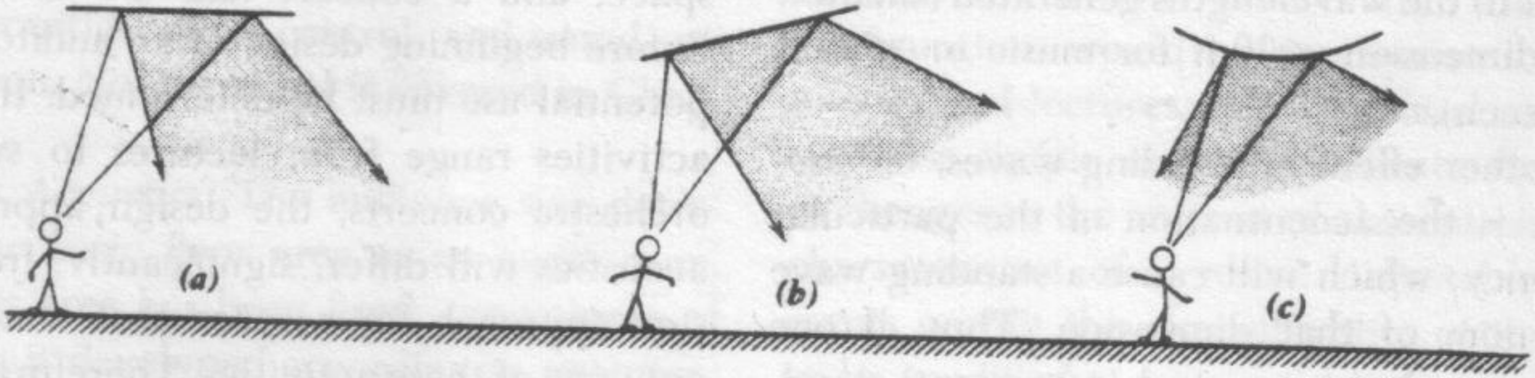


***Fig. 26.33** Auditorium section showing the causes and remedies for two typical echoes.*

***Fig. 26.34** (below) Sound diffusion can be created with different shape reflectors, ranging from the horizontal flat* (a), *inclined flat* (b), *or convex* (c). *Diffusion improves from* (a) *to* (c).



**FOCUSING**

**CONCAVE DOMES, VAULTS OR WALLS WILL FOCUS REFLECTED SOUND INTO CERTAIN AREA OF ROOMS**

**-→ HOT SPOT**

**DIFFUSION**

**CONVERSE OF FOCUSING AND OCCURS PRIMARILY WHEN SOUND IS REFLECTED FROM CONVEX SURFACE**

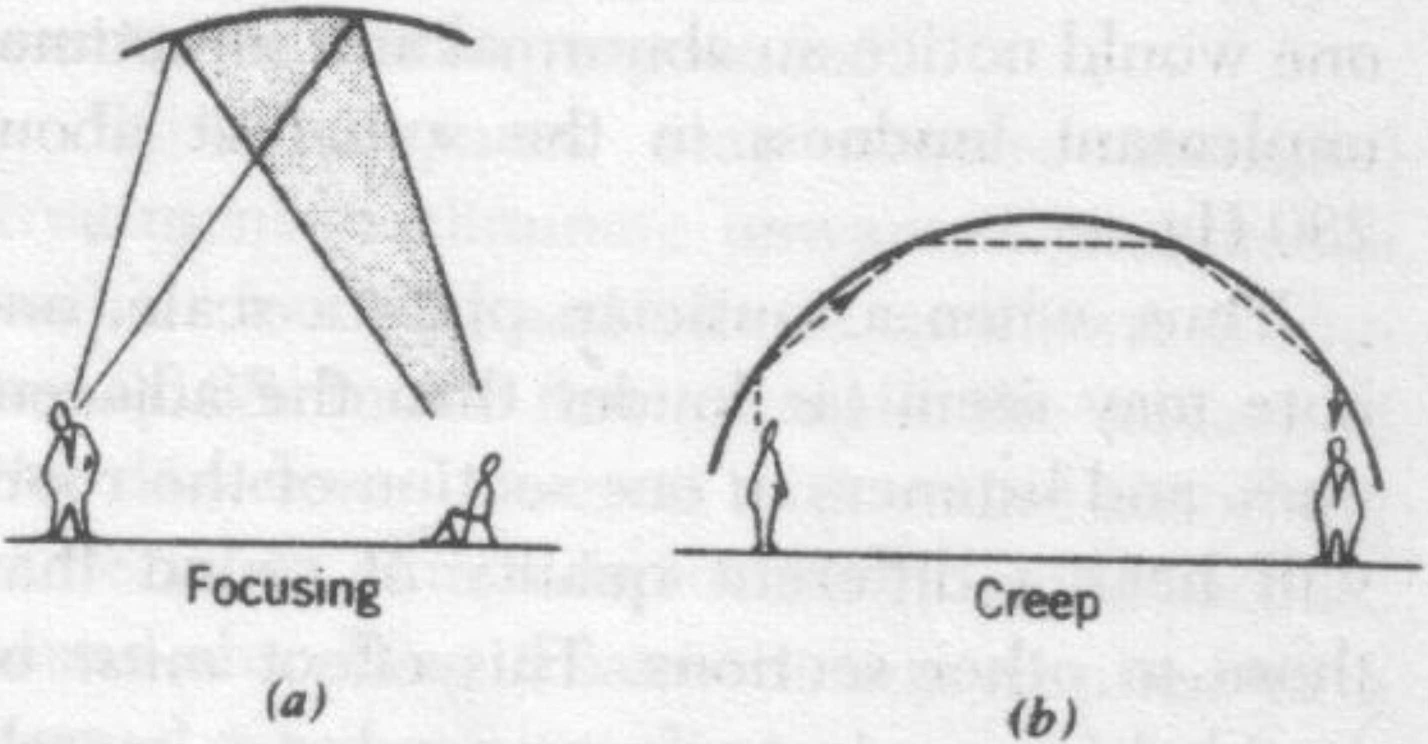


**Fig. 26.35** *Two undesirable phenomena in room acoustics.*

CREEP

REFLECTION OF SOUND ALONG A CURVED SURFACE FROM A SOURCE NEAR THE SURFACE

-→ INAUDIBLE AWAY FROM THE SURFACE

STANDING WAVES

FLUTTER …SIMILAR IN PRINCIPLE AND CAUSE

# AUDITORIUM DESIGN

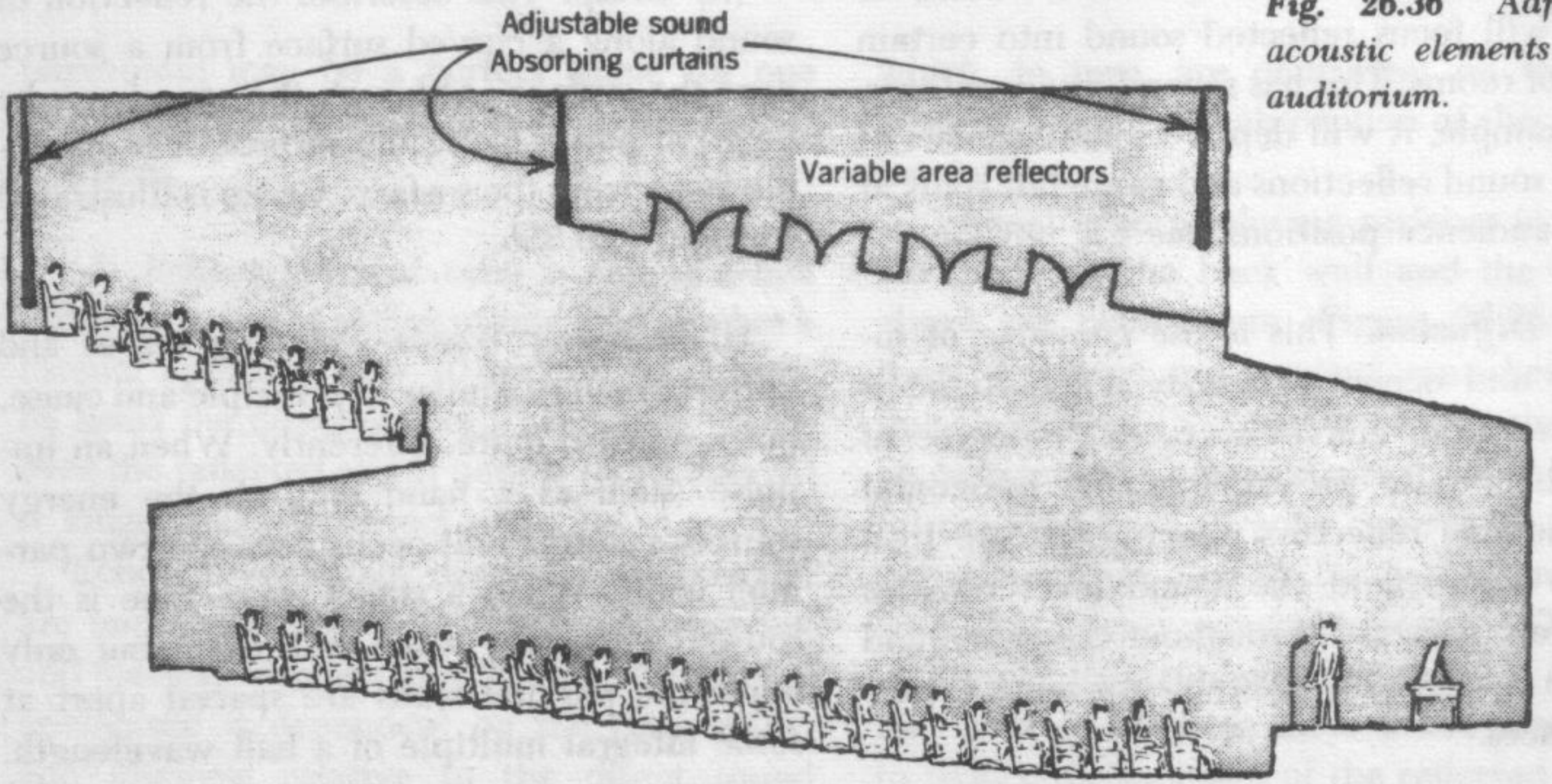


*Fig. 26.36 Adjustable acoustic elements in an auditorium.*

# SOUND REINFORCEMENT SYSTEM

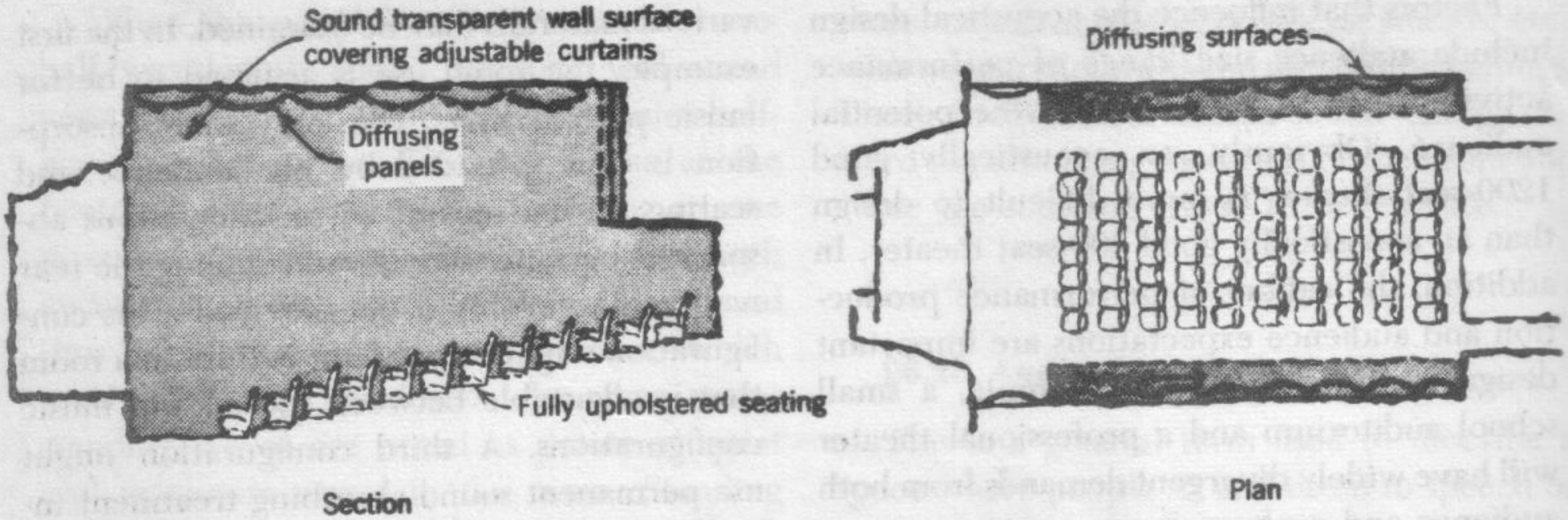


**Fig. 26.37** *Auditorium with surface treatments for control of reflections and reverberation.*

**Simplified calculations of midfrequency (500 Hz & 1000 Hz) average reverberation times.**

$$\text{Reverberation Time (RT)} = \frac{0.049 \times \text{Volume (cu. ft.)}}{\text{Total Absorption (sabins)}}$$

Volume = 155,500 cu. ft.

**More Reverberant Condition**
**(Curtains Retracted)**

| | Area | $\alpha$ | Absorption |
|---|---|---|---|
| Seating and Stage (with audience and performers) | 3323 | .92 | 3060 |
| Wall Area—Concrete Block | 8000 | .2 | 1600 |
| Lower Rear Wall—Permanent Sound Absorbing Treatment | 450 | .88 | 396 |
| | | | 5056 |

Total Absorption
More Reverberant
Condition

$$RT = \frac{0.049 \times 155{,}500}{5056}$$

= 1.48 sec.
= 1.5 seconds

**Less Reverberant Condition**
**(Curtains Exposed)**

| | Area (sq. ft. = ) | $\alpha$ | Absorption |
|---|---|---|---|
| Seating and Stage (with audience and performers) | 3323 | .92 | 3060 |
| Wall Area—Concrete Block (Balance covered by curtains) | 3600 | .2 | 720 |
| Curtains | 4400 | .45 | 1970 |
| Lower Rear Wall—Permanent Sound Absorbing Treatment | 450 | .88 | 396 |
| | | | 6146 |

Total Absorption
Less Reverberant
Condition

$$RT = \frac{0.049 \times 155{,}500}{6146}$$

= 1.22 sec.
= 1.2 seconds

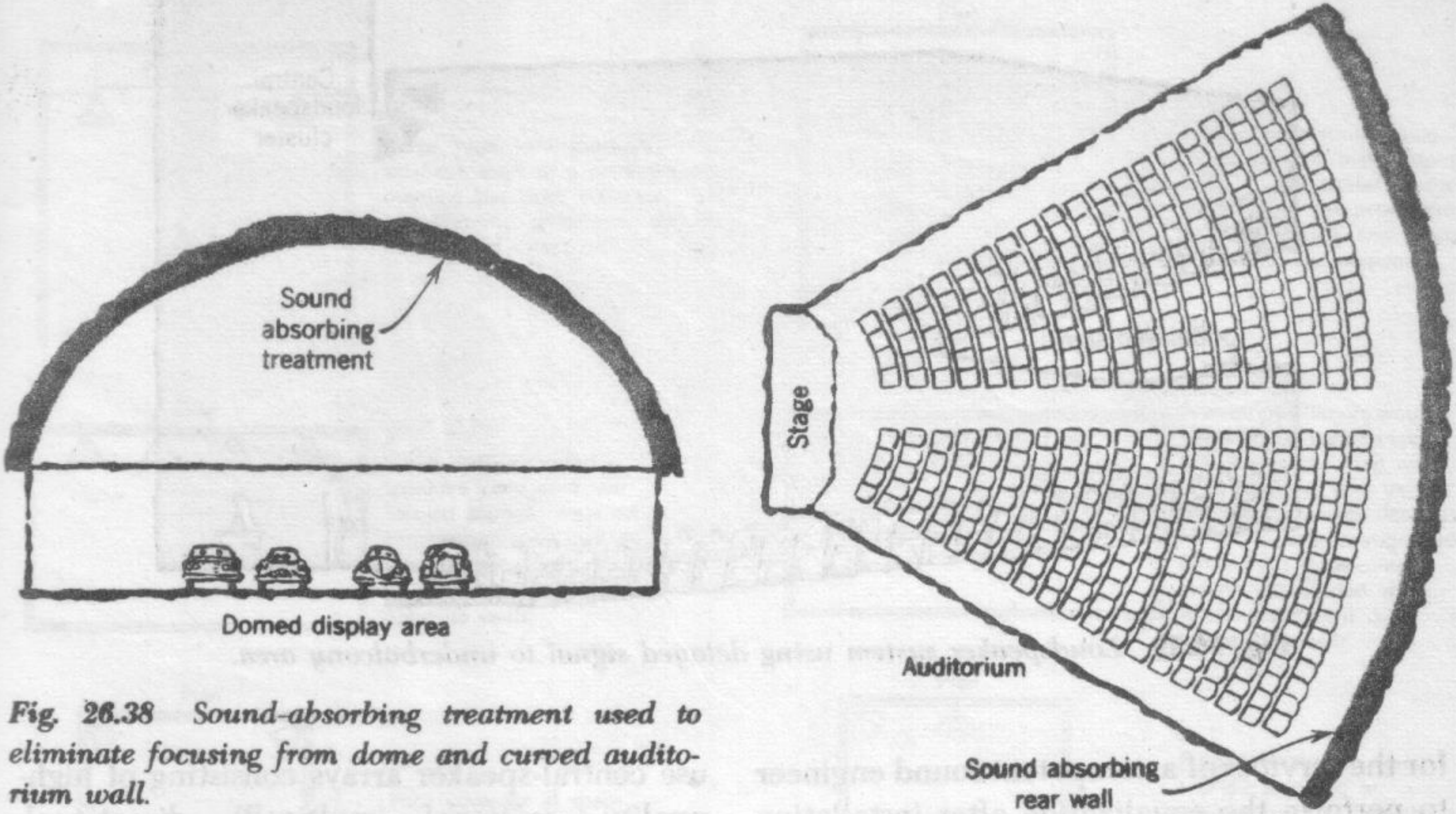


*Fig. 26.38 Sound-absorbing treatment used to eliminate focusing from dome and curved auditorium wall.*

# LOUDSPEAKER CONSIDERATIONS

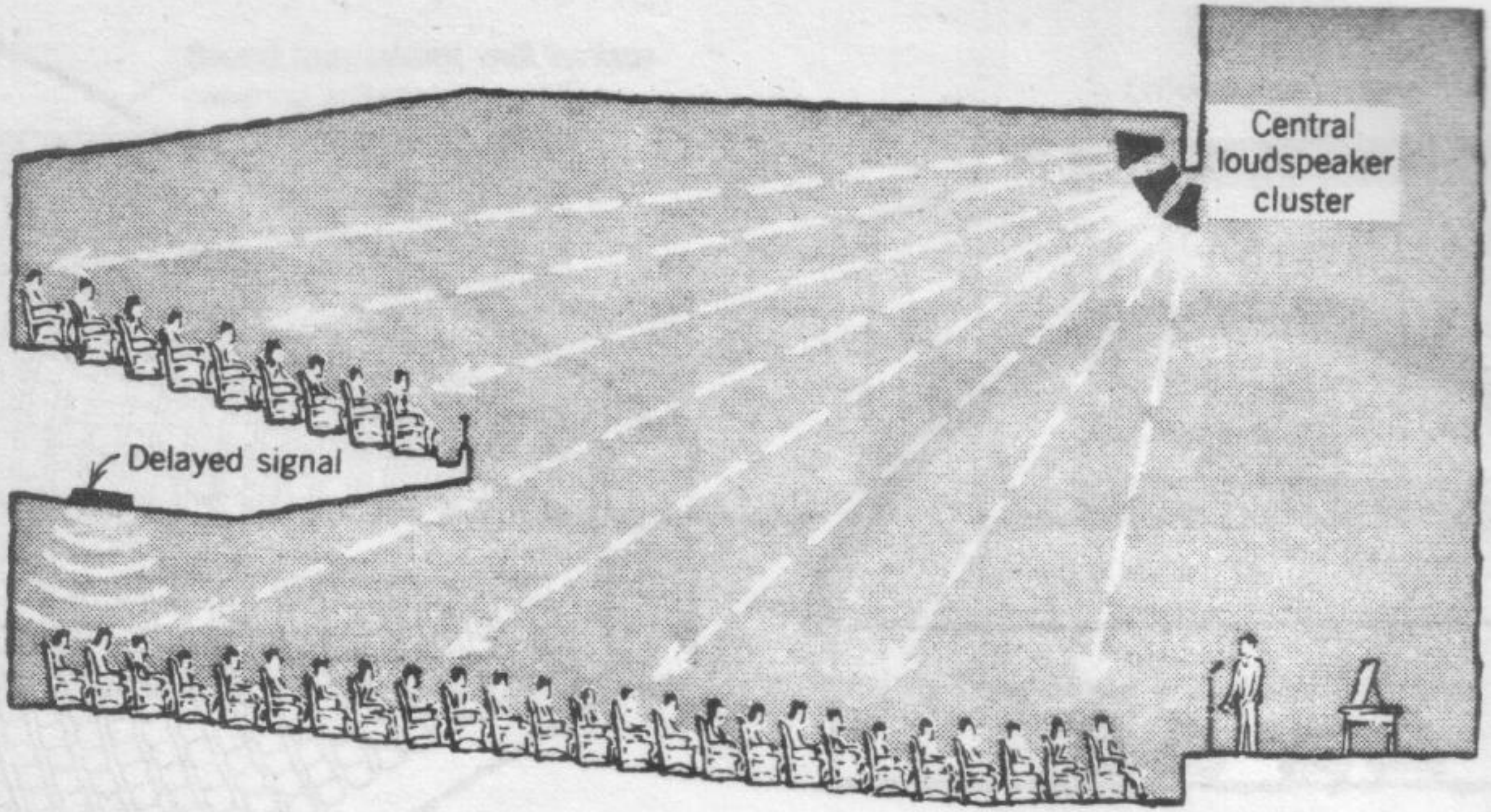
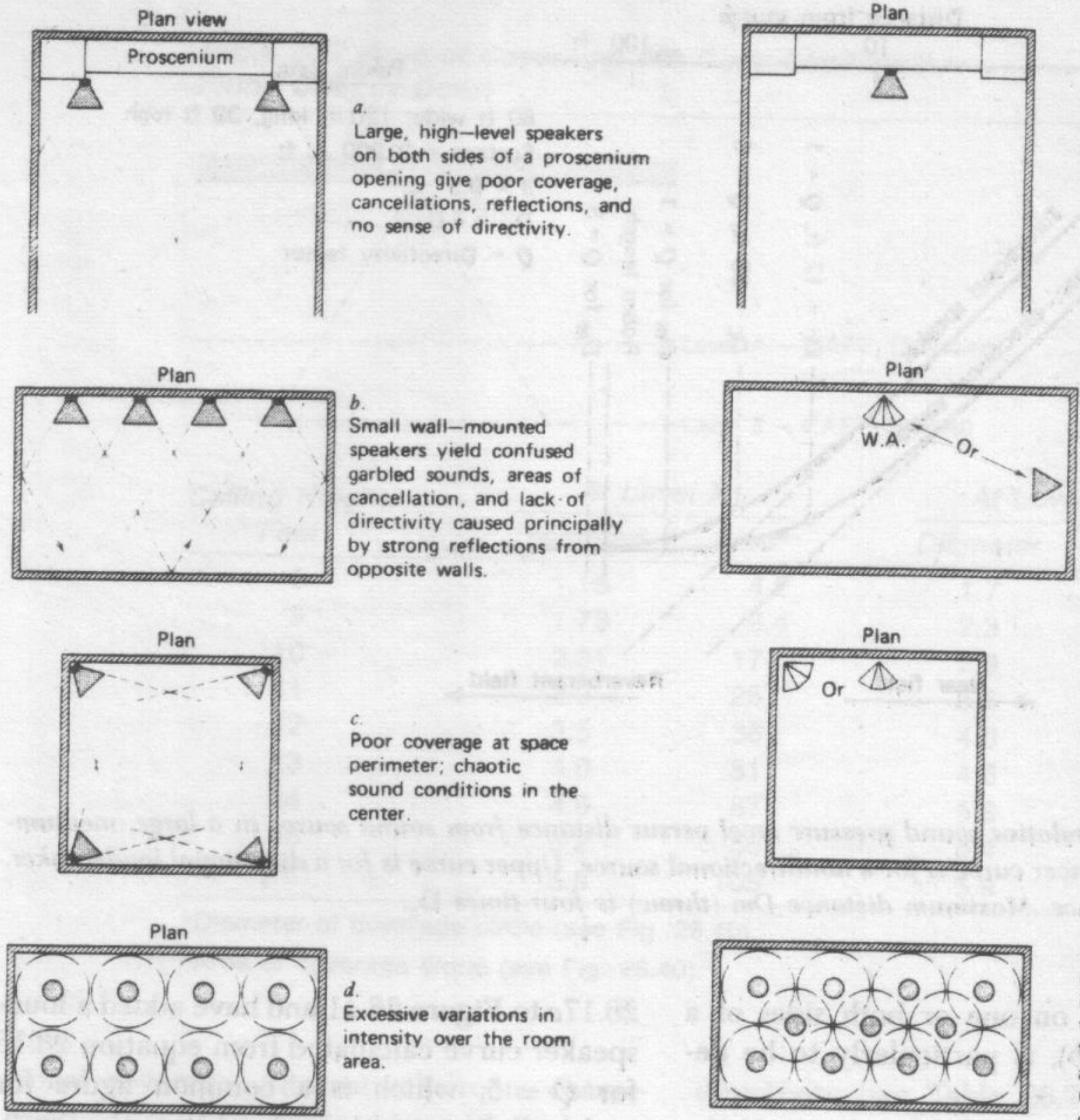


**Fig. 26.39** *Loudspeaker system using delayed signal to underbalcony area.*



*a.*
Large, high-level speakers on both sides of a proscenium opening give poor coverage, cancellations, reflections, and no sense of directivity.

*a*-1
Proper installation would locate a single high-intensity array, at the center of the room above the proscenium, near the ceiling, and angled down into the audience.

*b.*
Small wall-mounted speakers yield confused garbled sounds, areas of cancellation, and lack of directivity caused principally by strong reflections from opposite walls.

*b*-1
Proper installation would use a single wide-angle unit facing the long wall or a narrower unit on the short wall. Choice depends on room reverberation and dimensions. Low-level, ceiling-distributed system is also possible if directivity is not important.

*c.*
Poor coverage at space perimeter; chaotic sound conditions in the center.

*c*-1
Proper installation uses a single standard or wide-angle unit depending on room characteristics. Ceiling system not advisable or necessary.

*d.*
Excessive variations in intensity over the room area.

*d*-1
A staggered pattern gives more uniform coverage in that speakers are closer together. Angle of coverage for low-level speakers is approximately 60°. Coverage circles are drawn on the working plane.

**Fig. 26.40** *Poor layouts a to d and good layouts a-1 to d-1. Wide-angle speakers are available to fit most needs. Ceiling speakers give effective coverage on a 60° cone. Working plane is taken to be 4 ft AFF for seated audience and 6 ft AFF for standing listeners.*

# BUILDING NOISE CONTROL

**PENGENDALIAN BISING DALAM BANGUNAN TERDIRI 3 JENIS :**

1. **REDUKSI BISING TRANSMISI DARI TITIK KE TITIK (SEPANJANG JALUR TRANSMISINYA) DENGAN CARA MEMILIH MATERIAL DAN KONSTRUKSI YANG TEPAT**
2. **REDUKSI BISING YANG TERJADI PADA SUMBERNYA DENGAN CARA MEMILIH DAN INSTALASI PERALATAN**
3. **REDUKSI BISING PADA PENERIMA DENGAN CARA TREATMENT AKUSTIKAL DARI RUANG UNTUK MEMENUHI KRITERIA NC**

# PRINSIP REDUKSI BISING

PD DASARNYA SEBAGAI ILMU KONVERSI ENERGI AKUSTIKAL KE LAINNYA, BENTUK ENERGI YG KURANG MENGGANGGU – PANAS, jumlah panas biasanya dapat diabaikan

130 db → 1/1000 dr 1 watt = 0,003 Btu

→ ABSORPSI

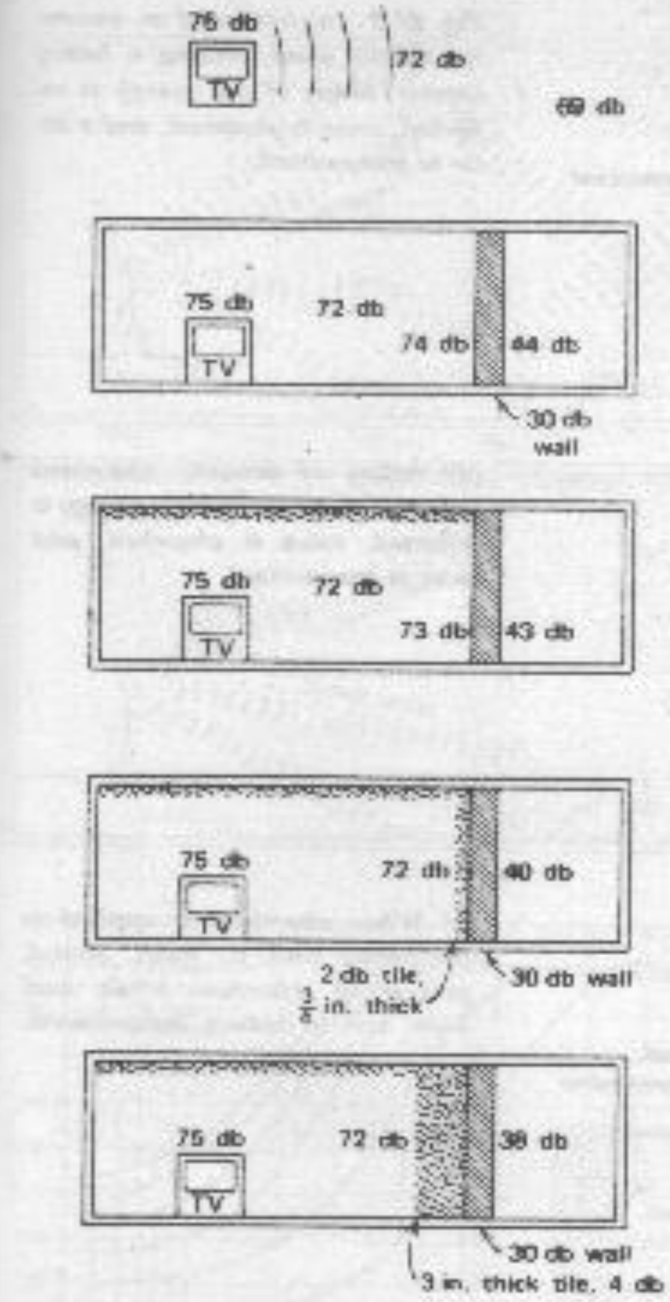
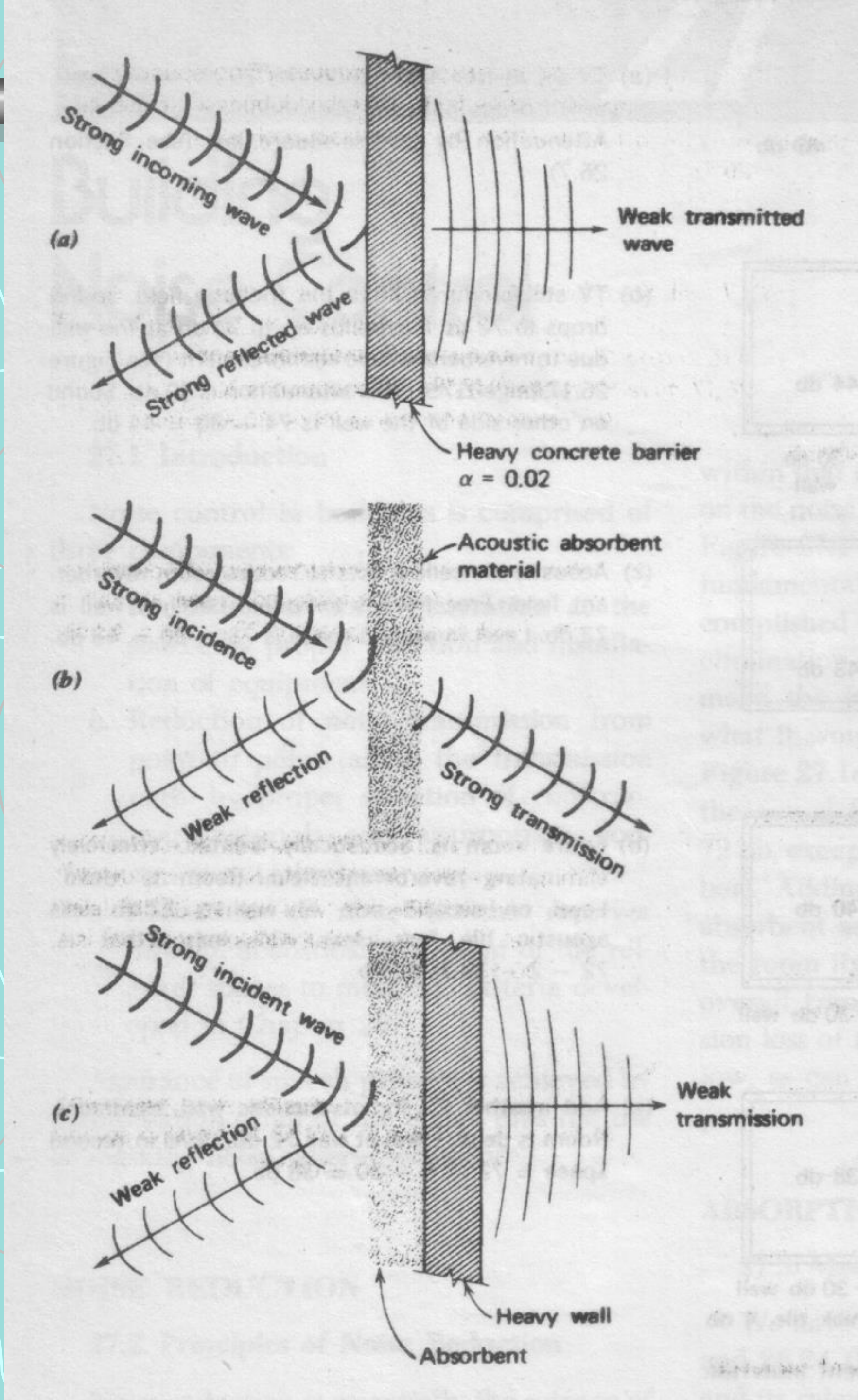
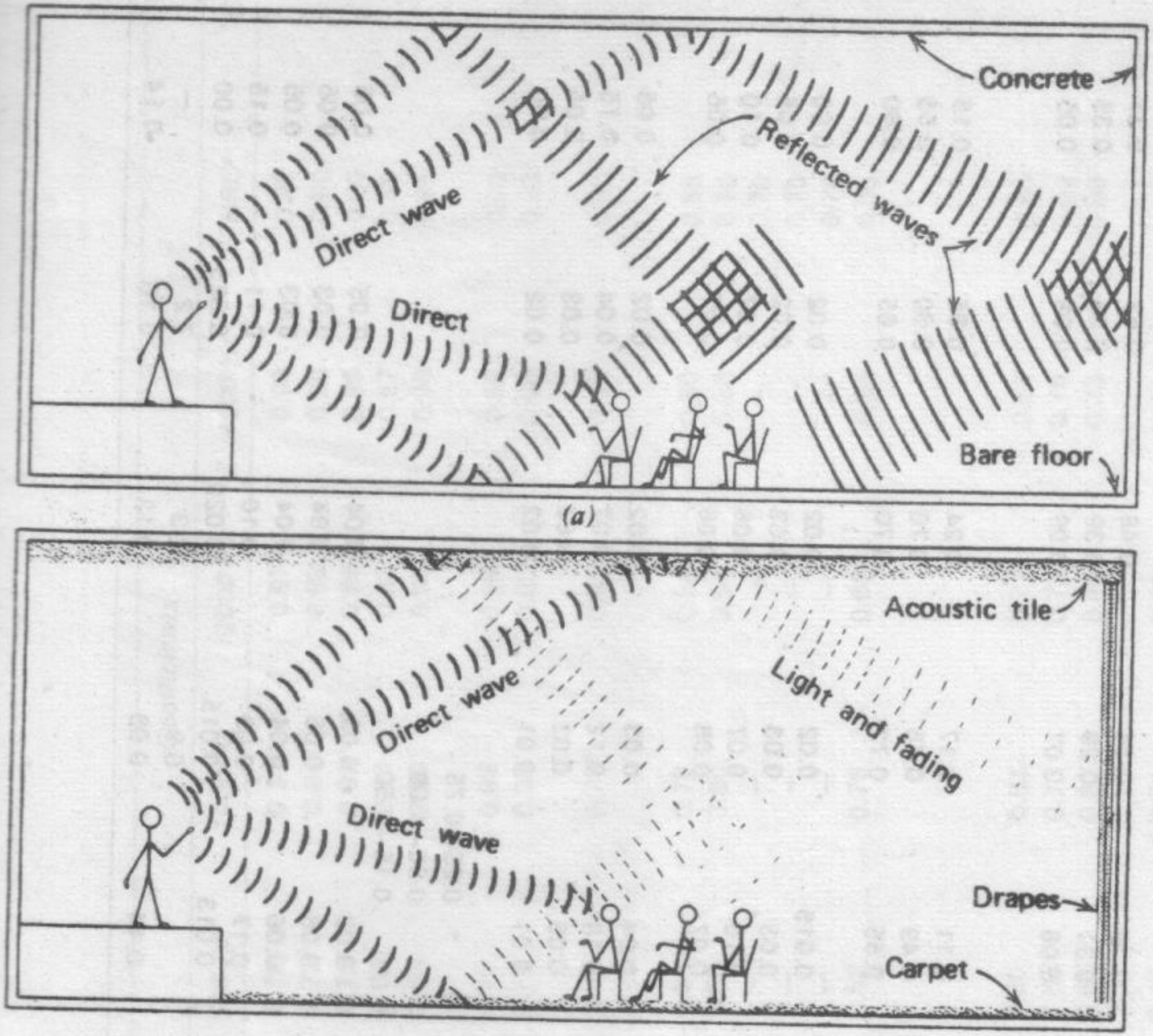


*Fig. 27.1 Action of acoustic absorbent material.*

# ABSORPSI


Strong incoming wave
(a)
Weak transmitted wave
Strong reflected wave
Heavy concrete barrier
α = 0.02
Acoustic absorbent material
Strong incidence
(b)
Weak reflection
Strong transmission
Strong incident wave
(c)
Weak transmission
Weak reflection
Heavy wall
Absorbent



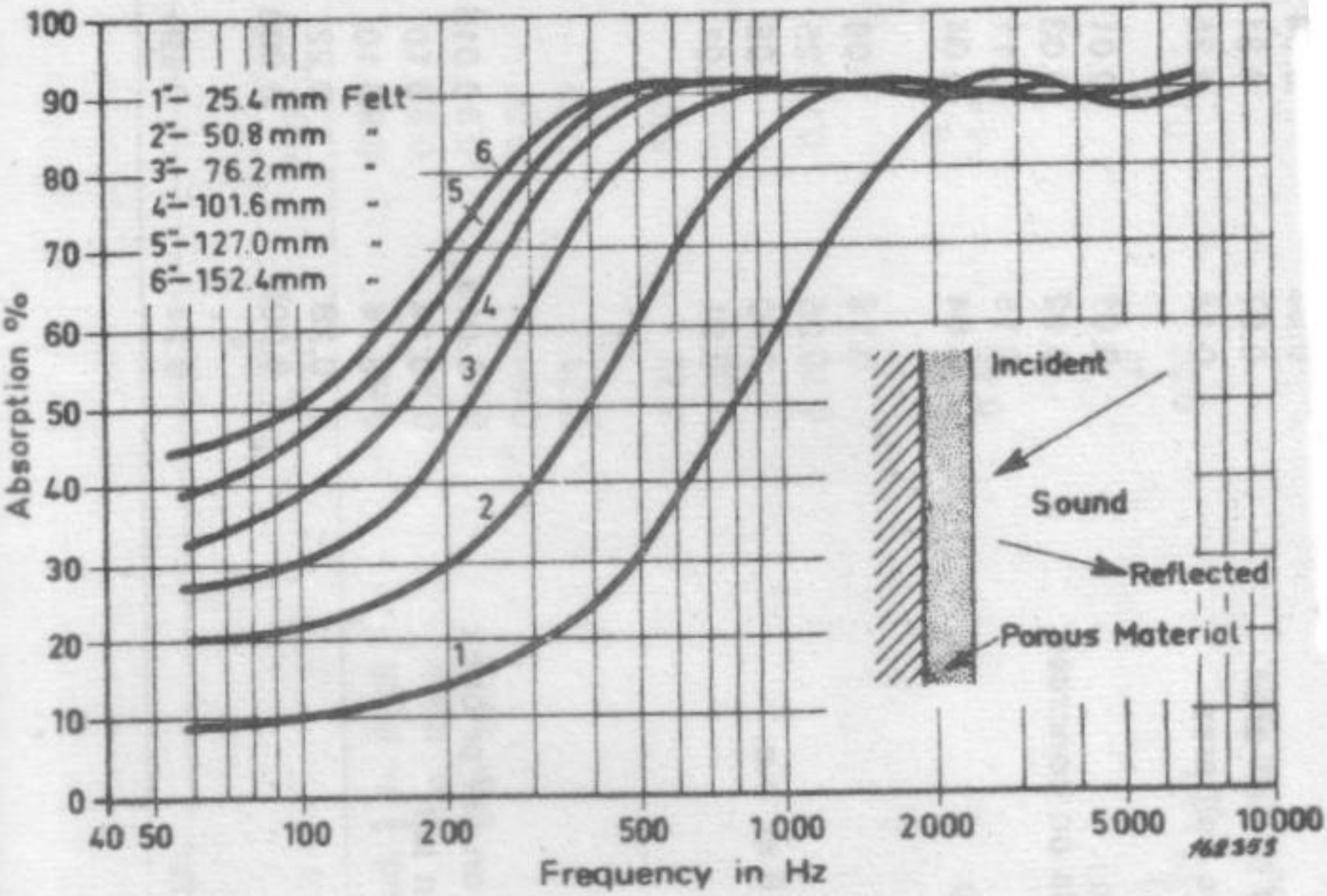
(a)

(b)

**Fig. 27.3** *In the untreated space* (a) *reverberant* (*reflected*) *sound constitutes the greater portion of received sound in much of the room. These reflections are largely eliminated in* (b) *by wall and ceiling absorption. Note that direct wave is completely unaffected.*

UNTUK MATERIAL PENYERAP, ABSORPSI BIASANYA LEBIH TINGGI PADA FREKUENSI TINGGI DARIPADA RENDAH

ABSORPSI TIDAK SELALU BERBANDING LURUS DENGAN KETEBALAN BAHAN, TETAPI TERGANTUNG PADA TIPE MATERIAL YANG DIGUNAKAN DAN METODE INSTALASINYA


100
90
80
70
60
50
40
30
20
10
0
Absorption %
1"– 25.4 mm Felt
2"– 50.8 mm "
3"– 76.2 mm "
4"– 101.6 mm "
5"– 127.0 mm "
6"– 152.4 mm "
6
5
4
3
2
1
Incident
Sound
Reflected
Porous Material
40
50
100
200
500
1000
2000
5000
10000
Frequency in Hz
162555

# NOISE REDUCTION COEFFICIENT (NRC)

REDUKSI BISING DENGAN ABSORPSI

PADA HAMPIR SEMUA RUANG, NOISE LEVEL=

$IL = PWL - 10 \log \Sigma S\alpha + 6$ db atau

$IL = PWL - 10 \log \Sigma A + 6$ db dimana

$\Sigma S\alpha = \Sigma A$ = TOTAL ABSORPTION IN ROOM, sabins

$IL$ = INTENSITY LEVEL, db

$PWL$ = SOUND POWER LEVEL, db

MENINGKATKAN ABSORPSI MENURUNKAN TINGKAT BISING

# PANEL AND CAVITY RESONATORS

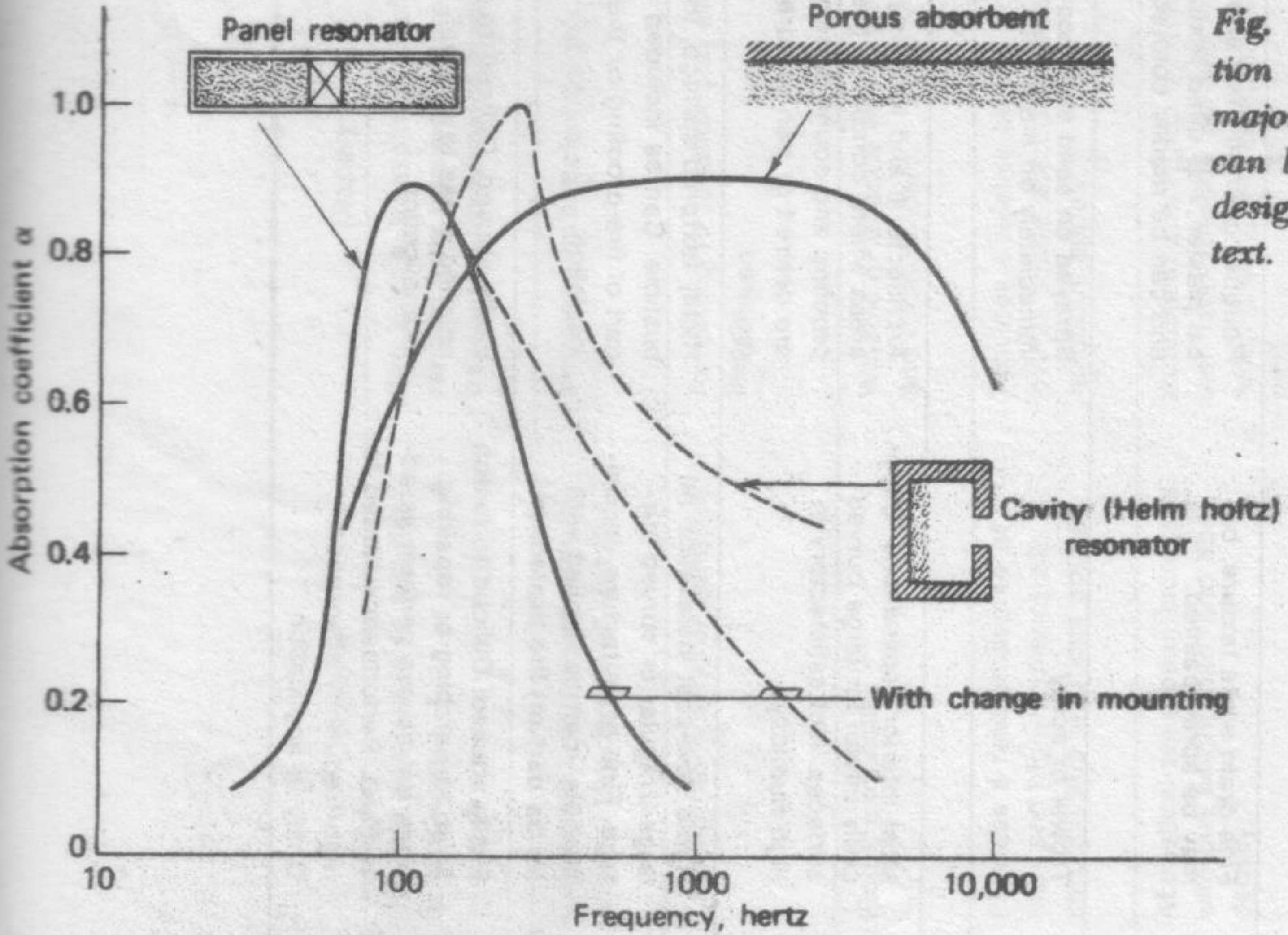


*Fig. 27.8 Typical absorption curves for the three major types of absorbers. All can be changed by varying design, as discussed in the text.*

**PANEL RESONATOR :**

**ABSORPSI EFISIEN PD FREKUENSI RENDAH, SERING DIGUNAKAN PADA STUDIO REKAMAN**

**VOLUME OR CAVITY RESONATOR:**

**UTK FREKUENSI TERTENTU DPT DI-ADJUST NECK OPENING**

**POROUS ABSORBENT:**

**UTK FREKUENSI TINGGI**

REKOMENDASI TEKNIK ABSORPSI BERGUNA DAN EFEKTIF :

UNTUK MERUBAH KARAKTERISTIK REVERBERASI RUANG

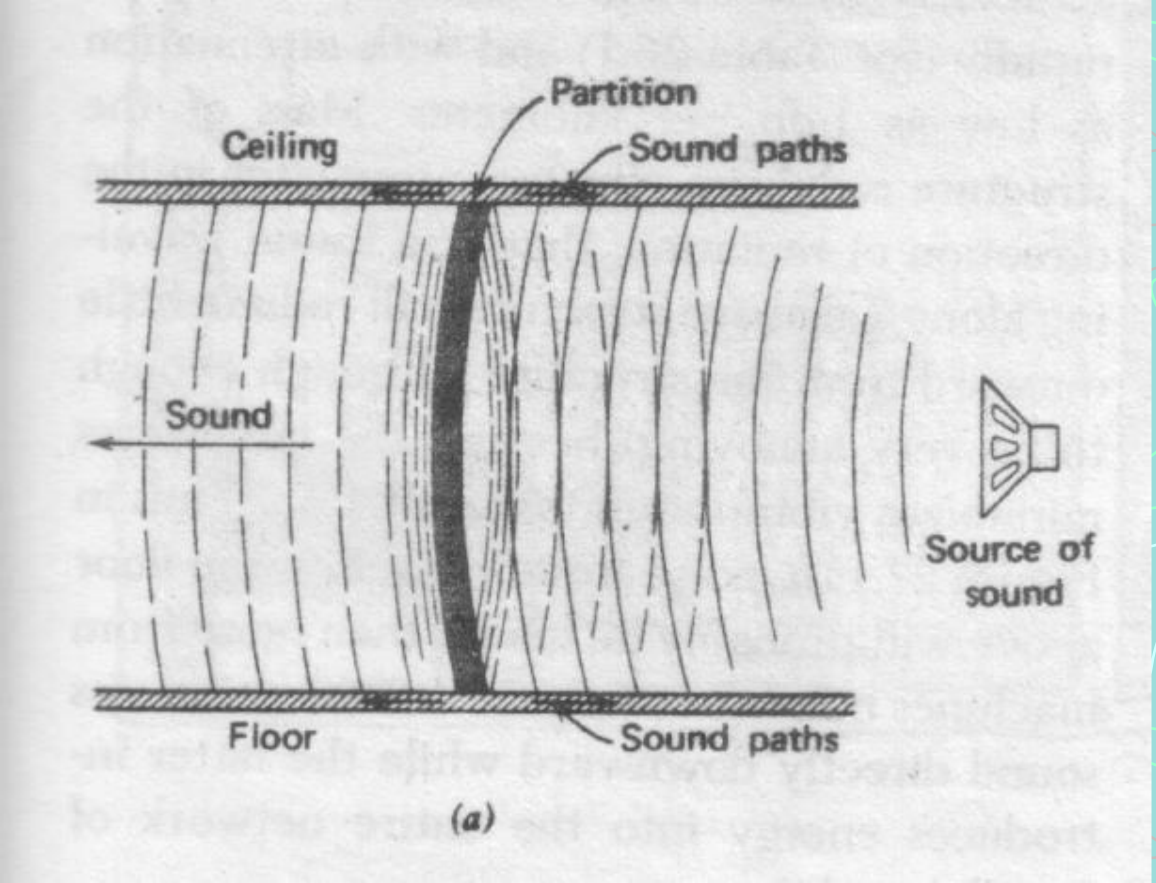
DALAM RUANG DENGAN SUMBER BISING YG TERSEBAR SEPERTI KANTOR, SEKOLAH DLL

DALAM RUANG DENGAN PERMUKAAN YG KERAS DAN SEDIKIT PENYERAP

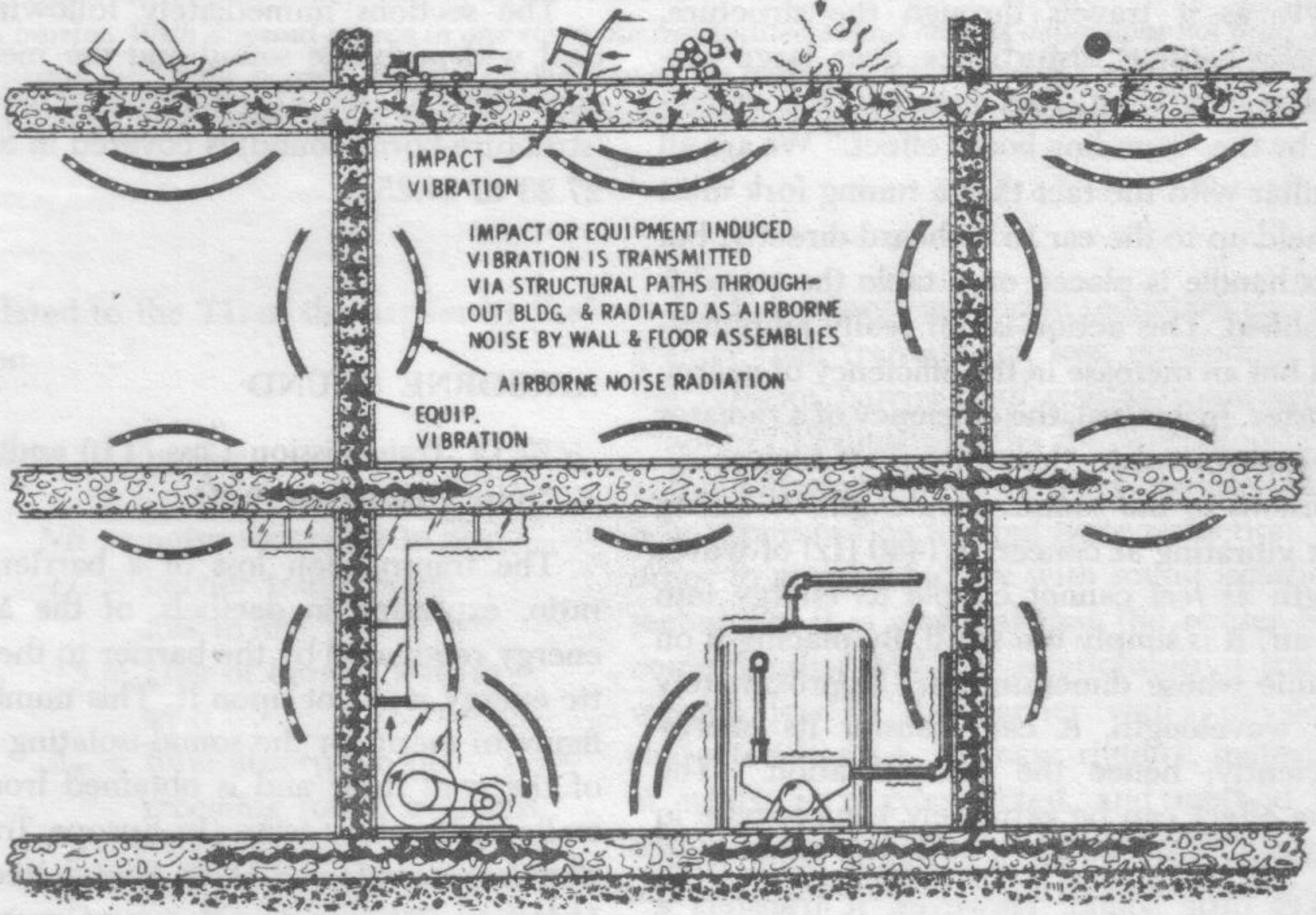
KETIKA PENDENGAR BERADA DALAM MEDAN REVERBERASI

# ISOLASI BUNYI

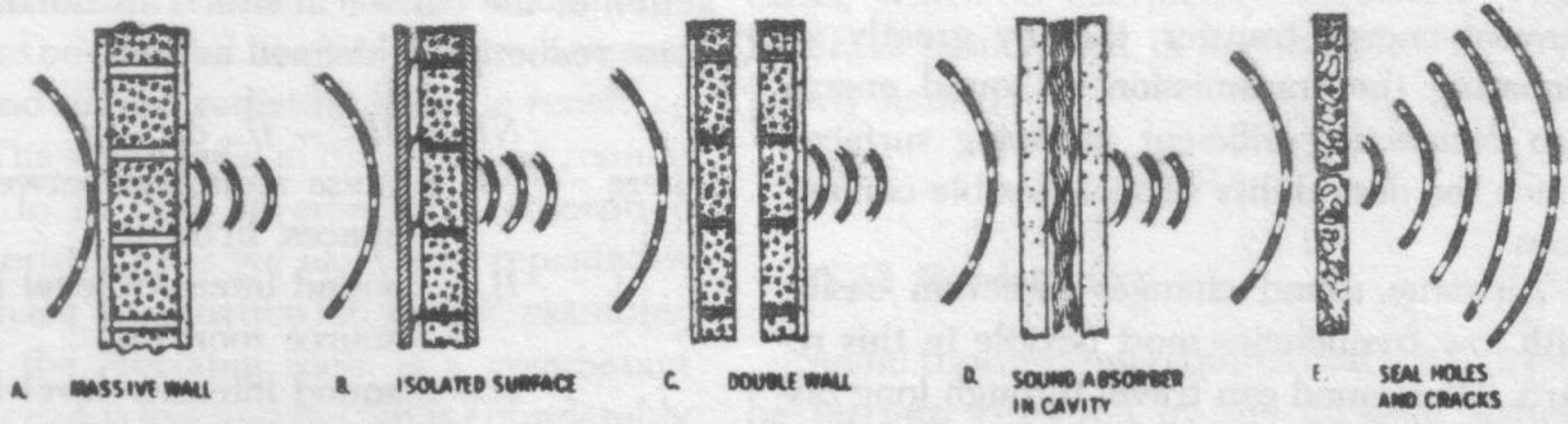
## AIRBORNE AND STRUCTURE-BORNE SOUND



**AIRBORNE SOUND ORIGINATES IN A SPACE WITH ANY SOUND-PRODUCING SOURCE AND CHANGES TO STRUCTURE BORNE SOUND WHEN THE SOUND WAVE STRIKES THE ROOM BOUNDARIES.**



Transmission of Impact and Structure—Borne Noise.



**BEBERAPA TEKNIK UNTUK MENGENDALIKAN AIRBORNE SOUND**

# AIRBORNE SOUND

**TRANSMISSION LOSS (TL) AND NOISE REDUCTION (NR)**

**NR = IL1 – IL 2 db**

**NR = NOISE REDUCTION BETWEEN SPACE, db**

**IL1 = SOUND INTENSITY LEVEL IN SOURCE ROOM, db**

**IL2 = SOUND INTENSITY LEVEL IN RECEIVING ROOM, db**

**DIHUBUNGKAN DENGAN TL DARI PENGHALANG**

**NR = TL – 10 log S/Ag**

**NR = NOISE REDUCTION, db**

**TL = BARRIER TRANSMISSION LOSS, db**

**S = AREA OF BARRIER WALL, sq ft**

**Ag = TOTAL ABSORPTION OF RECEIVING ROOM, sabins**

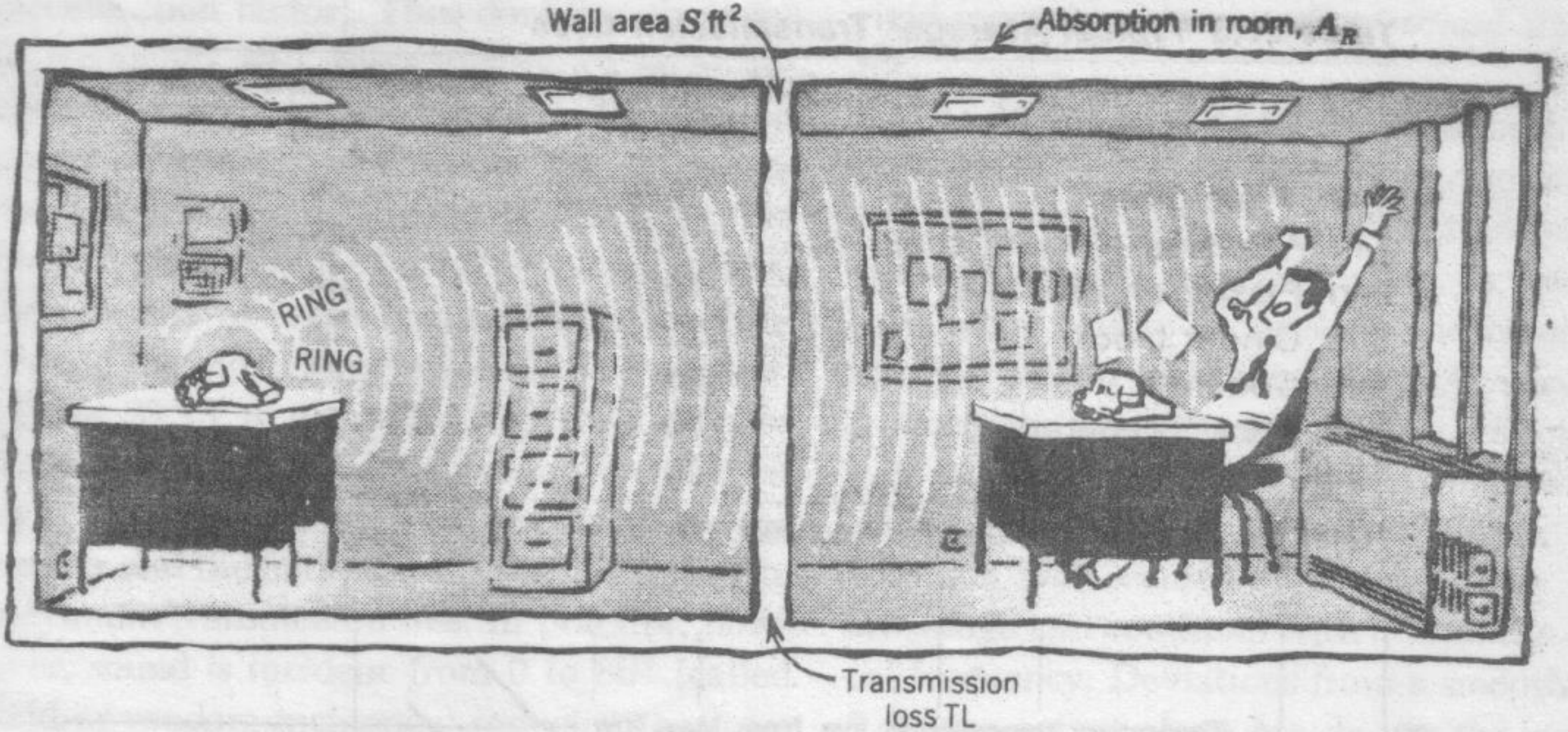
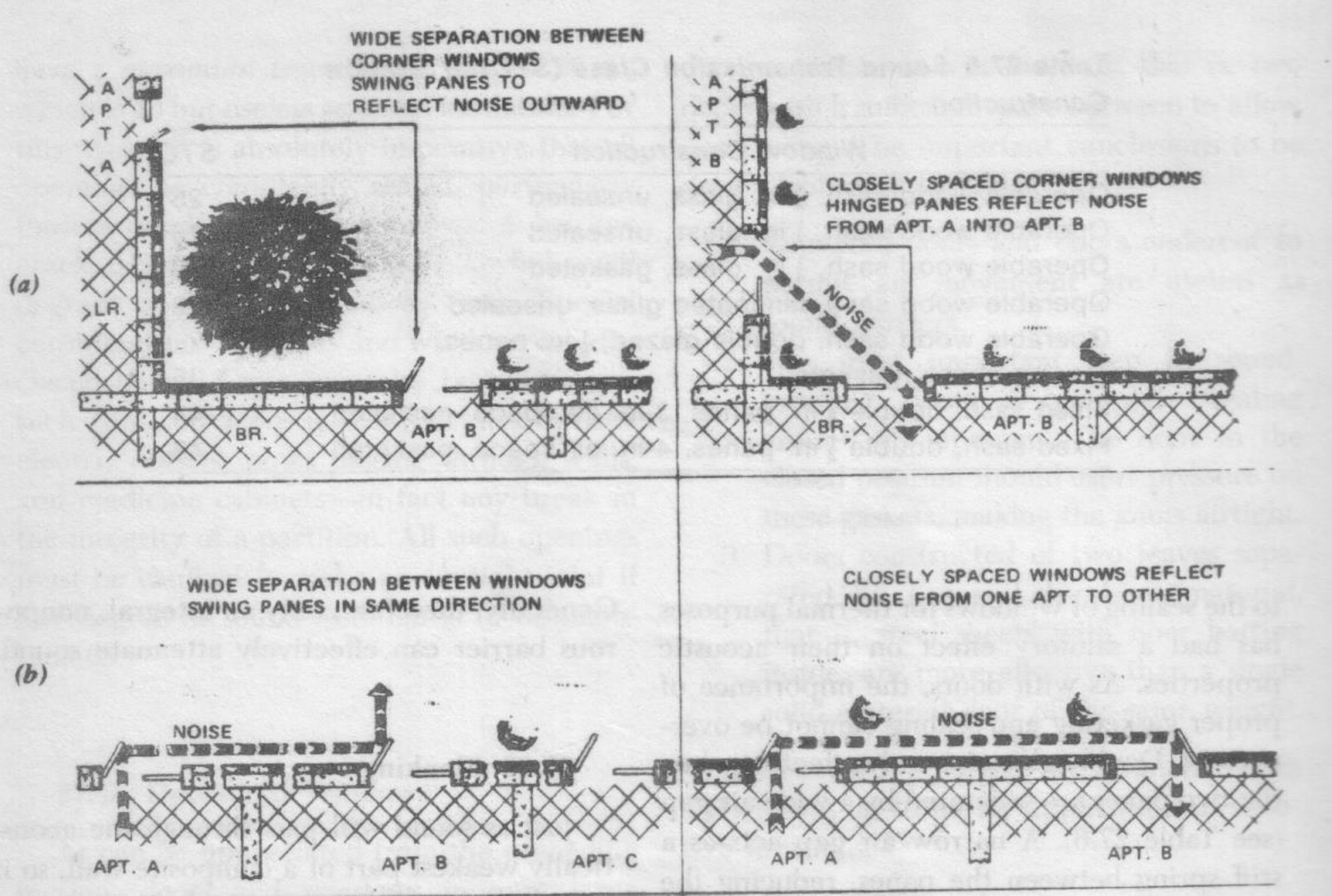
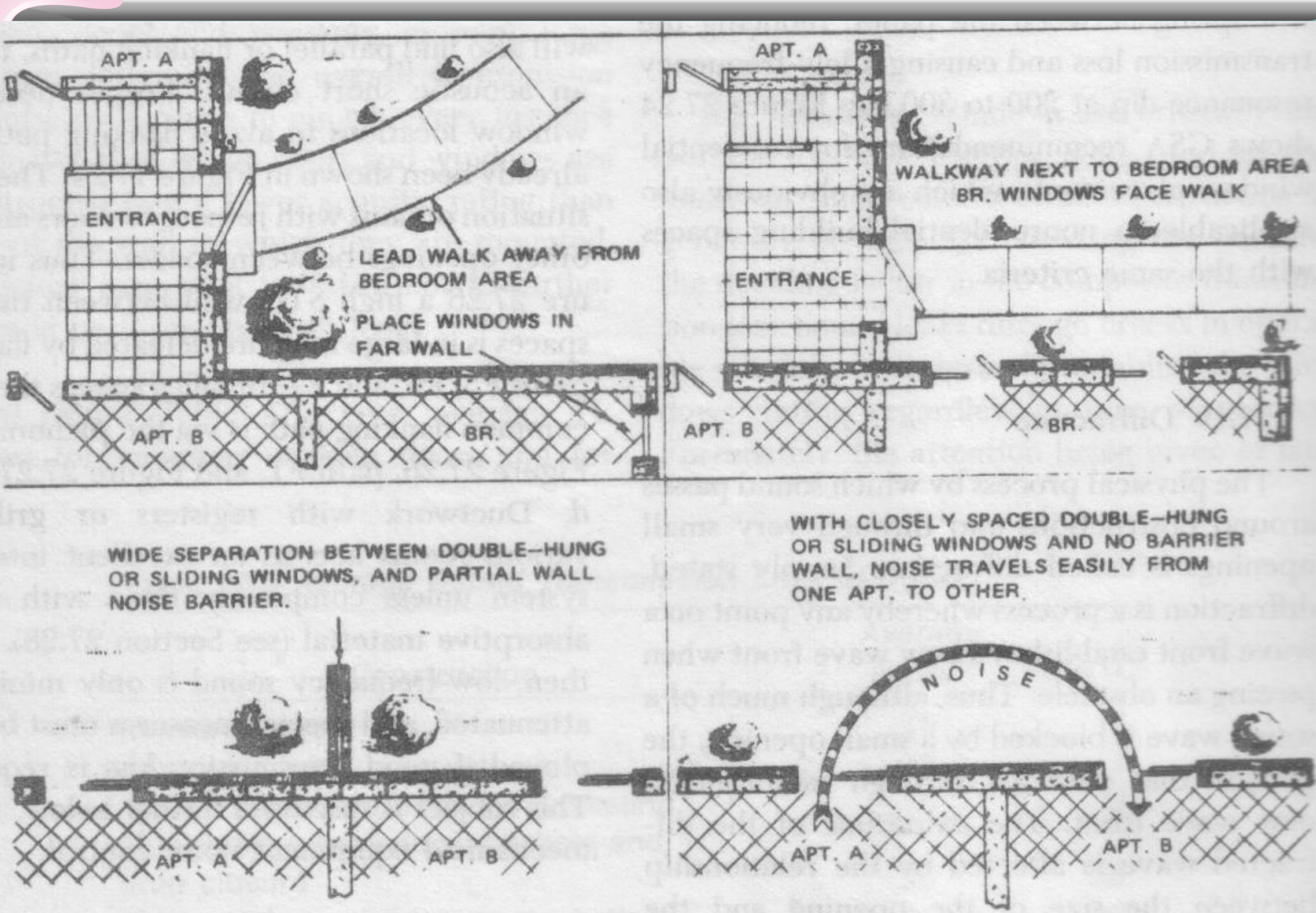


**Fig. 27.12** *Illustration of the simple case of airborne sound transmission between adjacent rooms through a common barrier. With a sound source in one room the transmitted sound level is dependent not only on the transmission loss of the barrier, but also on the area of the barrier and the receiving-room absorption. The actual background "masking" noise levels determine whether or not the transmitted sound will be heard.*

# REKOMENDASI PELETAKAN JENDELA





LEAD WALK AWAY FROM BEDROOM AREA

PLACE WINDOWS IN FAR WALL

WALKWAY NEXT TO BEDROOM AREA BR. WINDOWS FACE WALK

WIDE SEPARATION BETWEEN DOUBLE-HUNG OR SLIDING WINDOWS, AND PARTIAL WALL NOISE BARRIER.

WITH CLOSELY SPACED DOUBLE-HUNG OR SLIDING WINDOWS AND NO BARRIER WALL, NOISE TRAVELS EASILY FROM ONE APT. TO OTHER.

# STRUCTURE-BORNE SOUND

## STRUCTURE-BORNE IMPACT NOISE

### CONTROL OF IMPACT NOISE:

**BY PREVENTING OR MINIMIZING THE IMPACT**

**BY ATTENUATING IT ONCE IT HAS OCCURRED**

*Fig. 27.32 Methods of controlling impact sound transmission through floors. From* Quieting: A Practical Guide to Noise Control, *National Bureau of Standard Handbook 119, July 1976, p. 50.*

# MECHANICAL SYSTEM NOISE CONTROL

**QUIETING OF MACHINES:**

**REDUCE THE VIBRATION ITSELF**

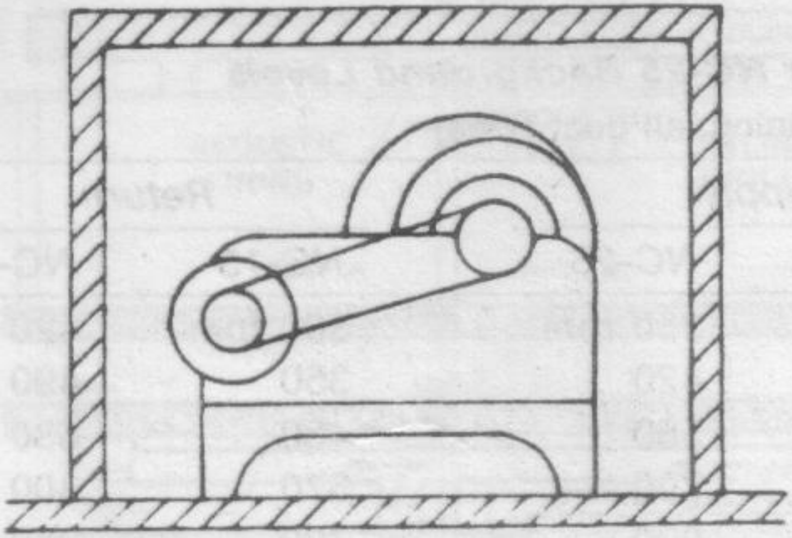
**REDUCE THE AIRBORNE NOISE BY DECOUPLING**

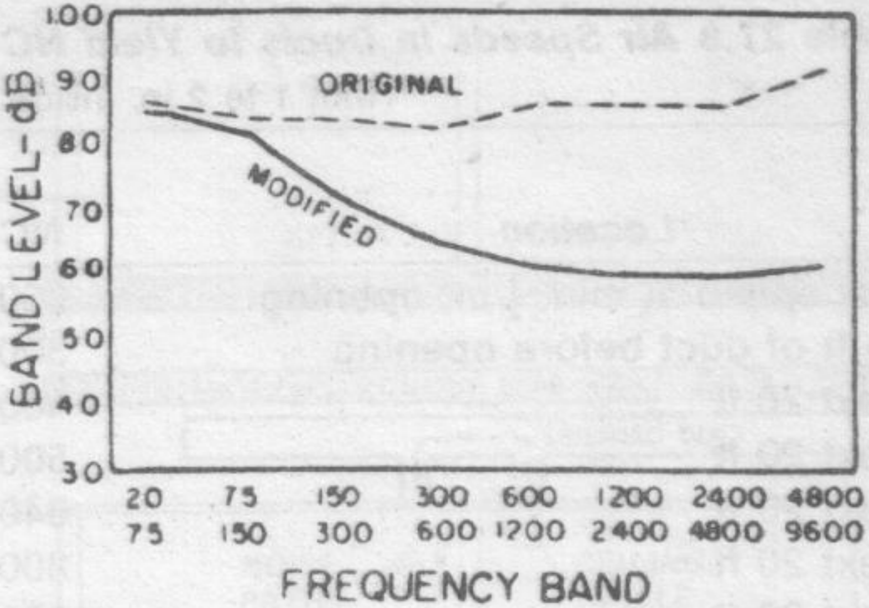
**DECOUPLE THE VIBRATING SOURCE FROM THE STRUCTURE**

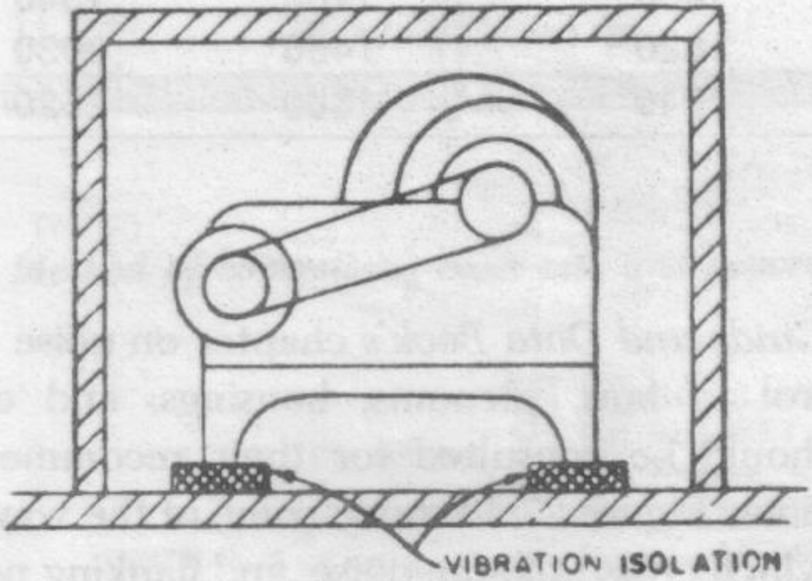
## VIBRATION REDUCTION : DAMPING AND ISOLATION

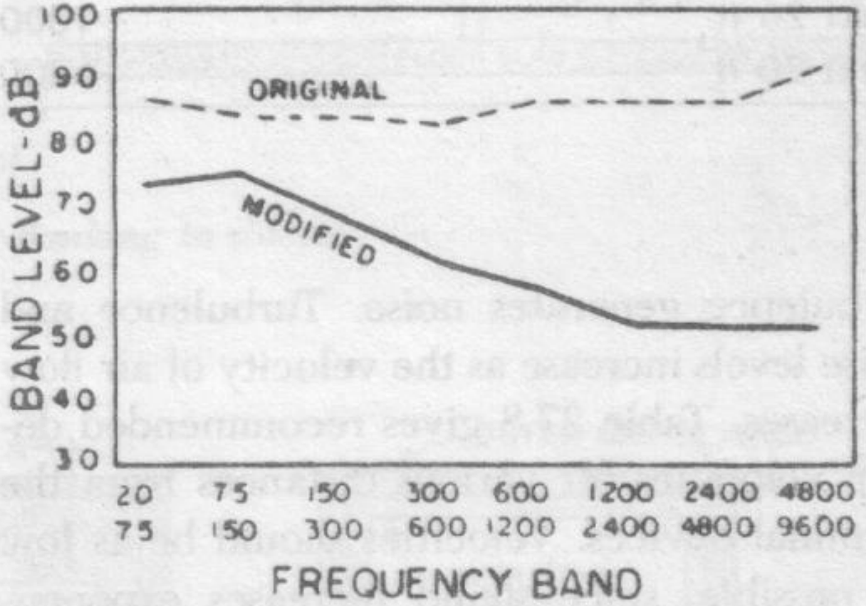
RIGID, SEALED ENCLOSURE

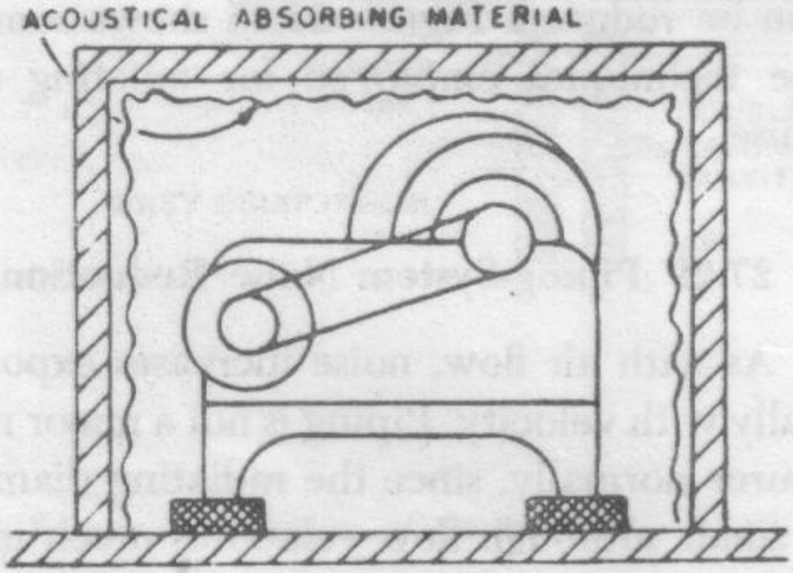
OCTAVE-BAND ANALYSIS OF NOISE

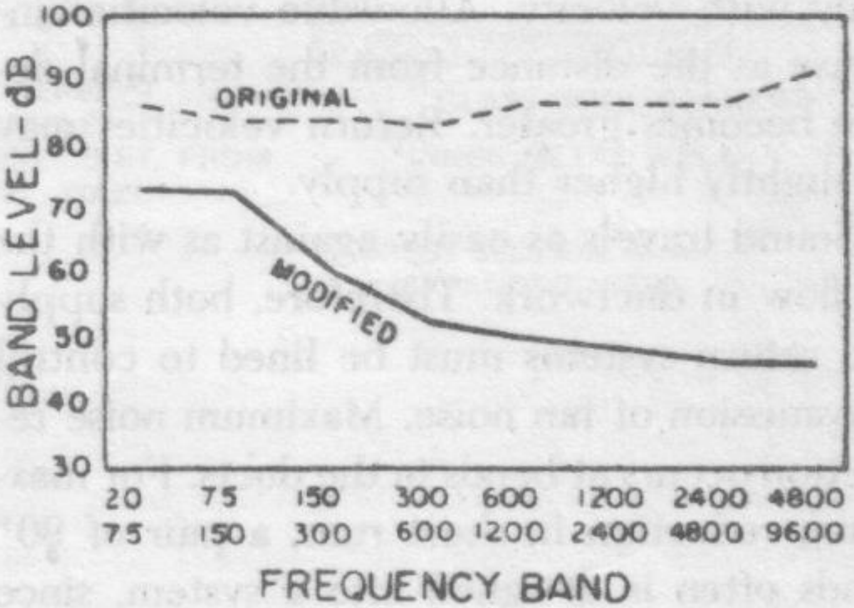


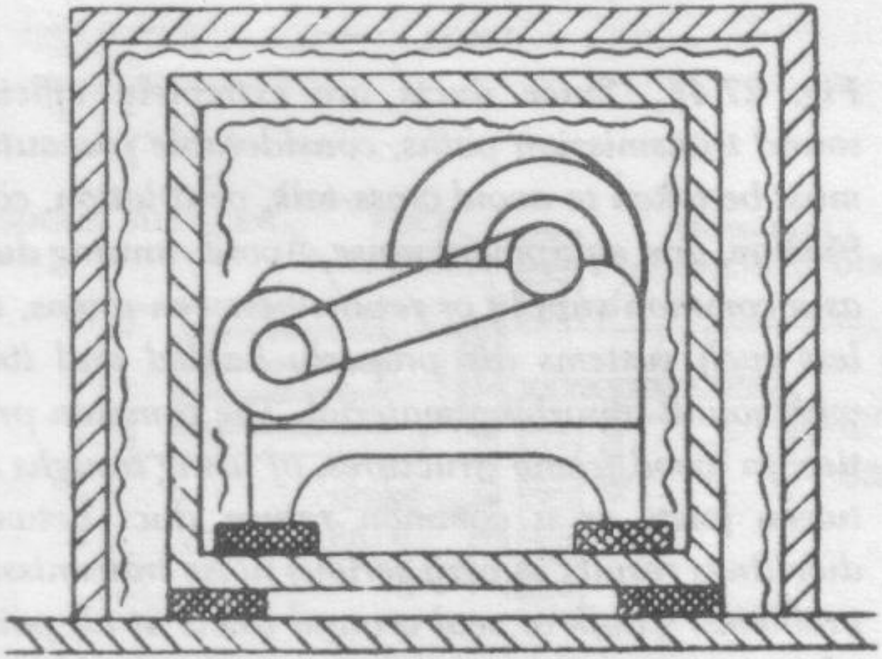


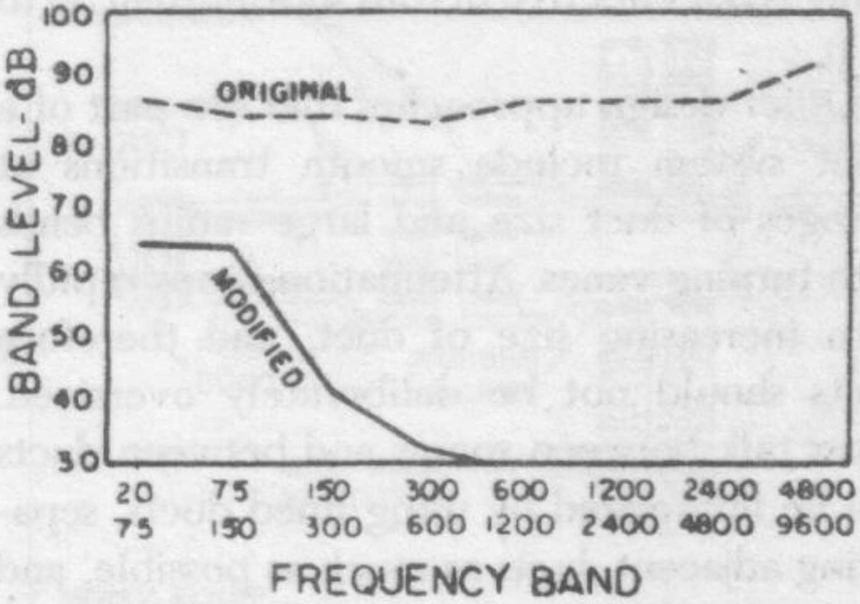





ACOUSTICAL ABSORBING MATERIAL


BAND LEVEL-dB
100
90
80
70
60
50
40
30
ORIGINAL
MODIFIED
20 75
75 150
150 300
300 600
600 1200
1200 2400
2400 4800
4800 9600
FREQUENCY BAND




BAND LEVEL-dB
100
90
80
70
60
50
40
30
ORIGINAL
MODIFIED
20 75
75 150
150 300
300 600
600 1200
1200 2400
2400 4800
4800 9600
FREQUENCY BAND

# PIPING-SYSTEM NOISE REDUCTION

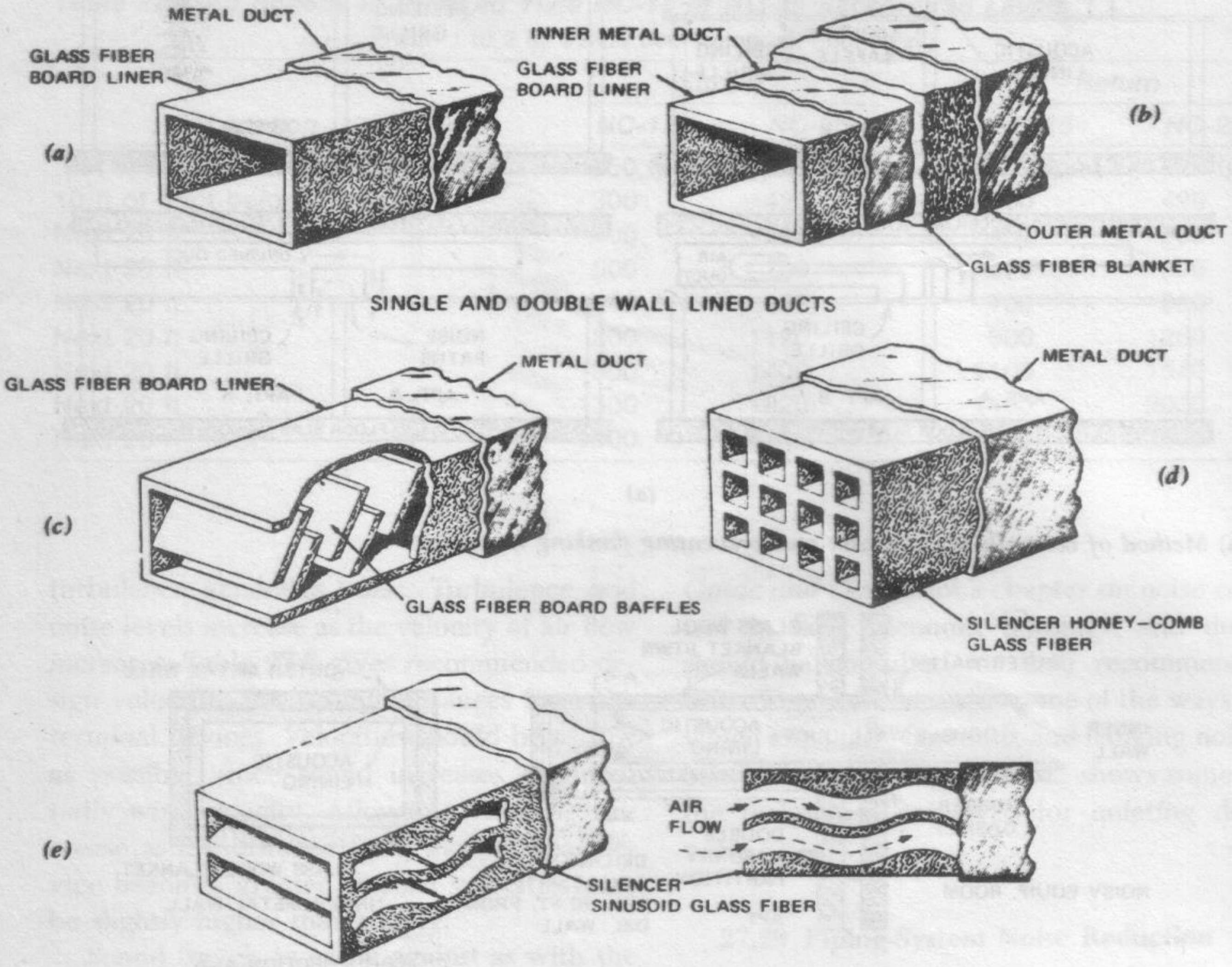


*Fig. 27.45 Unlined duct has negligible attenuation, and acts as an excellent speaking-tube. Inside lining* (a) *gives 2 to 3 db attenuation per foot in the 1 to 2 kHz range, dropping rapidly above and below those frequencies, and giving negligible low-frequency attenuation.* (b) *Double lining gives higher attenuation and reduces crosstalk between ducts. Duct silencers and baffles* (c–e) *give high broadband attenuation—maximum of 10 to 12 db/ft in the 1 to 2 kHz range, and lower above and below. They are useful to reduce fan noise in short runs but cause considerable pressure drop. From* A Guide to Airborne, Impact and Structure-Borne Noise Control in Multi-Family Dwellings, *U.S. Dept. of Housing and Urban Development, Washington, D.C., 1963, Figure 8–66.*

# BUILDING SITING; ROOM ARRANGEMENT

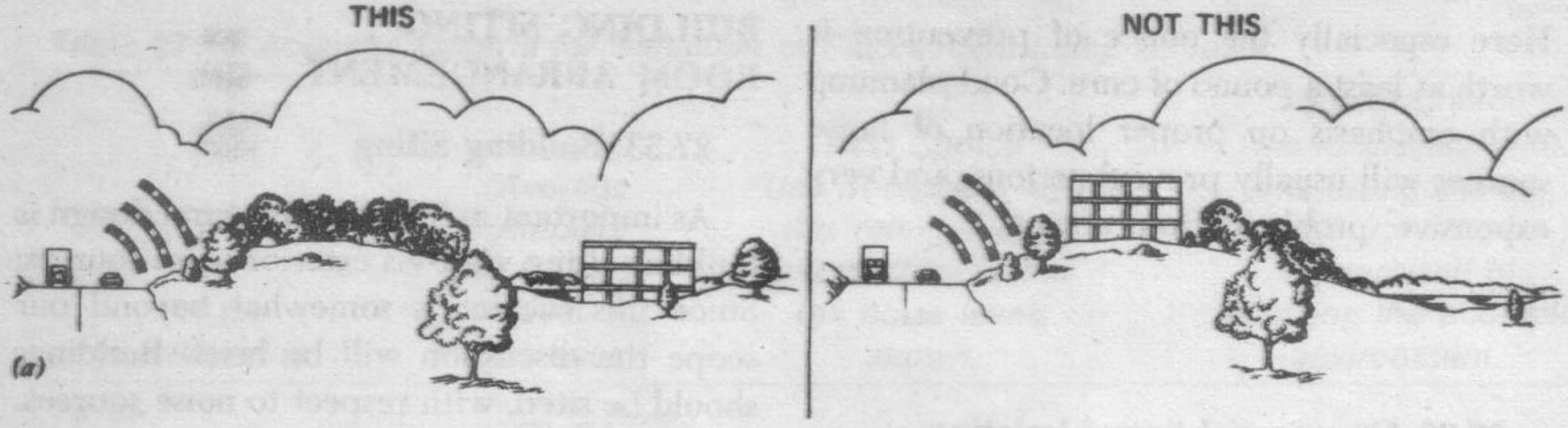
BANGUNAN DILETAKKAN DENGAN MEMPERHATIKAN SUMBER BISING:

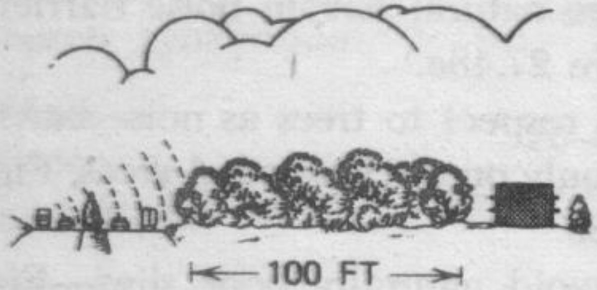
MENGGUNAKAN BARRIER ALAMIAH; KEADAAN LAPANGAN

MENGGUNAKAN POHON SEBAGAI BARRIER – HUTAN

MENGHINDARI TAPAK YANG TIDAK BAIK

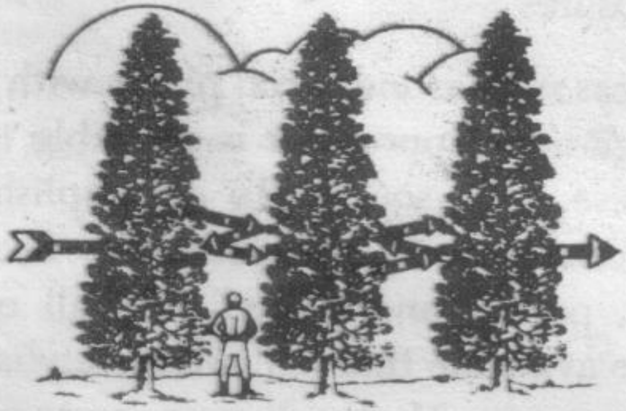
MENGHINDARI PANTULAN BUNYI DARI BANGUNAN LAIN





A THICK GROWTH OF LEAFY TREES AND UNDERBRUSH REDUCES NOISE ABOUT 6 to 7 DB/100 FT (AVERAGE OVER AUDIBLE FREQ. RANGE)

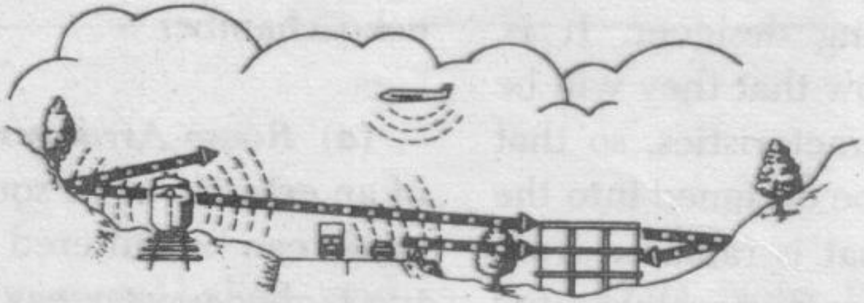
LOW–FREQ. LOSS: 3–4 dB
HIGH–FREQ. LOSS: 10–12 dB



HIGH FREQ. REDUCTION 3–4 dB

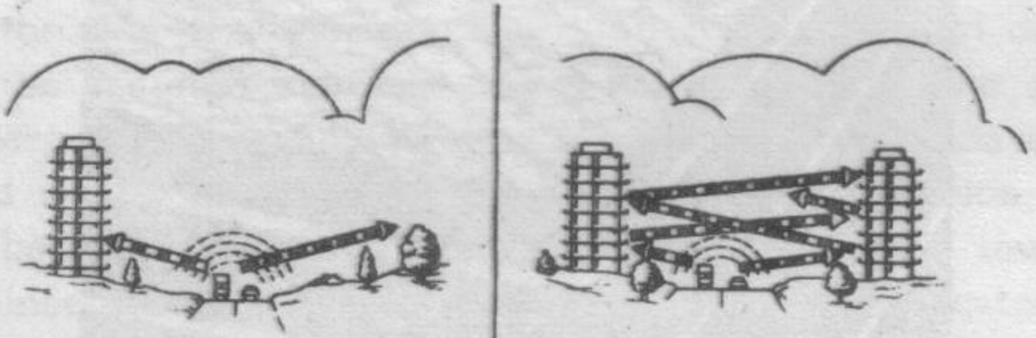
SINGLE ROW OF TREES IS WORTHLESS AS NOISE BARRIER. DUE TO INTER–REFLECTION MULTI–ROWS OF TREES ARE MORE EFFECTIVE

(c)



AVOID HOLLOWS OR DEPRESSIONS.
THEY ARE GENERALLY NOISIER THAN
FLAT OPEN LAND.

(d)



BUILDING SITES IN OPEN
AREAS ARE LESS NOISY
THAN SITES IN CONGESTED
BUILDING AREAS

TRAFFIC ARTERIES BETWEEN
TALL BUILDINGS ARE
QUITE NOISY.

**Fig. 27.48** (a) *Use of natural noise barriers.* (b) *Effectiveness of wooded areas as noise barriers. Noise reduction of trees.* (c) *An example of a poor building site.* (d) *Building sites near traffic arteries and other buildings. From* A Guide to Airborne, Impact and Structure-Borne Noise Control in Multi-Family Dwellings. *U.S. Dept. of Housing and Urban Development, Washington, D.C., 1963, p. 5–2.*

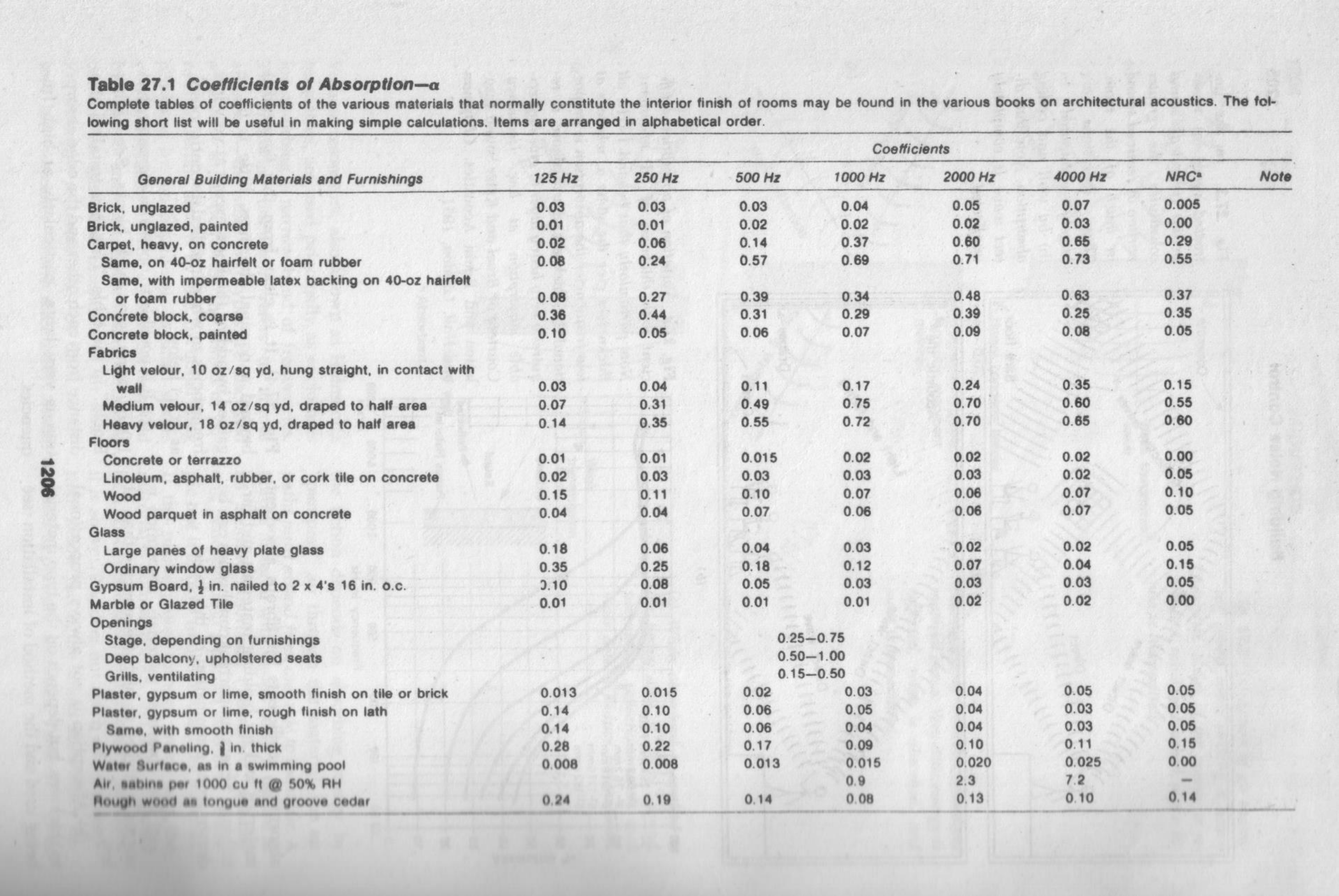
# TUGAS 2

DESAIN AUDITORIUM, LUAS LANTAI 15 X 40 M TINGGI RATA-RATA 5M, TENTUKAN KAPASITAS MAKSIMALNYA DENGAN MENATA PANGGUNG DAN BARISAN TEMPAT DUDUK SECARA TERSKALA, TENTUKAN BAHAN-BAHAN INTERIORNYA DAN ALTERNATIF BAHAN PILIHAN SEHINGGA SECARA AKUSTIKAL OPTIMAL.

HITUNG DAN TENTUKAN LUAS MATERIAL TSB DENGAN KOEFISIEN SERAPAN BUNYI, TENTUKAN REVERBERATION TIME TERBAIK, GUNAKAN RAY DIAGRAM (GRAFIS) UNTUK SEMUA POSISI TERUTAMA PADA ZONE KRITIS.

LIHAT TABEL KOEFISIEN ABSORPSI, GUNAKAN f = 500Hz.

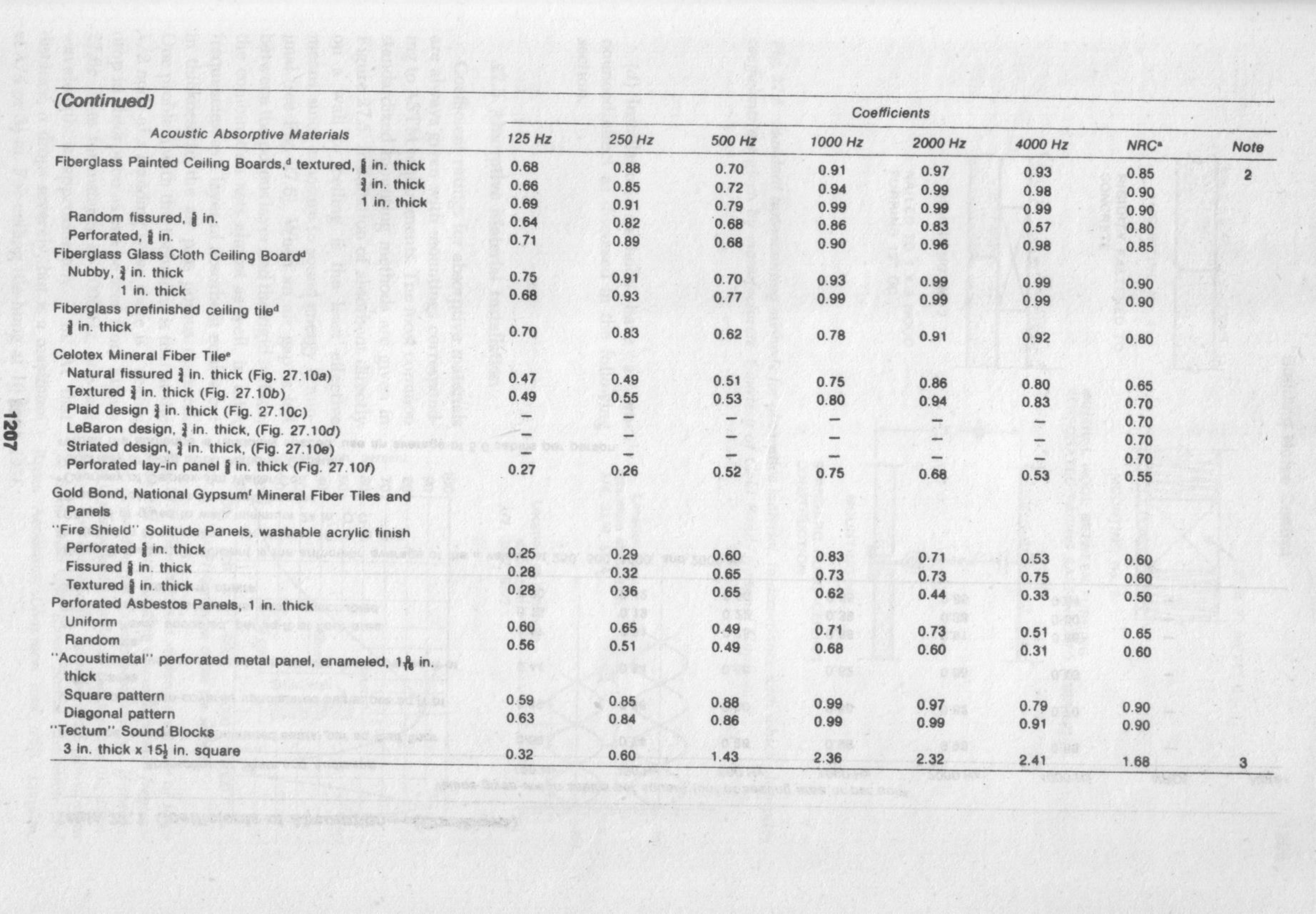
USULAN DESAIN PLAFON DAN ELEMEN AKUSTIKAL LAINNYA SEHINGGA DAPAT TERHINDAR DARI KEJADIAN AKUSTIK YG TDK DIINGINKAN SEPERTI ECHO, FLUTTER DLL.



## Table 27.1 *Coefficients of Absorption—α*

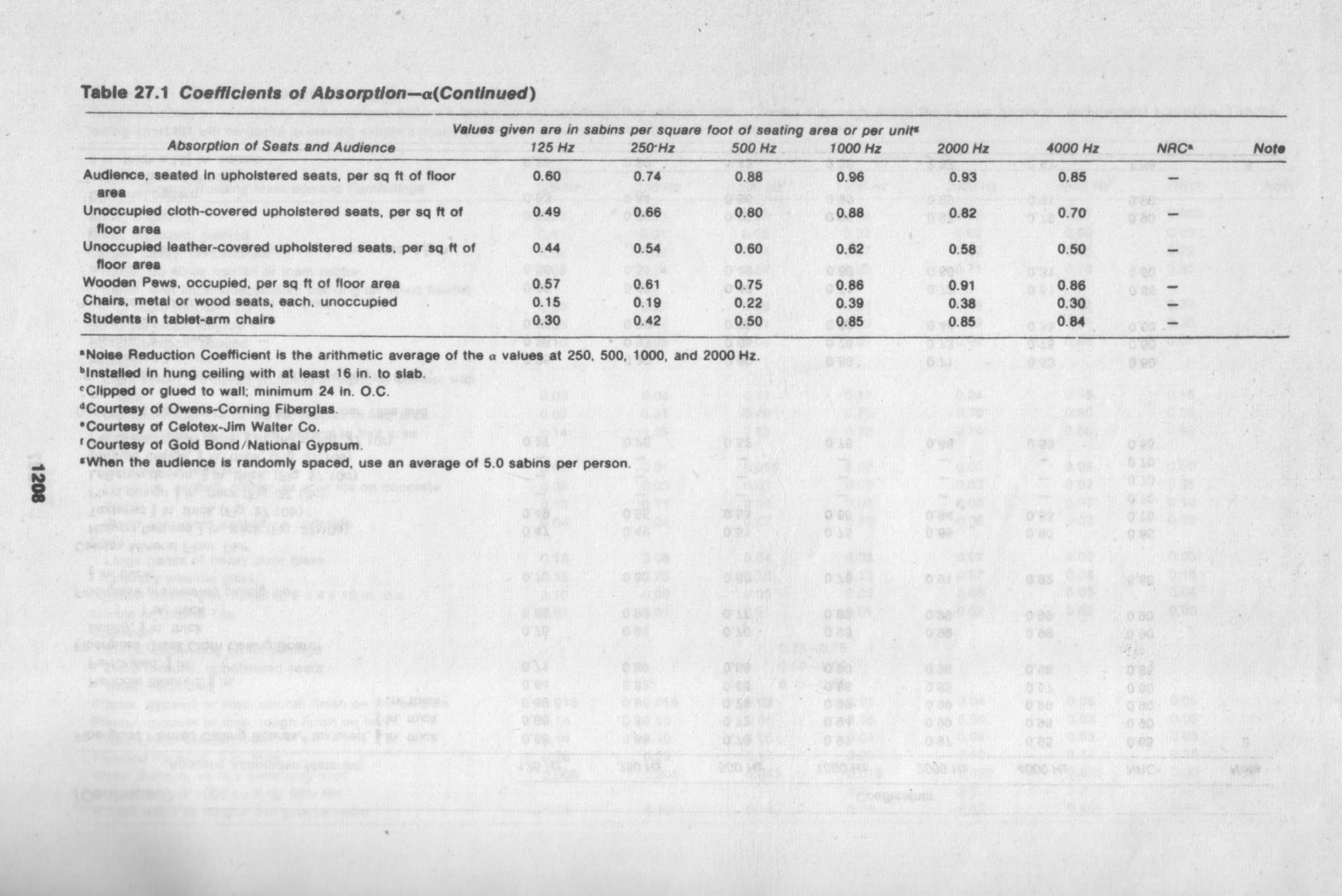
**Complete tables of coefficients of the various materials that normally constitute the interior finish of rooms may be found in the various books on architectural acoustics. The following short list will be useful in making simple calculations. Items are arranged in alphabetical order.**

| *General Building Materials and Furnishings* | *Coefficients*<br>*125 Hz* | *250 Hz* | *500 Hz* | *1000 Hz* | *2000 Hz* | *4000 Hz* | *NRC*[a] | *Note* |
|---|---|---|---|---|---|---|---|---|
| Brick, unglazed | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.07 | 0.005 | |
| Brick, unglazed, painted | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.00 | |
| Carpet, heavy, on concrete | 0.02 | 0.06 | 0.14 | 0.37 | 0.60 | 0.65 | 0.29 | |
| Same, on 40-oz hairfelt or foam rubber | 0.08 | 0.24 | 0.57 | 0.69 | 0.71 | 0.73 | 0.55 | |
| Same, with impermeable latex backing on 40-oz hairfelt or foam rubber | 0.08 | 0.27 | 0.39 | 0.34 | 0.48 | 0.63 | 0.37 | |
| Concrete block, coarse | 0.36 | 0.44 | 0.31 | 0.29 | 0.39 | 0.25 | 0.35 | |
| Concrete block, painted | 0.10 | 0.05 | 0.06 | 0.07 | 0.09 | 0.08 | 0.05 | |
| Fabrics | | | | | | | | |
| Light velour, 10 oz/sq yd, hung straight, in contact with wall | 0.03 | 0.04 | 0.11 | 0.17 | 0.24 | 0.35 | 0.15 | |
| Medium velour, 14 oz/sq yd, draped to half area | 0.07 | 0.31 | 0.49 | 0.75 | 0.70 | 0.60 | 0.55 | |
| Heavy velour, 18 oz/sq yd, draped to half area | 0.14 | 0.35 | 0.55 | 0.72 | 0.70 | 0.65 | 0.60 | |
| Floors | | | | | | | | |
| Concrete or terrazzo | 0.01 | 0.01 | 0.015 | 0.02 | 0.02 | 0.02 | 0.00 | |
| Linoleum, asphalt, rubber, or cork tile on concrete | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.05 | |
| Wood | 0.15 | 0.11 | 0.10 | 0.07 | 0.06 | 0.07 | 0.10 | |
| Wood parquet in asphalt on concrete | 0.04 | 0.04 | 0.07 | 0.06 | 0.06 | 0.07 | 0.05 | |
| Glass | | | | | | | | |
| Large panes of heavy plate glass | 0.18 | 0.06 | 0.04 | 0.03 | 0.02 | 0.02 | 0.05 | |
| Ordinary window glass | 0.35 | 0.25 | 0.18 | 0.12 | 0.07 | 0.04 | 0.15 | |
| Gypsum Board, ½ in. nailed to 2 x 4's 16 in. o.c. | 0.10 | 0.08 | 0.05 | 0.03 | 0.03 | 0.03 | 0.05 | |
| Marble or Glazed Tile | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.00 | |
| Openings | | | | | | | | |
| Stage, depending on furnishings | | | 0.25–0.75 | | | | | |
| Deep balcony, upholstered seats | | | 0.50–1.00 | | | | | |
| Grills, ventilating | | | 0.15–0.50 | | | | | |
| Plaster, gypsum or lime, smooth finish on tile or brick | 0.013 | 0.015 | 0.02 | 0.03 | 0.04 | 0.05 | 0.05 | |
| Plaster, gypsum or lime, rough finish on lath | 0.14 | 0.10 | 0.06 | 0.05 | 0.04 | 0.03 | 0.05 | |
| Same, with smooth finish | 0.14 | 0.10 | 0.06 | 0.04 | 0.04 | 0.03 | 0.05 | |
| Plywood Paneling, ⅜ in. thick | 0.28 | 0.22 | 0.17 | 0.09 | 0.10 | 0.11 | 0.15 | |
| Water Surface, as in a swimming pool | 0.008 | 0.008 | 0.013 | 0.015 | 0.020 | 0.025 | 0.00 | |
| Air, sabins per 1000 cu ft @ 50% RH | | | | 0.9 | 2.3 | 7.2 | — | |
| Rough wood as tongue and groove cedar | 0.24 | 0.19 | 0.14 | 0.08 | 0.13 | 0.10 | 0.14 | |



*(Continued)*

| *Acoustic Absorptive Materials* | *125 Hz* | *250 Hz* | *500 Hz* | *1000 Hz* | *2000 Hz* | *4000 Hz* | *NRC*[a] | *Note* |
|---|---|---|---|---|---|---|---|---|
| | *Coefficients* | | | | | | | |
| Fiberglass Painted Ceiling Boards,[d] textured, 5/8 in. thick | 0.68 | 0.88 | 0.70 | 0.91 | 0.97 | 0.93 | 0.85 | 2 |
| 3/4 in. thick | 0.66 | 0.85 | 0.72 | 0.94 | 0.99 | 0.98 | 0.90 | |
| 1 in. thick | 0.69 | 0.91 | 0.79 | 0.99 | 0.99 | 0.99 | 0.90 | |
| Random fissured, 5/8 in. | 0.64 | 0.82 | 0.68 | 0.86 | 0.83 | 0.57 | 0.80 | |
| Perforated, 5/8 in. | 0.71 | 0.89 | 0.68 | 0.90 | 0.96 | 0.98 | 0.85 | |
| Fiberglass Glass Cloth Ceiling Board[d] | | | | | | | | |
| Nubby, 3/4 in. thick | 0.75 | 0.91 | 0.70 | 0.93 | 0.99 | 0.99 | 0.90 | |
| 1 in. thick | 0.68 | 0.93 | 0.77 | 0.99 | 0.99 | 0.99 | 0.90 | |
| Fiberglass prefinished ceiling tile[d] | | | | | | | | |
| 5/8 in. thick | 0.70 | 0.83 | 0.62 | 0.78 | 0.91 | 0.92 | 0.80 | |
| Celotex Mineral Fiber Tile[e] | | | | | | | | |
| Natural fissured 3/4 in. thick (Fig. 27.10*a*) | 0.47 | 0.49 | 0.51 | 0.75 | 0.86 | 0.80 | 0.65 | |
| Textured 3/4 in. thick (Fig. 27.10*b*) | 0.49 | 0.55 | 0.53 | 0.80 | 0.94 | 0.83 | 0.70 | |
| Plaid design 3/4 in. thick (Fig. 27.10*c*) | — | — | — | — | — | — | 0.70 | |
| LeBaron design, 3/4 in. thick, (Fig. 27.10*d*) | — | — | — | — | — | — | 0.70 | |
| Striated design, 3/4 in. thick, (Fig. 27.10*e*) | — | — | — | — | — | — | 0.70 | |
| Perforated lay-in panel 5/8 in. thick (Fig. 27.10*f*) | 0.27 | 0.26 | 0.52 | 0.75 | 0.68 | 0.53 | 0.55 | |
| Gold Bond, National Gypsum[f] Mineral Fiber Tiles and Panels | | | | | | | | |
| "Fire Shield" Solitude Panels, washable acrylic finish | | | | | | | | |
| Perforated 5/8 in. thick | 0.25 | 0.29 | 0.60 | 0.83 | 0.71 | 0.53 | 0.60 | |
| Fissured 5/8 in. thick | 0.28 | 0.32 | 0.65 | 0.73 | 0.73 | 0.75 | 0.60 | |
| Textured 5/8 in. thick | 0.28 | 0.36 | 0.65 | 0.62 | 0.44 | 0.33 | 0.50 | |
| Perforated Asbestos Panels, 1 in. thick | | | | | | | | |
| Uniform | 0.60 | 0.65 | 0.49 | 0.71 | 0.73 | 0.51 | 0.65 | |
| Random | 0.56 | 0.51 | 0.49 | 0.68 | 0.60 | 0.31 | 0.60 | |
| "Acoustimetal" perforated metal panel, enameled, 1 9/16 in. thick | | | | | | | | |
| Square pattern | 0.59 | 0.85 | 0.88 | 0.99 | 0.97 | 0.79 | 0.90 | |
| Diagonal pattern | 0.63 | 0.84 | 0.86 | 0.99 | 0.99 | 0.91 | 0.90 | |
| "Tectum" Sound Blocks | | | | | | | | |
| 3 in. thick x 15½ in. square | 0.32 | 0.60 | 1.43 | 2.36 | 2.32 | 2.41 | 1.68 | 3 |



### Table 27.1 *Coefficients of Absorption—α(Continued)*

| *Absorption of Seats and Audience* | *Values given are in sabins per square foot of seating area or per unit*[g]<br>*125 Hz* | *250 Hz* | *500 Hz* | *1000 Hz* | *2000 Hz* | *4000 Hz* | *NRC*[a] | *Note* |
|---|---|---|---|---|---|---|---|---|
| Audience, seated in upholstered seats, per sq ft of floor area | 0.60 | 0.74 | 0.88 | 0.96 | 0.93 | 0.85 | — | |
| Unoccupied cloth-covered upholstered seats, per sq ft of floor area | 0.49 | 0.66 | 0.80 | 0.88 | 0.82 | 0.70 | — | |
| Unoccupied leather-covered upholstered seats, per sq ft of floor area | 0.44 | 0.54 | 0.60 | 0.62 | 0.58 | 0.50 | — | |
| Wooden Pews, occupied, per sq ft of floor area | 0.57 | 0.61 | 0.75 | 0.86 | 0.91 | 0.86 | — | |
| Chairs, metal or wood seats, each, unoccupied | 0.15 | 0.19 | 0.22 | 0.39 | 0.38 | 0.30 | — | |
| Students in tablet-arm chairs | 0.30 | 0.42 | 0.50 | 0.85 | 0.85 | 0.84 | — | |

[a] Noise Reduction Coefficient is the arithmetic average of the α values at 250, 500, 1000, and 2000 Hz.

[b] Installed in hung ceiling with at least 16 in. to slab.

[c] Clipped or glued to wall; minimum 24 in. O.C.

[d] Courtesy of Owens-Corning Fiberglas.

[e] Courtesy of Celotex-Jim Walter Co.

[f] Courtesy of Gold Bond/National Gypsum.

[g] When the audience is randomly spaced, use an average of 5.0 sabins per person.