Acoustic Considerations in the Design of Commercial Buildings

Nick Boulter
Do acoustics matter in an office?

- Ability to communicate
- Health and well-being
- Comfort
- Privacy
- Efficiency and stamina
Maslow’s hierarchy of needs

- **Physiological**: breathing, food, water, sex, sleep, homeostasis, excretion
- **Safety**: security of: body, employment, resources, morality, the family, health, property
- **Love/belonging**: friendship, family, sexual intimacy
- **Esteem**: self-esteem, confidence, achievement, respect of others, respect by others
- **Self-actualization**: morality, creativity, spontaneity, problem solving, lack of prejudice, acceptance of facts


Acoustic Maslow?
- Noise vs Sound
Noise outside offices
Planning

• Offices are ‘live-in’ noise barriers
• Creates tranquil zones behind for non-airconditioned accommodation
• Intelligent planning
Reflective noise barriers

- Timber
- Concrete
Absorptive barriers
Transparent barriers
Semi enclosure
Noise in offices
Response to noise

LEVEL 1
Noise begins or is relatively quiet
Curiosity...
... or irritation

LEVEL 2
Noise continues or becomes louder
Annoyance, anger, bitterness, feeling aggrieved...
... or tension, pressure, frustration, resignation, feeling fraught and anxious

LEVEL 3
Noise gets worse still
Hatred, hostility, desire for revenge, bloodshed (I could murder, strangle, kill...)
Depression, tiredness: taking it out on others, feeling upset and frightened

*Source: C Grimwood ‘The effects of environmental noise on people at home’ BRE IP 22/93
SOUND IN ROOMS

- Sound level at a point comprises:
  - direct sound
  - reflected sound
Materials

- **sound insulation**
  - resistance to passage of sound
    - function of mass
    - function of thickness

- **sound absorption**
  - reduced reflections from surface
  - affects room acoustics
    - activity noise
    - PA intelligibility
Controlled porosity
Other issues

- **Slip / stick noise from expansion**
  - Design of movement joints
  - Choice of materials

- **Wind noise**
  - Sharp edged slots
  - Arrays of elements with similar dimensions
  - Loose / poorly damped fittings
  - Airborne and structureborne noise
Privacy
Sound insulation depends on:

- Performance of partition
- Size of partition
- Acoustics of rooms
- Sound transfer around the partition (‘flanking’)
Privacy depends on...

- **Sound insulation**
- **PLUS**
  - Level of ‘source’ noise
  - Level of masking noise in ‘receiver’
Effect of ambient sound
Privacy and disturbance

For ‘communication’ read ‘disturbance’
Speech transmission index

- Bad STI – good privacy – minimal disturbance
- Excellent STI – bad privacy – maximum of disturbance
Rating Privacy

- Add sound insulation to masking noise (NR + Dw)
- Upper range of ‘good’ for offices
- ‘Excellent’ for meeting rooms
<table>
<thead>
<tr>
<th>Normal Speech</th>
<th>Raised Voices</th>
<th>Continuous Listener</th>
<th>Background</th>
<th>Noise Level</th>
<th>D_{w} + NR</th>
<th>Speech Privacy Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NR30</td>
<td>NR35</td>
<td>NR40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room-to-Room Weighted Level Difference $D_{w}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intelligible</td>
<td>Clearly intelligible and possibly disturbing</td>
<td>&lt;35</td>
<td>&lt;30</td>
<td>&lt;25</td>
<td>&lt;65</td>
<td>Poor</td>
</tr>
<tr>
<td>Audible. Could be intelligible if speaker and/or subject well known</td>
<td>Intelligible</td>
<td>35-40</td>
<td>30-35</td>
<td>25-30</td>
<td>65-70</td>
<td>Fair</td>
</tr>
<tr>
<td>Audible but not intelligible</td>
<td>Audible. Could be intelligible if speaker and/or subject well known</td>
<td>40-45</td>
<td>35-40</td>
<td>30-35</td>
<td>70-75</td>
<td>Good</td>
</tr>
<tr>
<td>Just audible</td>
<td>Audible but not intelligible</td>
<td>45-55</td>
<td>40-50</td>
<td>35-45</td>
<td>75-85</td>
<td>Very Good</td>
</tr>
<tr>
<td>Inaudible</td>
<td>Just audible</td>
<td>&gt;55</td>
<td>&gt;50</td>
<td>&gt;45</td>
<td>&gt;85</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
Sound Insulation
Typical constructions

Typical constructions:

- **D_w 45**
  - 2x12.5 mm plasterboard (675 kg/m³)
  - 70 mm stud, 25 mm insulation (32 kg/m³)
  - Dw 45

- **Cavity size**

- **D_w 50**
  - 2x15 mm plasterboard (800 kg/m³)
  - 146 mm stud, 50 mm insulation (32 kg/m³)
  - Dw 50

- **Discontinuity**

- **D_w 55**
  - 2x12.5 mm plasterboard (800 kg/m³)
  - 60 mm staggered stud in 72 mm channel
  - 50 mm insulation (32 kg/m³), Dw 55

- **D_w 60**
  - 2x15 mm plasterboard (800 kg/m³)
  - 92 mm stud in 148 mm channel
  - 100 mm insulation (32 kg/m³), Dw 60
Flanking Paths

- Ceiling void
- Transfer through mullions
- Floor void
- Ducts and cable trunking
- Transfer along ceilings and floors
- Doors
Sound Flanking
Flanking through slab edge detail
Flanking through mullion
Horizontal sound insulation – weak mullion

Rw45

Rw40 for 20% of the area

Rw50 for 80% of area
Treatment to mullions

Pack inside of mullion

Over-clad mullion

Split mullion
Important factors that control privacy and disturbance

• steady background noise levels at the ‘receiving’ work stations
• screening between work stations
• distance between work stations
• sensitivity of users of the work stations to intrusive noise
• level and character of intrusive noise sources
• sound absorption around the work stations
• orientation of speakers and listeners
> 6dB(A) reduction at 180°, > 2dB(A) at 90°
Poor orientation of speakers and listeners
Better orientation
Team orientation
In the end –

- It doesn’t matter what you do, if you don’t have a steady, ‘nicely’ shaped background noise level it will be very difficult to minimise disturbance and maximise privacy – within the parameters already discussed.

- You still have to consider more than one cluster of work stations.

- There is the probability that some cellular offices will be needed.

- Modelling?
Worst orientation
Soundscapes and Soundmarks: Aural identity
Auralization

Emitted impulse

Real Hall or Computer Model

Impulse Response

Amplitude

Amplitude

Amplitude

Anechoic Music

Impulse Response

Sound in the SoundLab

\[ t \]

\[ t \]
Any questions?