Acoustic Design and changes to the National Building Code

Alan Oldfield
Why Acoustics Matters
Acoustics
sound propagation and transmission
Home

– #1 Quality of Life Complaint in NYC i

– 1 in 5 people in Europe regularly exposed to sound levels at night that could “significantly damage health” ii

i Associated Press, 2014.
Education Facilities

– Poor acoustic conditions have a detrimental impact on learning and performance
– 60% of UK teachers experience voice problems

iii Durup, Shield, Dance & Sullivan, 2013.
Work

- Acoustics is the biggest complaint in office buildings
- 70% of workers said they could be more productive in a less noisy office environment

Healthcare Facilities

- Sensitivity to the environment (patients, staff, visitors)
- Acoustics affects health outcomes and staff performance and wellbeing
- Patient confidentiality: steps required to ensure privacy (US HIPAA)
Behaviour of Sound in Rooms
Behaviour of sound in rooms

Acoustic metric:

**Reverberation Time**

= how long it takes sound to decay by 60 dB.
Behaviour of sound in rooms

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Acoustic metric:

**Reverberation Time**

= how long it takes sound to decay by 60 dB.

- Dry Speech
  - Speech 0.8 s
  - Speech 1.3 s
  - Speech 2 s
  - Speech 5 s

- Classical music 2 s
- Pop music 2 s
- Pop music 0.6 s
Behaviour of sound in rooms

Acoustic metric: **Reverberation Time**

= how long it takes sound to decay by 60 dB.

**How can it be controlled?**

**Other considerations**

- Occupant reflex effects: vi
  - Lombard
  - Cocktail Party
  - Café

vi Campanella & Ryherd, 2008.
Behaviour of sound in rooms

Acoustics for Speech

Direct Sound

Early reflections (less than 50 ms)

Late reflections (arrive after 50 ms)
Behaviour of sound in rooms

Acoustics for Speech

Direct Sound

Early reflections
(less than 50 ms)

Late reflections
(arrive after 50 ms)
Behaviour of sound in rooms

Acoustics for Speech
Speech Intelligibility vs. Privacy
Speech Intelligibility vs. Privacy

Speech intelligibility – effective, detectable transmission

Speech privacy – blocked or masked transmission

– Influenced by:
  • Source characteristics
  • Room acoustics
  • Background noise
  • Transmission loss (separating elements, if present)
Speech Intelligibility vs. Privacy
Acoustics for Open Plan
Speech Intelligibility vs. Privacy

Acoustics for Open Plan
Speech Intelligibility vs. Privacy
Electronic Sound Masking

White Noise  v.
Pink Noise
Speech Intelligibility vs. Privacy

Electronic Sound Masking
Sound Insulation
Sound Transmission vs Insulation

Sound transmission = path(s) from one point to another

Insulation = transmission loss, degree of attenuation

STC = Sound Transmission Class (airborne insulation)

IIC = Impact Insulation Class
Sound Transmission Class (STC) Rating

\[ TL = L1 - L2 + 10 \log(S/A) \]

L1 = source room sound level; L2 = receiving room sound level
S = partition area
A = total Sabine absorption in the receiving room
Sound Transmission Class (STC) Rating

e.g. 190 mm solid concrete block
Sound Transmission Class (STC) Rating

e.g. 190 mm solid concrete block
Sound Transmission Class (STC) Rating

e.g. 190 mm solid concrete block
Sound Transmission Class (STC) Rating

e.g. 190 mm solid concrete block

Conditions for STC rating:
- Deficiencies ≤ 8
- Sum of deficiencies ≤ 32
Sound Transmission Class Rating

e.g. 190 mm solid concrete block

STC 55
Sound Transmission Class Rating

e.g. 190 mm solid concrete block vs. drywall assembly
Sound Transmission Class Rating

e.g. 190 mm solid concrete block vs. drywall assembly
Sound Transmission Class Rating

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Sound Transmission Class Rating

e.g. 190 mm solid concrete block vs. drywall assembly
Sound Transmission Class (STC) Rating

e.g. single stud vs. twin stud drywall assembly
Enhancing Sound Insulation

Increase Mass

(a) | (b) | (c)
---|----|----
STC 34 | STC 39 | STC 45

90 mm Solid STC 45 140 mm Solid STC 50 190 mm Solid STC 55
Enhancing Sound Insulation

Increase Cavity

- 64 mm stud
  - STC 36

- 92 mm stud
  - STC 38

- 152 mm stud
  - STC 41

Add Cavity Insulation

- STC 40
- STC 43
- STC 49
Enhancing Sound Insulation

Increase Isolation

Non-loadbearing studs (25 ga.) vs loadbearing (18 or 20 ga.)

STC 56 vs STC 38

Resilient channels or clips

STC 60

Staggered or Twin studs

STC 57

STC 65
Flanking Sound Transmission
Flanking Sound Transmission

Diagram showing sound transmission through a partition and methods to seal or improve the partition's effectiveness.
Airborne Sound Insulation

Direct Transmission only:

**STC**
Sound Transmission Class
(based on laboratory TL’s)

Direct + Flanking:

**ASTC**
Apparent STC
(based on in-situ TL’s)
Airborne Sound Insulation – other in-situ test metrics

Direct Transmission only (flanking paths suppressed):

**FSTC**, Field STC
(based on in-situ TL’s)

Direct + Flanking:

**NIC**, Noise Isolation Class
(based on in-situ LD’s)
2015 National Building Code Changes to Acoustical Performance Requirements
National Building Code 2010
and Ontario Building Code 2012

Separation between dwelling unit or hotel suite and every other space in a building: ≥ **STC 50**.

Separation between dwelling unit or hotel suite and an elevator shaft or refuse chute: ≥ **STC 55**.
National Building Code 2015

Separation between dwelling unit or hotel suite and every other space in a building: \( \geq \text{ASTC 47}, \) or:

\( \geq \text{STC 50} \) and adjoining constructions that conform to Article 9.11.1.4

Separation between dwelling unit or hotel suite and an elevator shaft or refuse chute: \( \geq \text{STC 55}. \)
Example

– With a continuous and bare sub floor:
  • Install additional flooring to both sides
  • Break the sub-floor and install a non-rigid fire block
National Building Code 2015

Compliance Options:

1. $\geq$ ASTC 47 from field measurements

2. $\geq$ ASTC 47 calculated according to:
   - Detailed Method; or:
   - Simplified Method.

3. $\geq$ STC 50 from laboratory measurements and flanking assemblies in Article 9.11.1.4
ASTC Calculation Methods

**Detailed Method**
- Uses frequency band data
- Multiple calculations and spreadsheets needed
- Incorporates vibration reduction index for junctions

**Simple Method**
- Uses single figure ratings
- Can be completed with a single spreadsheet or online calculator (soundPATHS)
- More conservative
ASTC Calculation
Simple Method Example 4.1.3 (from NRC Guide)

Separating Floor/Ceiling

- Separating surface area = 19.6 m²
- Wall/floor junction length = 4.6 m

Junction 1 or 3 with loadbearing side walls above and below the floor/ceiling assembly (wood I joists of floor are perpendicular to loadbearing wall). (Side view)

Junction 2 or 4 with non-loadbearing side walls above and below the floor/ceiling assembly (wood I joists of floor are parallel to the non-loadbearing wall). (Side view)
<table>
<thead>
<tr>
<th>Separating Partition (Wood-framed separating floor/ceiling)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab. Sound Transmission Class (STC)</td>
<td>RR-336, TLF-13-WIJ305-001</td>
<td>51.0</td>
</tr>
<tr>
<td>Effect of Airborne Flanking</td>
<td>No Leakage</td>
<td>0.0</td>
</tr>
<tr>
<td>Direct STC in situ (Path DD through separating floor)</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td><strong>Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flanking Path Ff_1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Flanking STC for Ff</td>
<td>RR-336, FTL-13-WIJ305-FW-LB-001</td>
<td>64.0</td>
</tr>
<tr>
<td>Normalization correction</td>
<td>Guide Eq. 1.5</td>
<td>-0.3</td>
</tr>
<tr>
<td><strong>Flanking Path Fd_1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Flanking STC for Fd</td>
<td>RR-336, FTL-13-WIJ305-FW-LB-001</td>
<td>57.0</td>
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<td><strong>Flanking STC for path Ff_1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Flanking STC for Df</td>
<td>RR-336, FTL-13-WIJ305-FW-LB-001</td>
<td>90+</td>
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<td></td>
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<tr>
<td>Laboratory Flanking STC for Df</td>
<td>RR-336, FTL-13-WIJ305-FW-LB-001</td>
<td>56.7</td>
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<td>-0.3</td>
</tr>
<tr>
<td><strong>Flanking STC for Junction_1</strong></td>
<td>Guide, Subset of Eq. 1.4</td>
<td>-10*LOG10(10^-6.4 + 10^-5.7 + 10^-9) = 56</td>
</tr>
<tr>
<td><strong>Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flanking Path Ff_2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Flanking STC for Ff</td>
<td>RR-336, FTL-13-WIJ305-FW-NLB-001</td>
<td>64.0</td>
</tr>
<tr>
<td>Normalization correction</td>
<td>Guide Eq. 1.5</td>
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<td></td>
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<tr>
<td><strong>Flanking STC for Junction_2</strong></td>
<td>Guide, Subset of Eq. 1.4</td>
<td>-10*LOG10(10^-6.5 + 10^-6.2 + 10^-9) = 60</td>
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<td><strong>Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)</strong></td>
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<td></td>
</tr>
<tr>
<td>All values the same as Junction 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flanking STC for Junction_3</strong></td>
<td>Same as Junction 1</td>
<td>56</td>
</tr>
<tr>
<td><strong>Junction 4 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All values the same as for Junction 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flanking STC for Junction_4</strong></td>
<td>Same as Junction 2</td>
<td>60</td>
</tr>
<tr>
<td>Combined transmission via all Flanking Paths</td>
<td>Guide, Subset of Eq. 1.4 for 12 flanking paths</td>
<td>52</td>
</tr>
<tr>
<td><strong>ASTC due to Direct plus Flanking Transmission</strong></td>
<td>Guide, Eq. 1.4 (Combine Direct and 12 Flanking Paths)</td>
<td>48</td>
</tr>
</tbody>
</table>
ASTC Calculation
*soundPATHS* example 1

Separating Wall | Top/Bottom | Front/back

Side view | Top view
ASTC Calculation
soundPATHS example 1

Separating Wall

Top/Bottom

Front/back

Side view  Top view

STC 57
ASTC Calculation
*soundPATHS* example 1

Separating Wall

Top/Bottom
- Flanking STC 57
- Flanking STC 45

Front/back
- Flanking STC 65
ASTC Calculation
soundPATHS example 1

Separating Wall

Top/Bottom
Flanking STC 57
Flanking STC 45

Front/back
Flanking STC 65

ASTC 44
ASTC Calculation

*soundPATHS* example 2

**Separating Wall**

- Side view
- Top view

- STC 57

**Top/Bottom**

- Flanking STC 57
- Flanking STC 53

**Front/back**

- Flanking STC 65
- Flanking STC 65

ASTC 50
ASTC Calculation
soundPATHS example 3

Separating Wall

Top/Bottom

Front/back

ASTC 49

Flanking STC 57

Flanking STC 50

Flanking STC 65

Flanking STC 65

Flanking STC 65
Additional considerations

Examples presented do not include any allowance for workmanship, leakage or airborne flanking transmission

Ensure perimeters and junctions are well sealed
Additional considerations

Avoid penetrations through separating assemblies

Avoid back-to-back electrical boxes – stagger if possible
Additional considerations

Do not short circuit resilient channels
Potential Changes for Future Editions?

Guidance for corridor partitions with entry doors
Potential Changes for Future Editions?

Guidance on impact insulation
Recommended standard for bare party floors: IIC 50
(Corresponding AIIC may be slightly lower)

Achieve impact insulation with
– Resilient floor finish, or
– Resilient layer between subfloor and floor finish
Guidance on Impact insulation

Examples:

150 mm thick concrete floor slab: IIC 28

Carpet + quality underlay: IIC 75-85

Concrete topping + mineral fibre board: IIC 60-65

Plywood + wood strapping + fibre board: IIC 50-55
Guidance on Impact insulation

Examples:

- Basic joist floor: IIC 40-45
- Carpet + quality underlay: IIC 75-85
- Concrete topping + resilient layer: IIC 55-65
- Plywood + wood strapping + fibre board: IIC 55-58
Guidance on Impact Insulation

Perimeter isolation must be maintained to avoid short circuit

- Resilient flanking strip
- Acoustic sealant
- Acoustic sealant – isolate base board and wall lining from concrete topping
- Perimeter insulation board isolate concrete topping from wall framework
Thank You

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