BUILDING ENVELOPE ACOUSTICS

Common Challenges and Industry Best Practices

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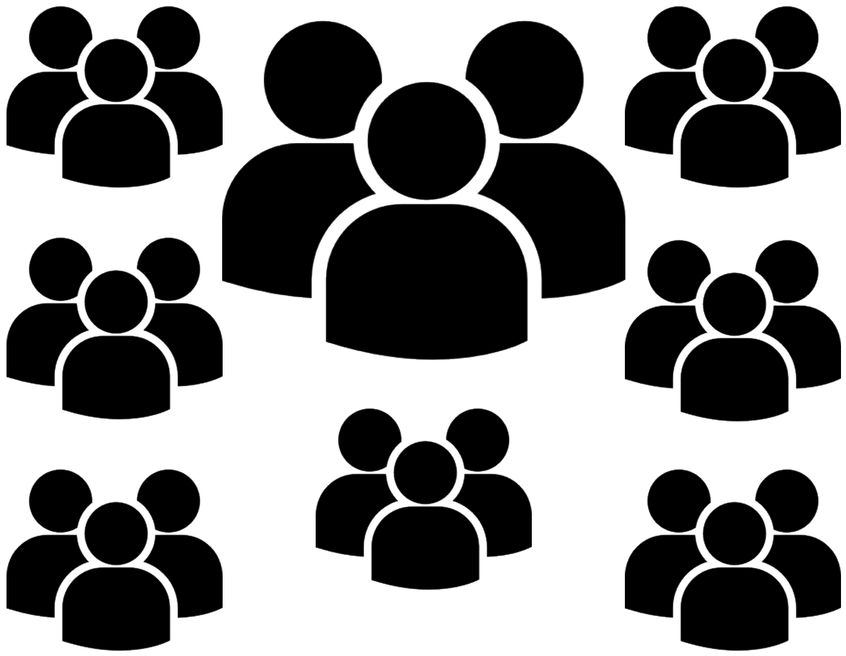
As the population grows,
so does demand for more housing.



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Overview

Three key points will be covered:

- Basics of building envelope acoustics
- Industry best practices
- What to avoid when designing building envelopes

Proper envelope design plays a crucial role in ensuring the acoustical comfort of building occupants.

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Why Does Acoustical Design Matter?

- New buildings near major noise sources
- Misunderstanding about acoustic performance of building envelope
- Acoustic requirements in municipalities is getting more stringent

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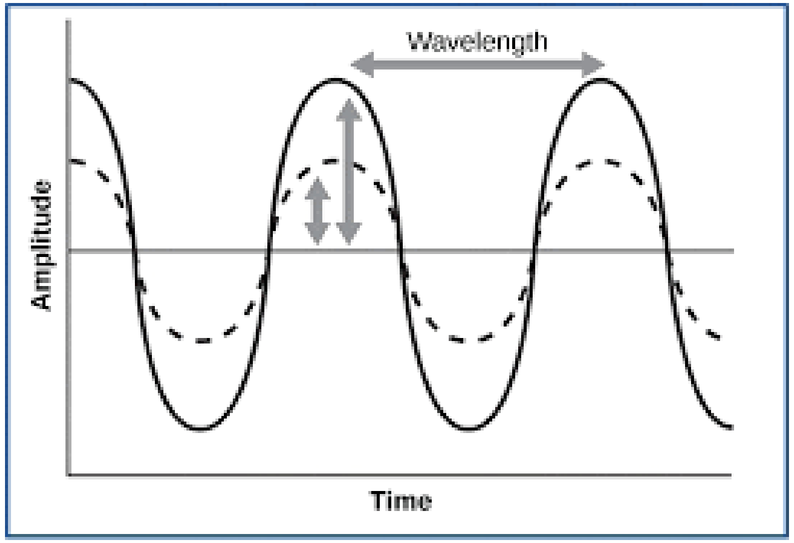
Health Effects of Noise

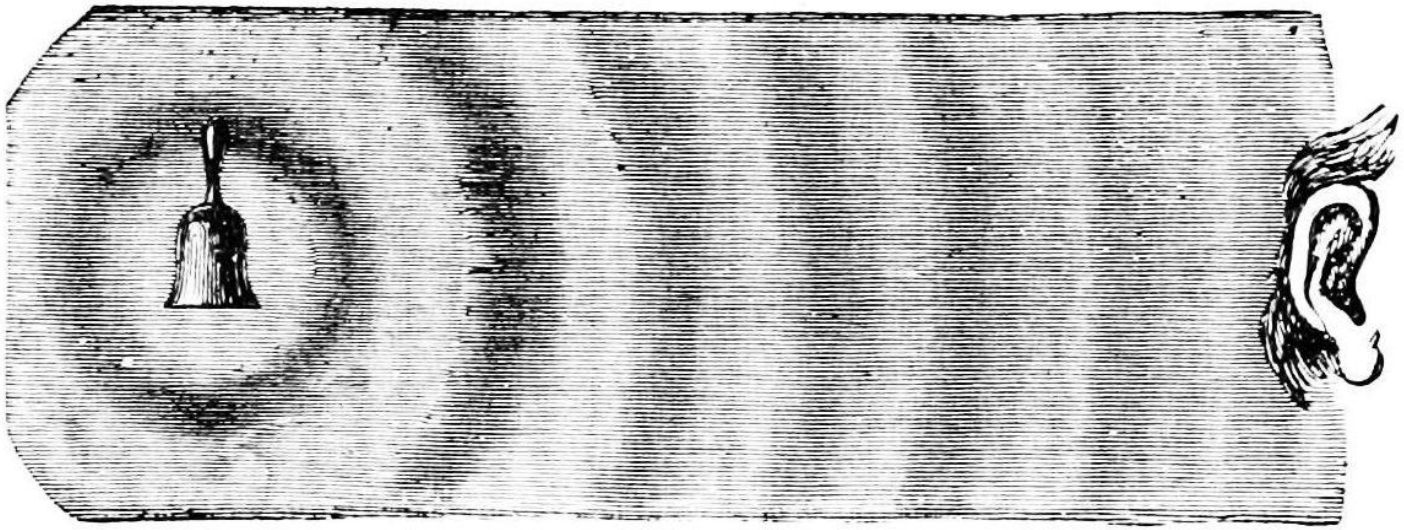
Proven health conditions include:

- CARDIOVASCULAR DISEASE
- COGNITIVE IMPAIRMENT
- ANNOYANCE
- HEARING IMPAIRMENT & TINNITUS
- EFFECTS ON SLEEP

What is Sound?

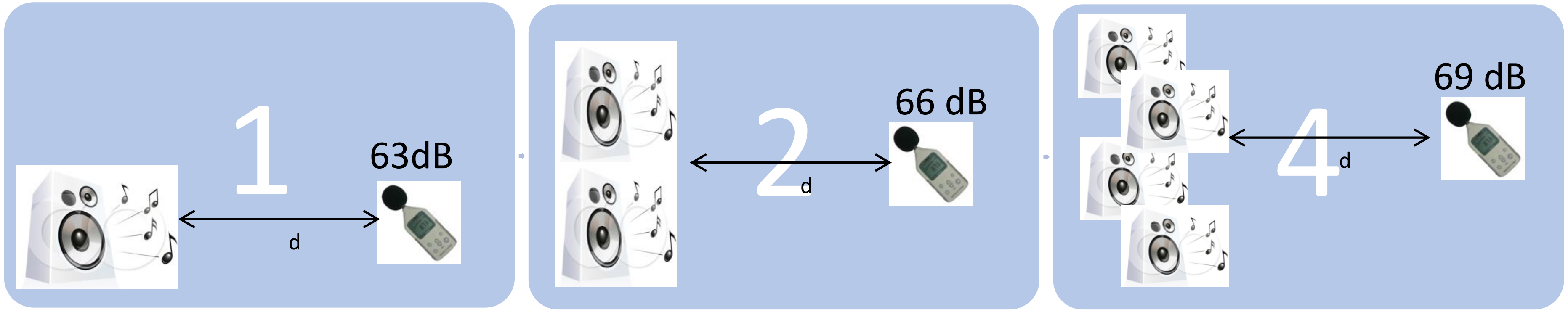
- Sound: Energy that is transmitted by pressure waves in air or other materials and is the objective cause of the sensation of hearing.
- Noise: Unwanted sound





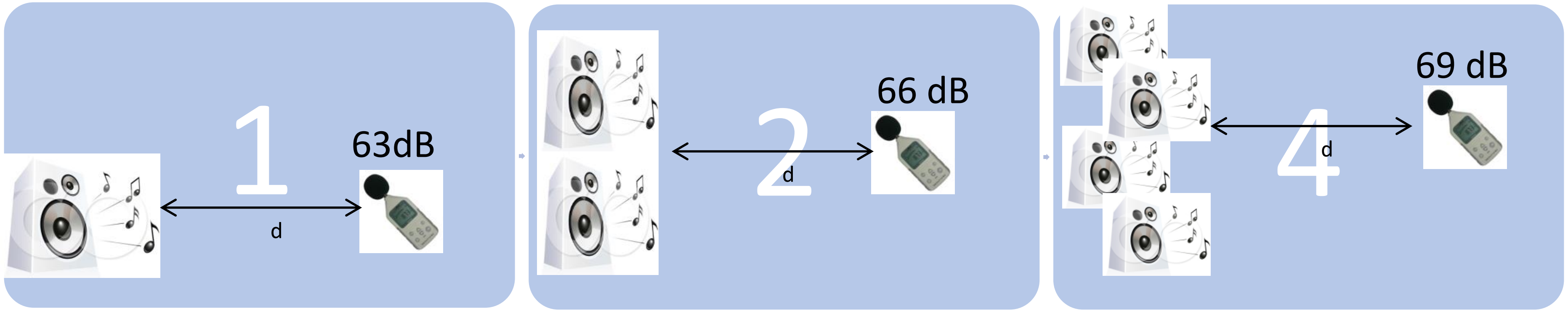
Levels and the Decibel

- The unit used to describe the magnitude of sound is the decibel (dB) which is 10 times the common logarithm of ratio of two quantities linearly related to power.
- A doubling of sound power/energy equates to a 3 dB increase in sound pressure level.



Loudness vs Sound Pressure Level

Change in Level dB	Change in Perceived Loudness
1	Imperceptible
3	Just Perceptible
6	Clearly Noticeable
10	Twice as loud
20	Four times as loud



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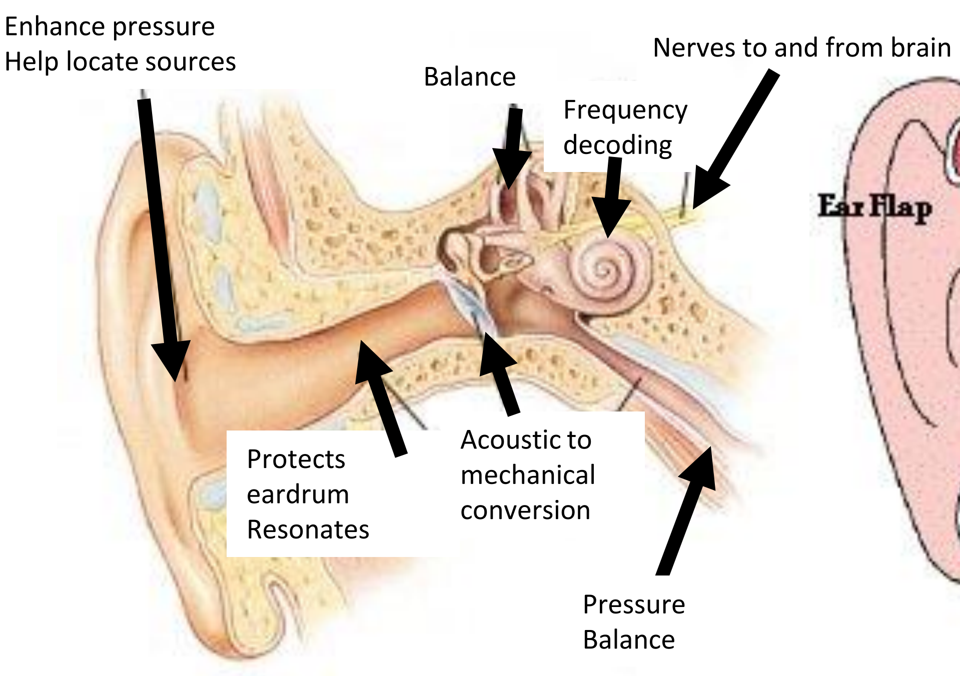
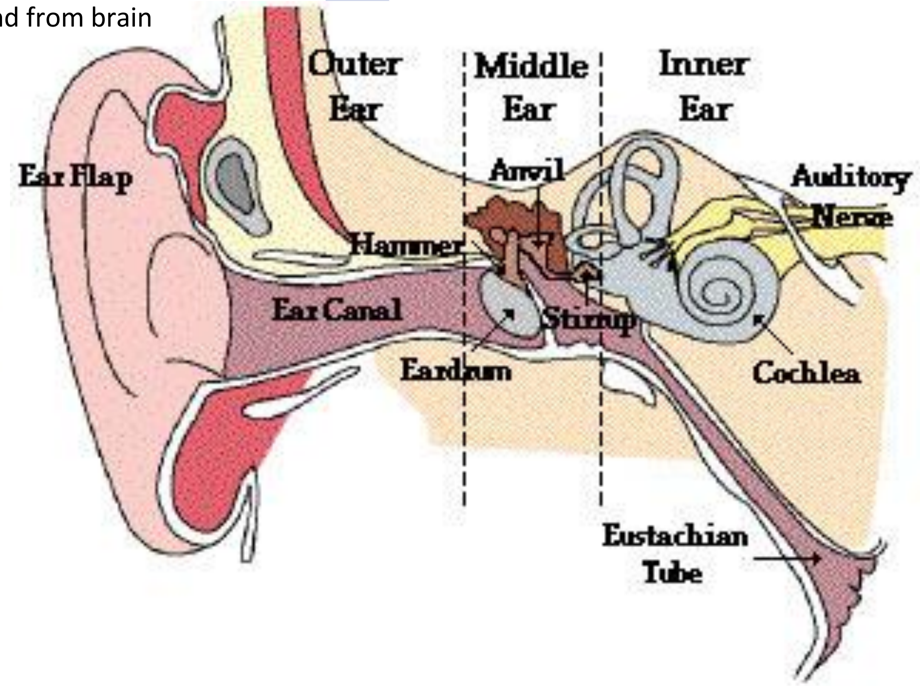
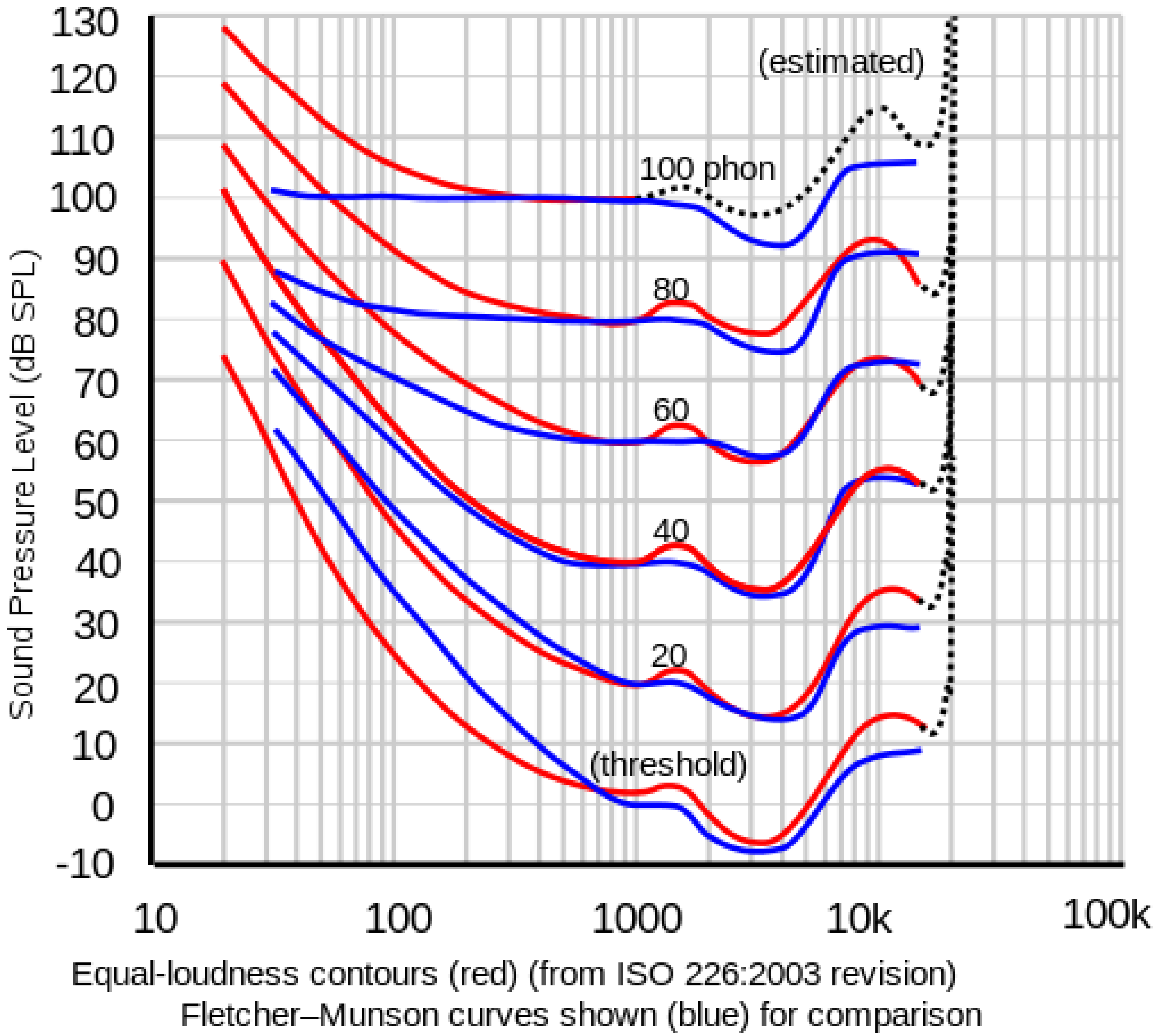
How Do We Hear Sound?





Do We Perceive All Sound Equally?

- We are more sensitive to middle frequency sound. We are less sensitive to sound to very low and very high frequency sound
- Resonance in outer ear amplified sound at middle frequency
- To approximate the response of human ear, A-weighted decibel level is typically used



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Frequency Descriptors

Frequency (Hz)
16
32
63
125
250
500
1000
2000
4000
8000
16000
32000

- Rumble
- Buzz
- Hum
- Whistle
- Hiss

$\left.\begin{array}{l}\text{Rumble}\\ \text{Buzz}\\ \text{Hum}\\ \text{Whistle}\\ \text{Hiss}\end{array}\right\}$ Broadband Sound

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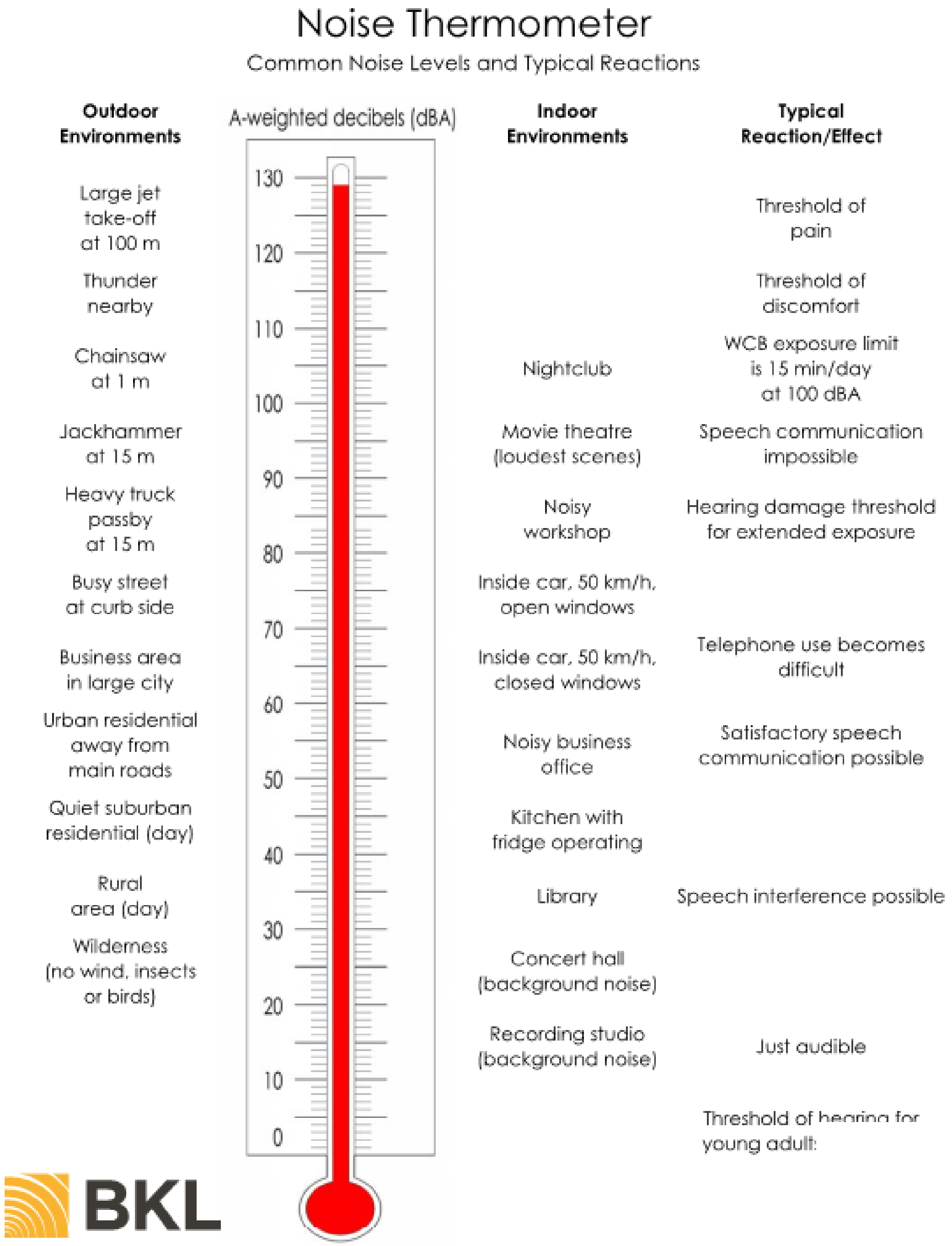
How Loud is a Certain Sound?

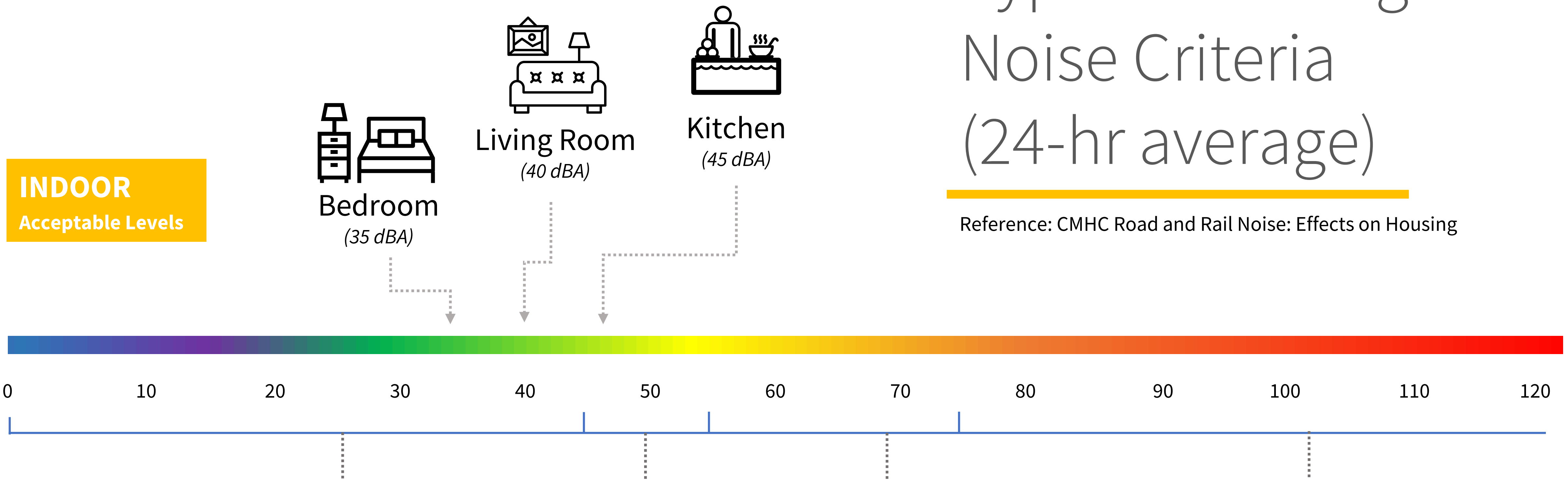


What Are the Noise Criteria?

- BC Building Code?
- WELL and LEED v4?
- CMHC?
- FTA?
- WHO?
- Municipal bylaws (rezoning, development and/or building permit phases)?

Typical Housing Noise Criteria (24-hr average)

Reference: CMHC Road and Rail Noise: Effects on Housing



OUTDOOR
Accessible Levels

Acceptable
(0-45 dBA)

- Noise exposure both indoors and outdoors is unobstrusive

Normally Acceptable
(46-55 dBA)

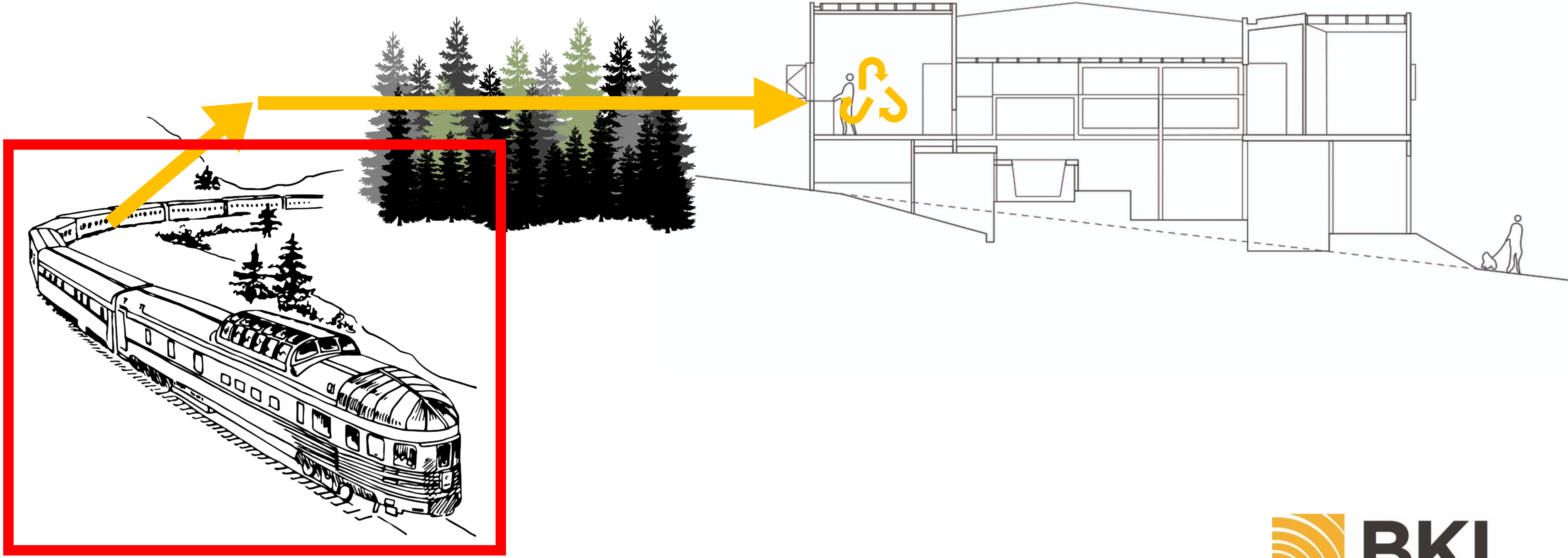
- Requires standard residential façade construction

Normally Unacceptable
(56-75 dBA)

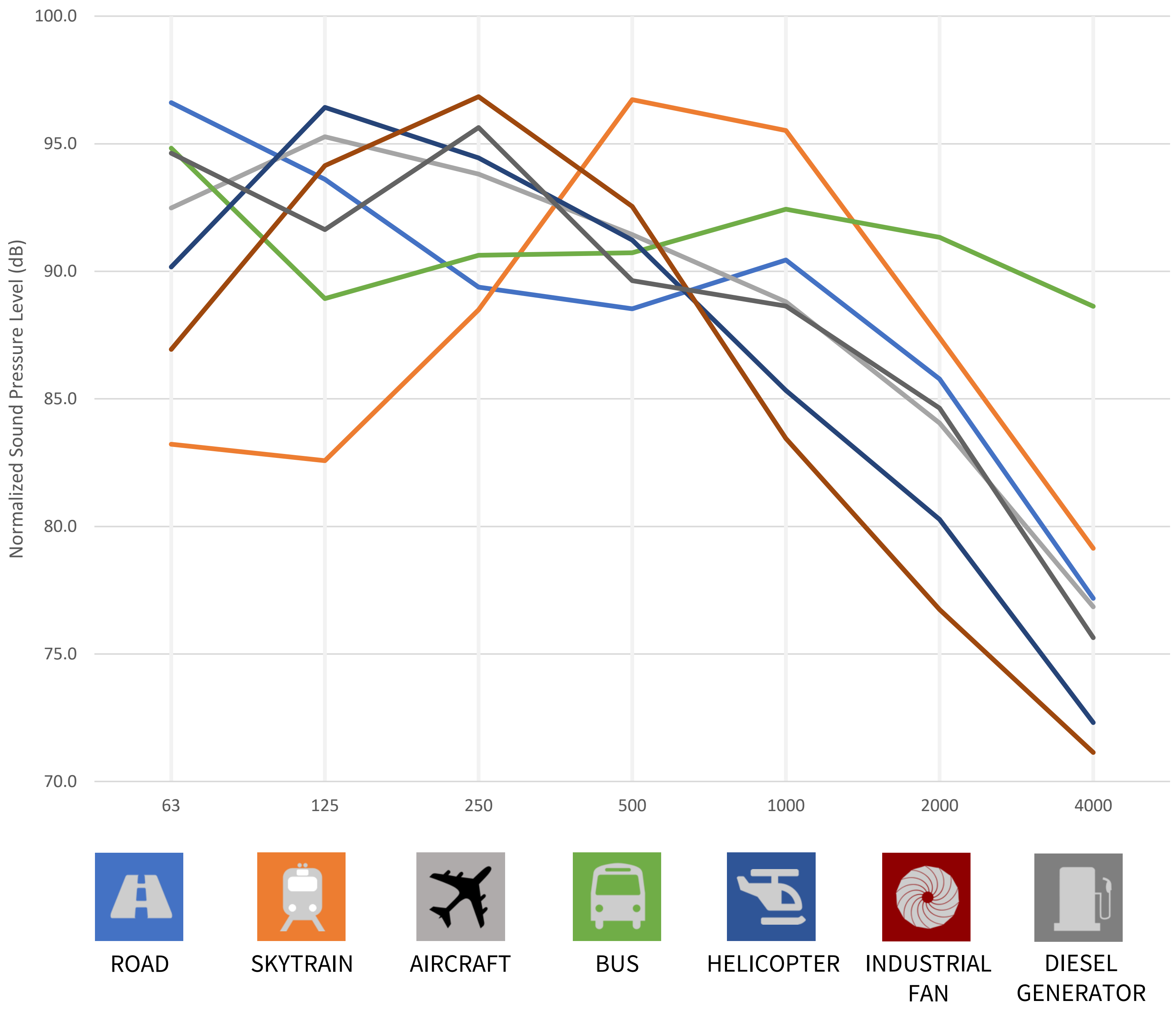
- Requires upgraded residential façade construction

Unacceptable
(75+ dBA)

Slight variations may be found for each municipalities.



Noise Sources



Typical noise sources

Large variations in source spectra. Best practice is to measure the noise emission from each source!!

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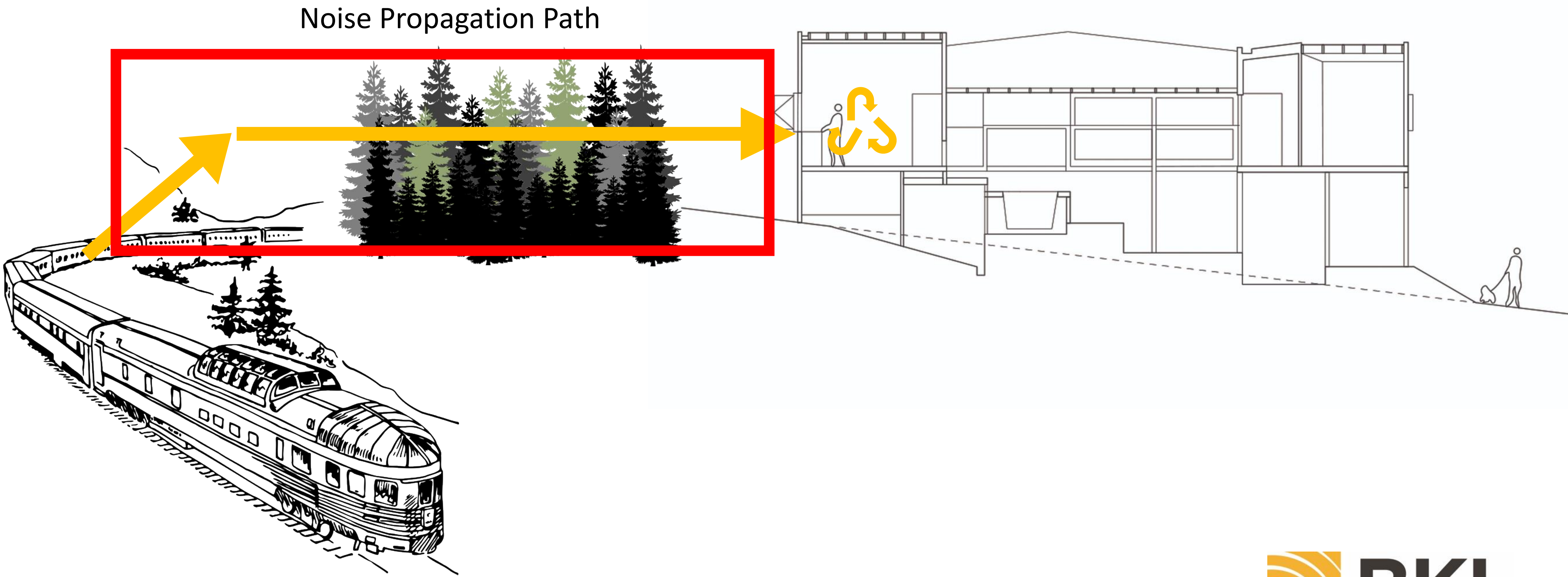
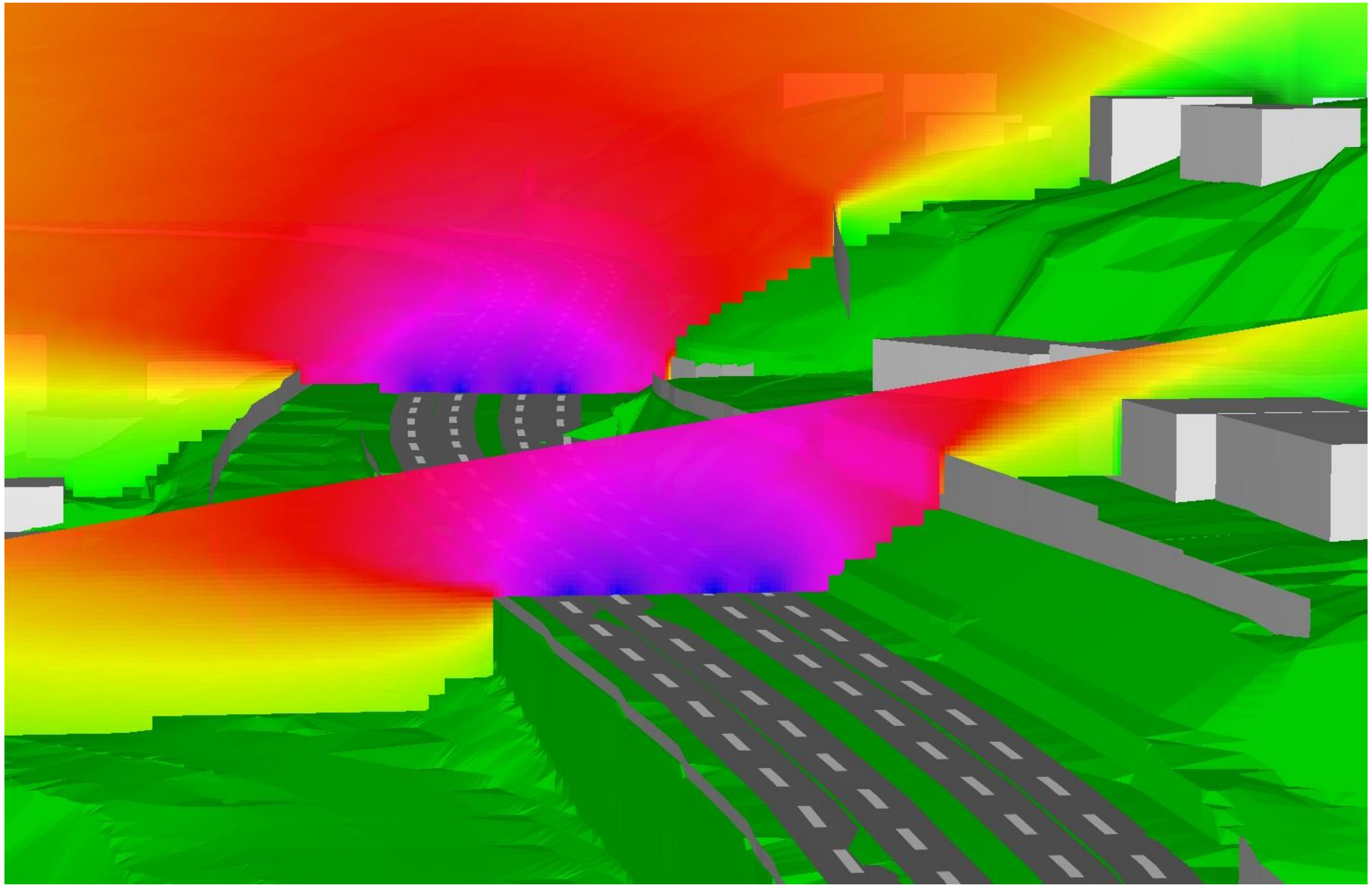

Noise Propagation Path

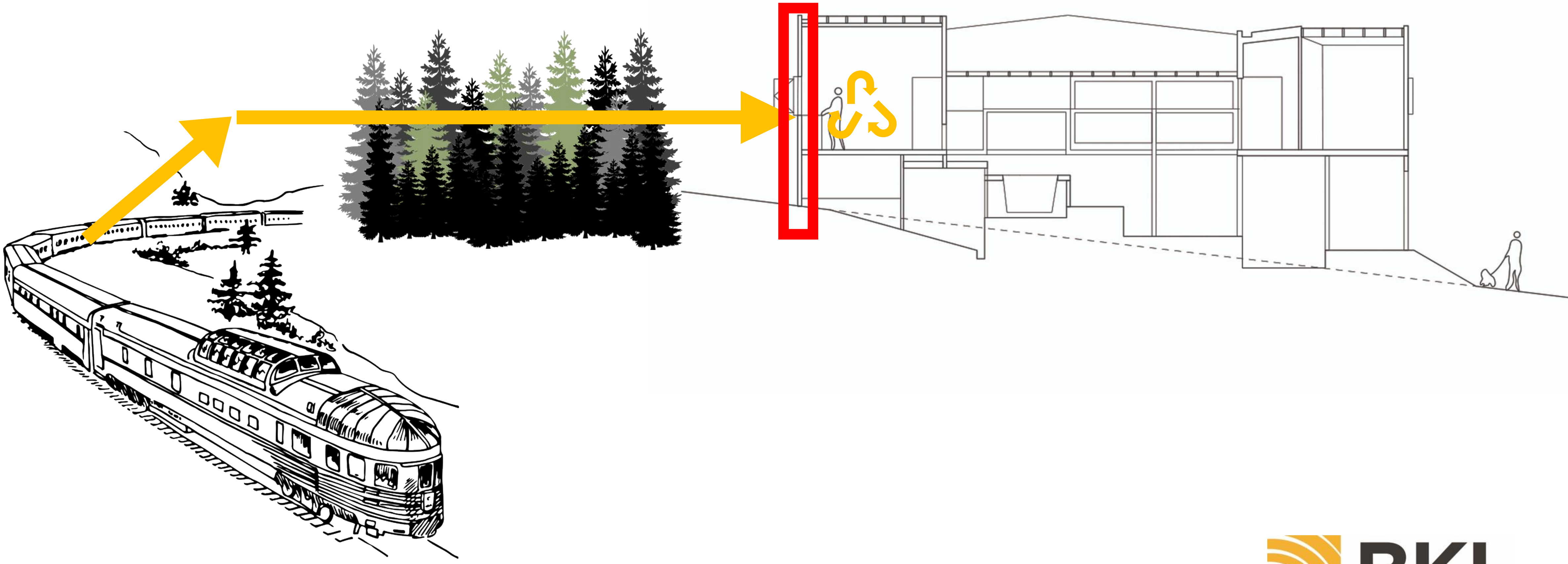
What Affects Sound Propagation?

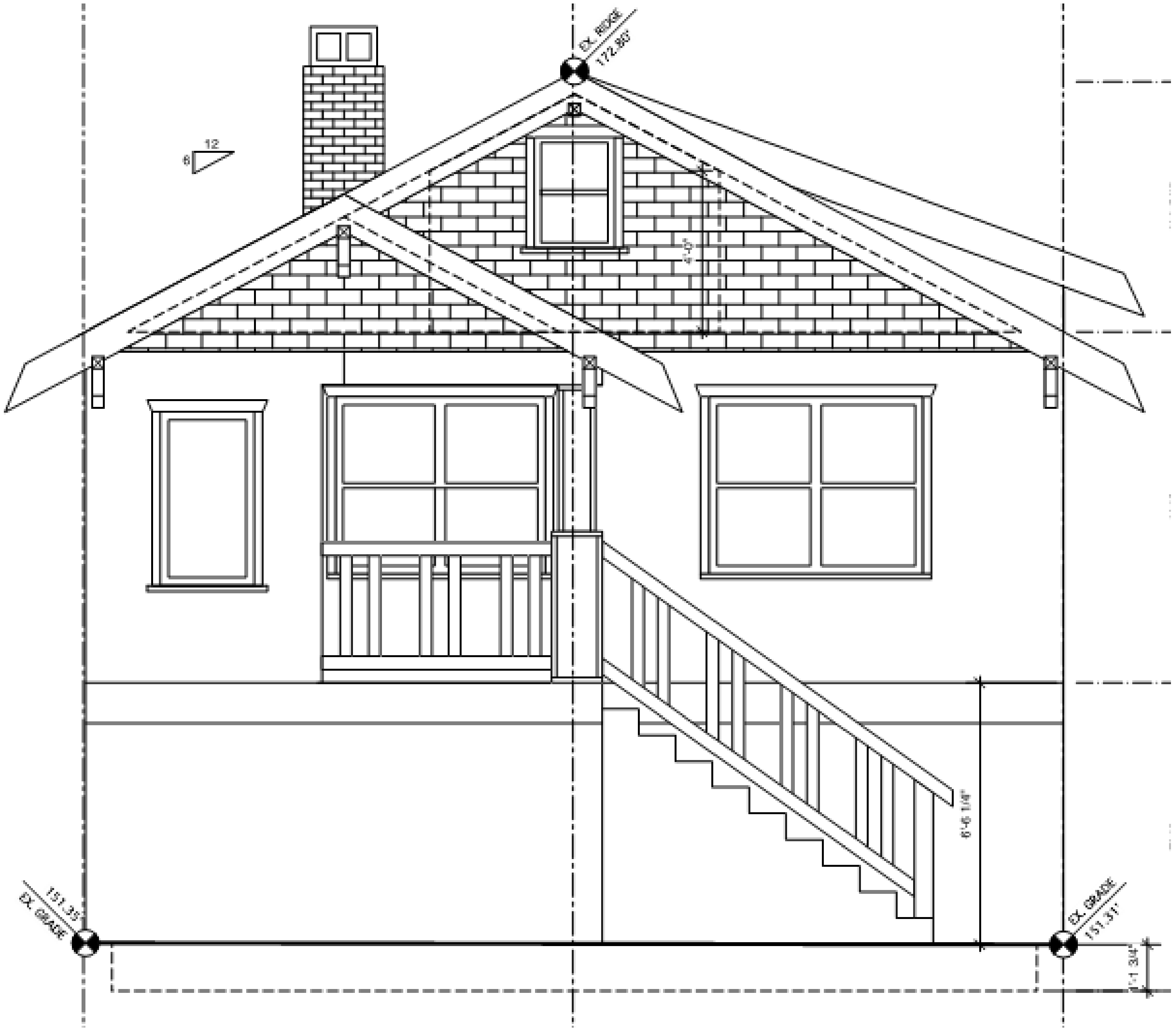
- Divergence
- Ground absorption
- Acoustical shielding
- Atmospheric absorption
- Refractive effect by wind
- Thermal effect

Acoustical Model



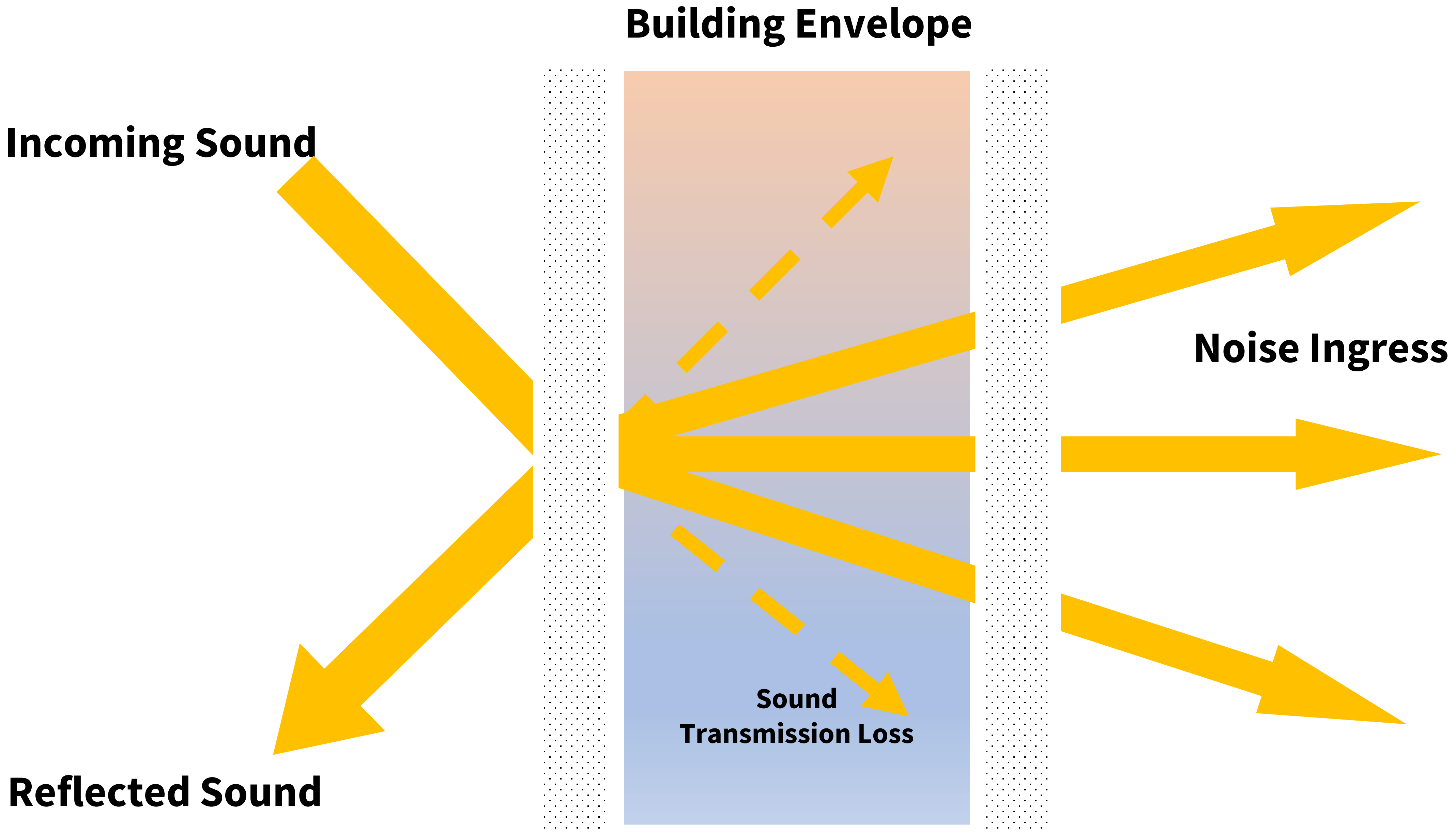
Building Envelope





What are the Transmission Paths for Noise?

- Exterior wall
- Windows and doors
- Roof
- Chimneys
- Air vents


Building Envelope
Incoming Sound
Noise Ingress
Sound
Transmission Loss
Reflected Sound

Sound Transmission Class (STC)

- Sound Transmission Class (STC) is a single number rating which allows a standardized comparison of the ability of a material to prevent sound passing through it.
- STC is calculated based on the sound transmission loss data at frequency range between 125 Hz and 4000 Hz
- STC is typically used for rating the performance of interior partition in buildings against speech transmission

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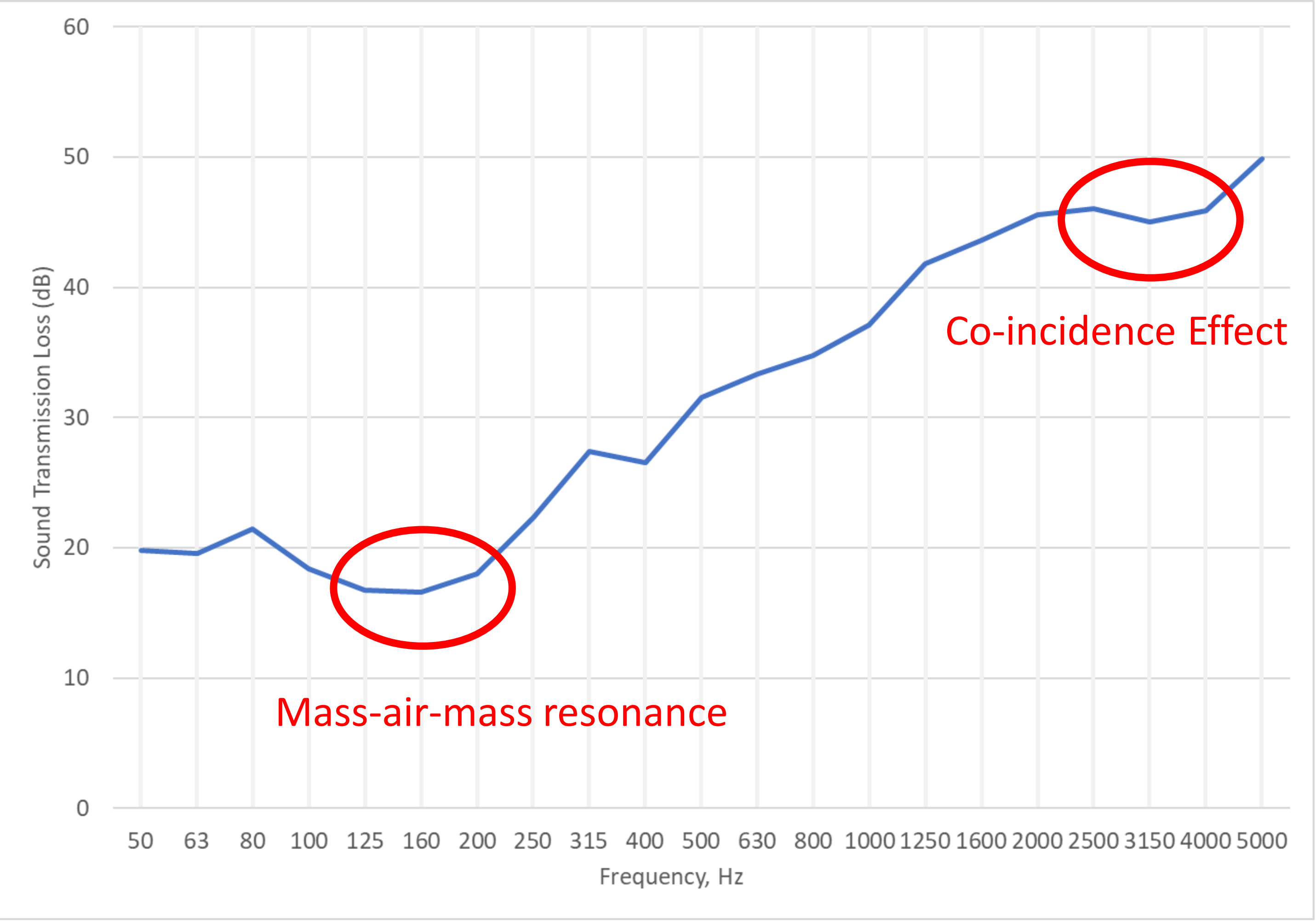
Outdoor-Indoor Transmission Class (OITC)

- Outdoor-Indoor Transmission Class (OITC) is a single number rating which can be used for assessing the isolation for the outdoor sound provided by a building or comparing building façade specimens
- OITC is calculated based on the sound transmission loss data at frequency range between 80 Hz and 4000 Hz
- **OITC is a more reliable rating for exterior noise ingress performance**

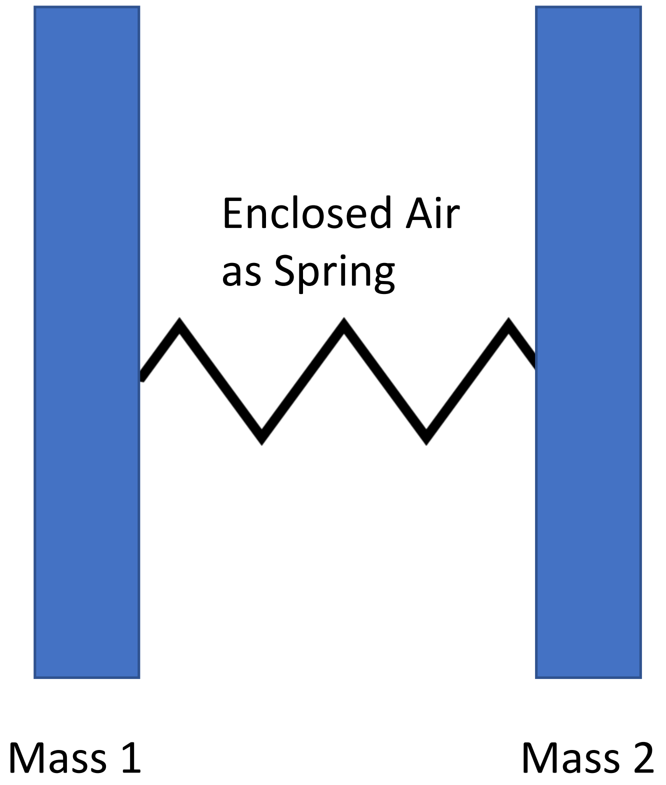
How to Interpret TL Data

Freq, Hz	TL, dB
50	20
63	20
80	21
100	18
125	17
160	17
200	18
250	22
315	27
400	27
500	32
630	33
800	35
1000	37
1250	42
1600	44
2000	46
2500	46
3150	45
4000	46
5000	50
STC	34
OITC	25

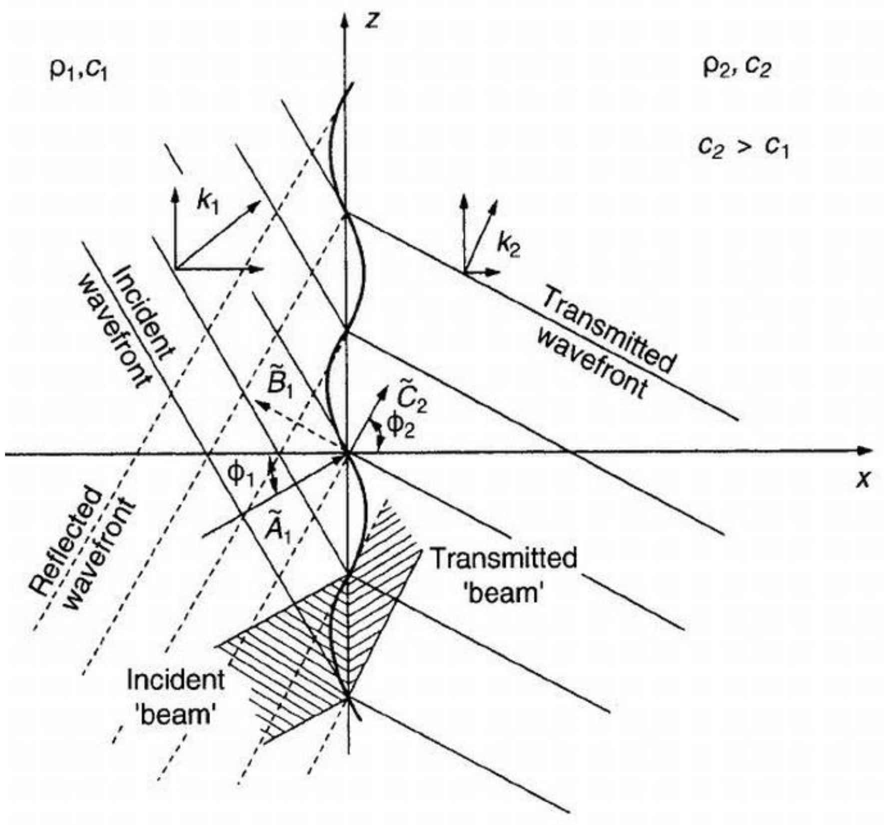


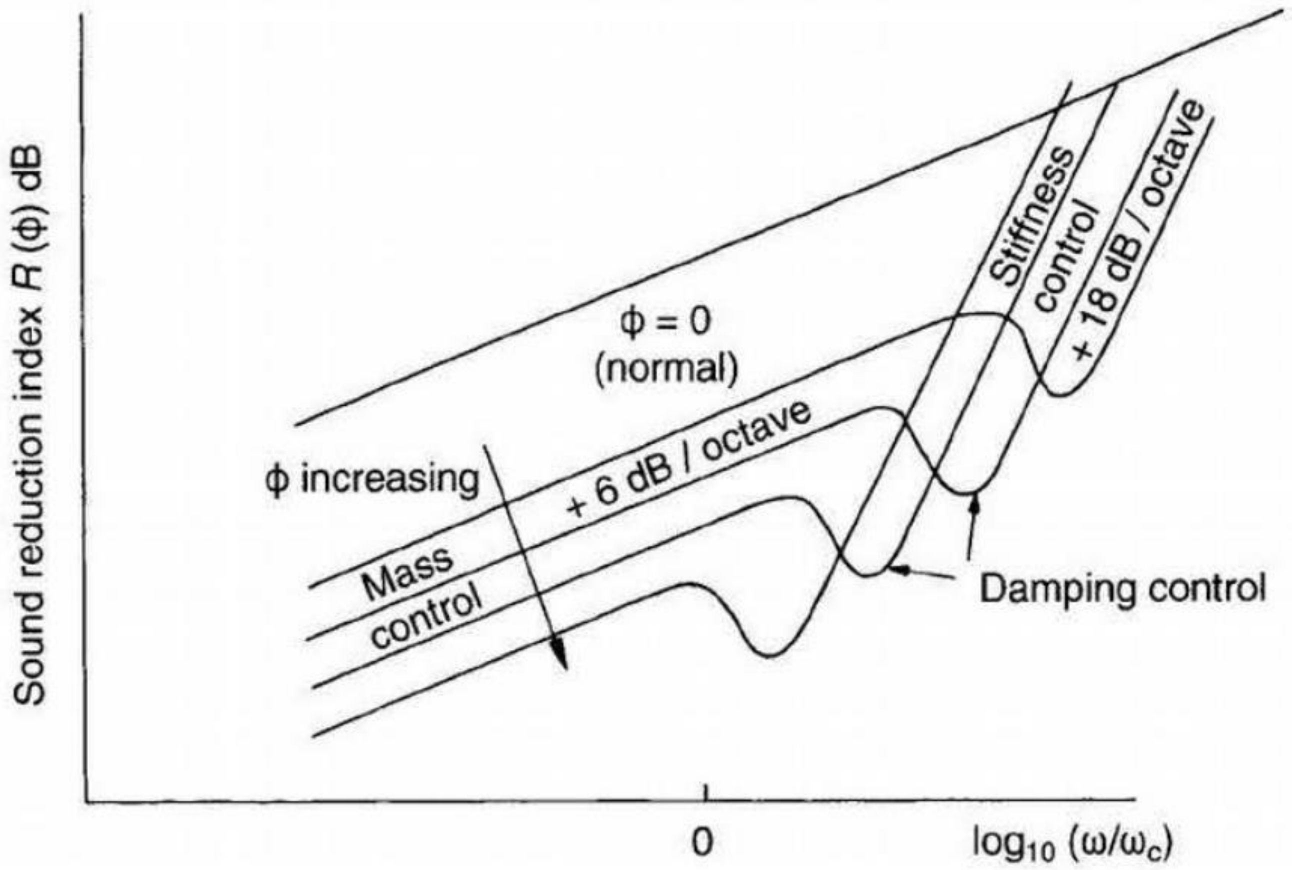
What is Mass-air-mass Resonance?

- At low frequency, the two panels act as one mass
- At certain frequency, mass-air-mass resonance will occur. The system behaves as two masses connected by a spring
- Above the resonance frequency, the air cavity effect increases the transmission loss



What is Co-incidence Effect?





Fahy, F. (2001) *Foundations of Engineering Acoustics*. Elsevier Academic Press, London.

- At certain frequency, frequency of the incident sound matches the natural bending frequency of the panel
- Energy is easily transmitted from air into panel as well as from panel to air

Composite Sound Isolation Rating

- Wall OITC = 40, Window OITC = 24
- Composite OITC = 29

What are the various factors which can increase or decrease sound transmission?

Increasing the Stud Size in Walls

- Two different walls with vinyl cladding, wood studs with glass fibre insulations, and 1 layer of ½" gypsum wall board are tested
- An increase in 1 OITC rating was found when stud size was increased from 2 X 4 studs to 2 X 6 studs

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Increasing the Stud Spacing in Walls

- Two different walls with vinyl cladding, wood studs with glass fibre insulations, and 1 layer of ½" gypsum wall board are tested
- An increase in 6 OITC rating was found when the stud spacing was increased from 400 mm to 600 mm

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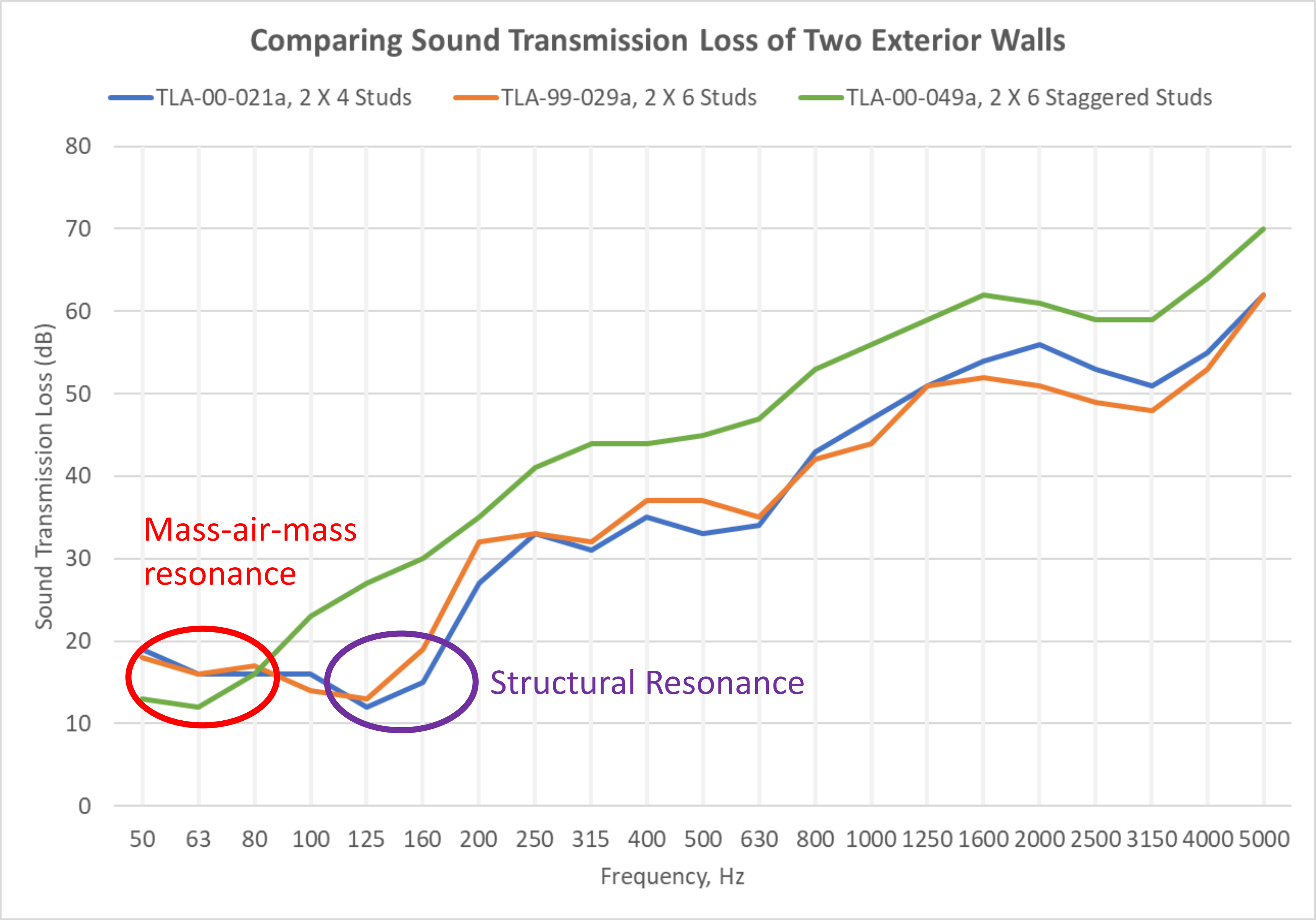
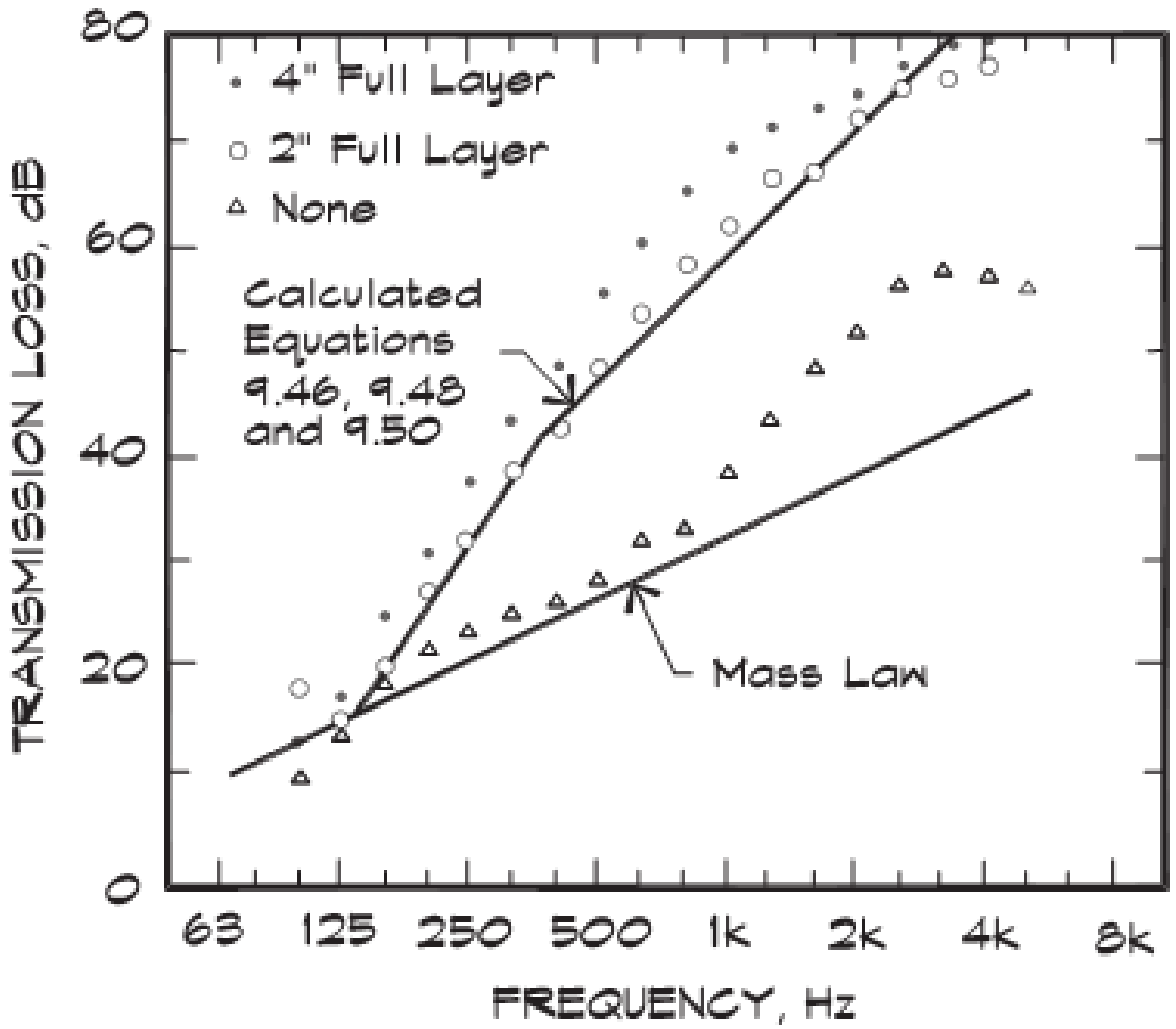


Using Staggered or Double Stud Configurations in Walls

- Two different walls with vinyl cladding, wood studs with glass fibre insulations, and 1 layer of ½” gypsum wall board are tested
- An increase in 8 OITC rating was found when staggered stud configuration was used



Sharp, Ben H. (1973) *A Study of Techniques to Increase Sound Insulation of Building Elements*. WR 73-5 Report. El Segundo, California

Adding Insulation Between Wall Panels

- Adding insulation between the panels will increase the sound transmission loss performance above the first resonant frequency

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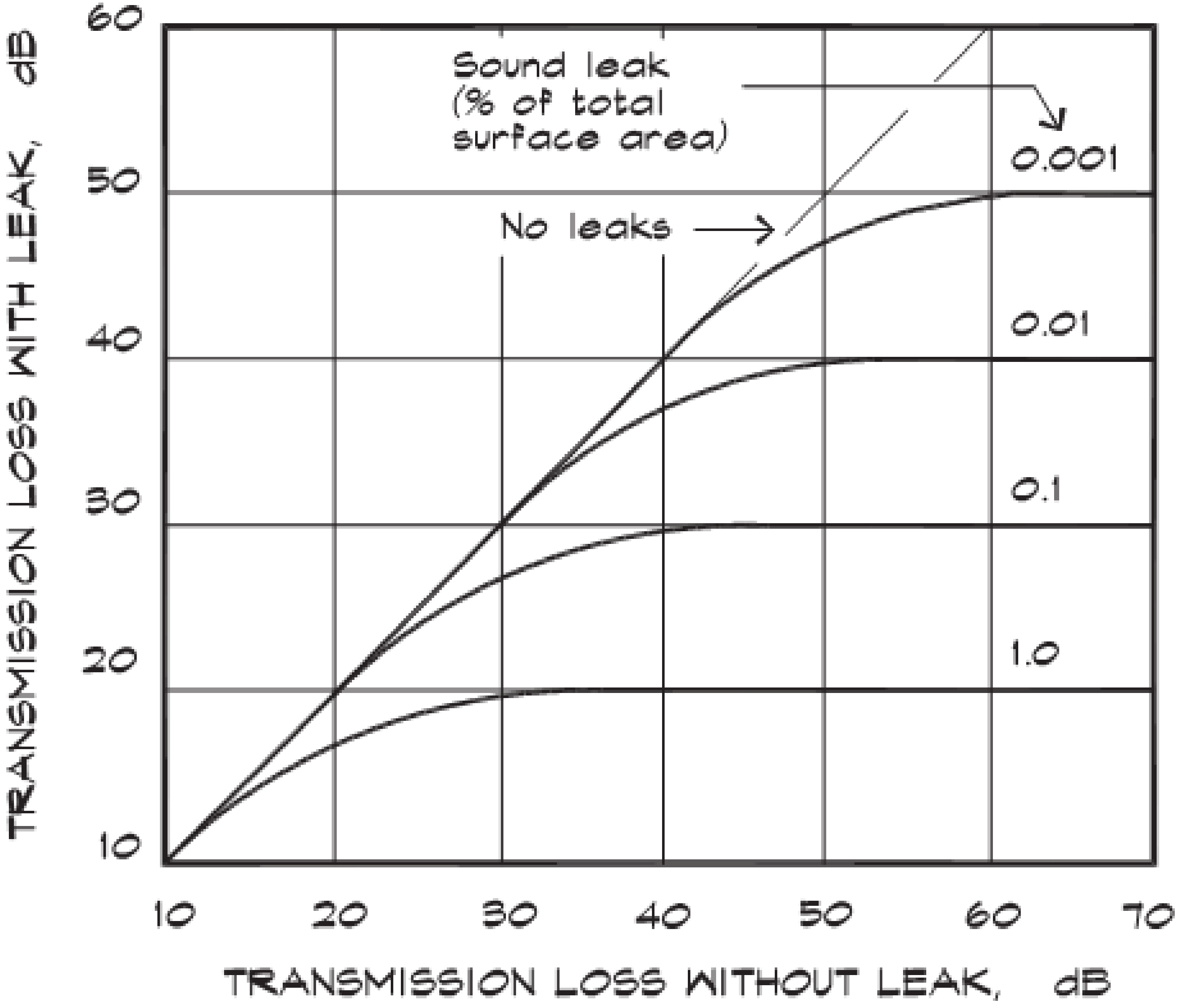

Sharp, Ben H. (1973) *A Study of Techniques to Increase Sound Insulation of Building Elements*. WR 73-5 Report. El Segundo, California

Sealing Air Gaps or Leakages

- Sealing air leakages will result in significant increase in transmission loss
- On the other hand, adding air vents will reduce the sound transmission loss performance of the building envelope
- For critical noise receiver room, It is recommended to avoid installing air vents with a direct line-of-sight to any major noise sources

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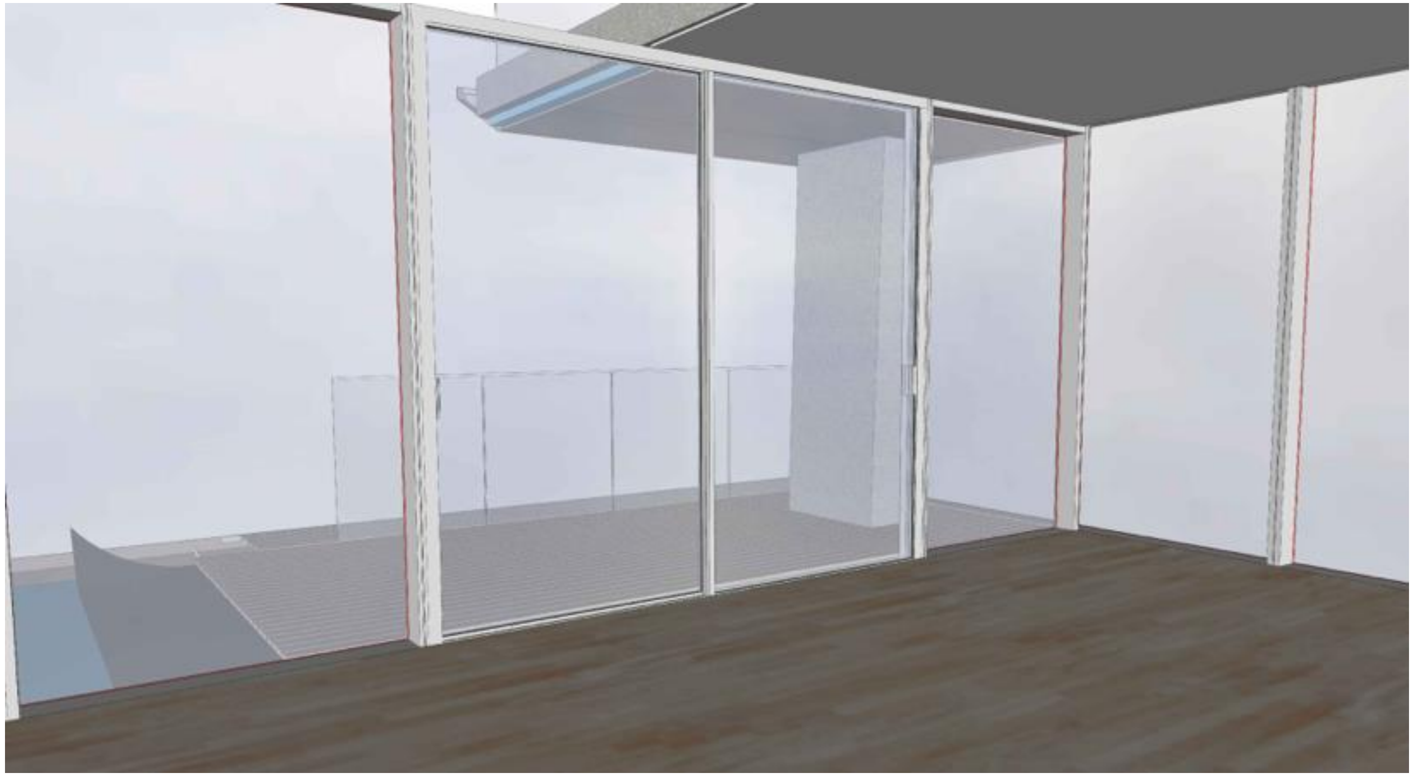

Using Windows with Smaller Panel Size

- Windows with smaller panel size will provide higher sound isolation performance compared to larger windows of the same configuration
- Large window pane may have 2-3 point reduction in performance

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Maximizing Transmission Loss of Walls and Windows

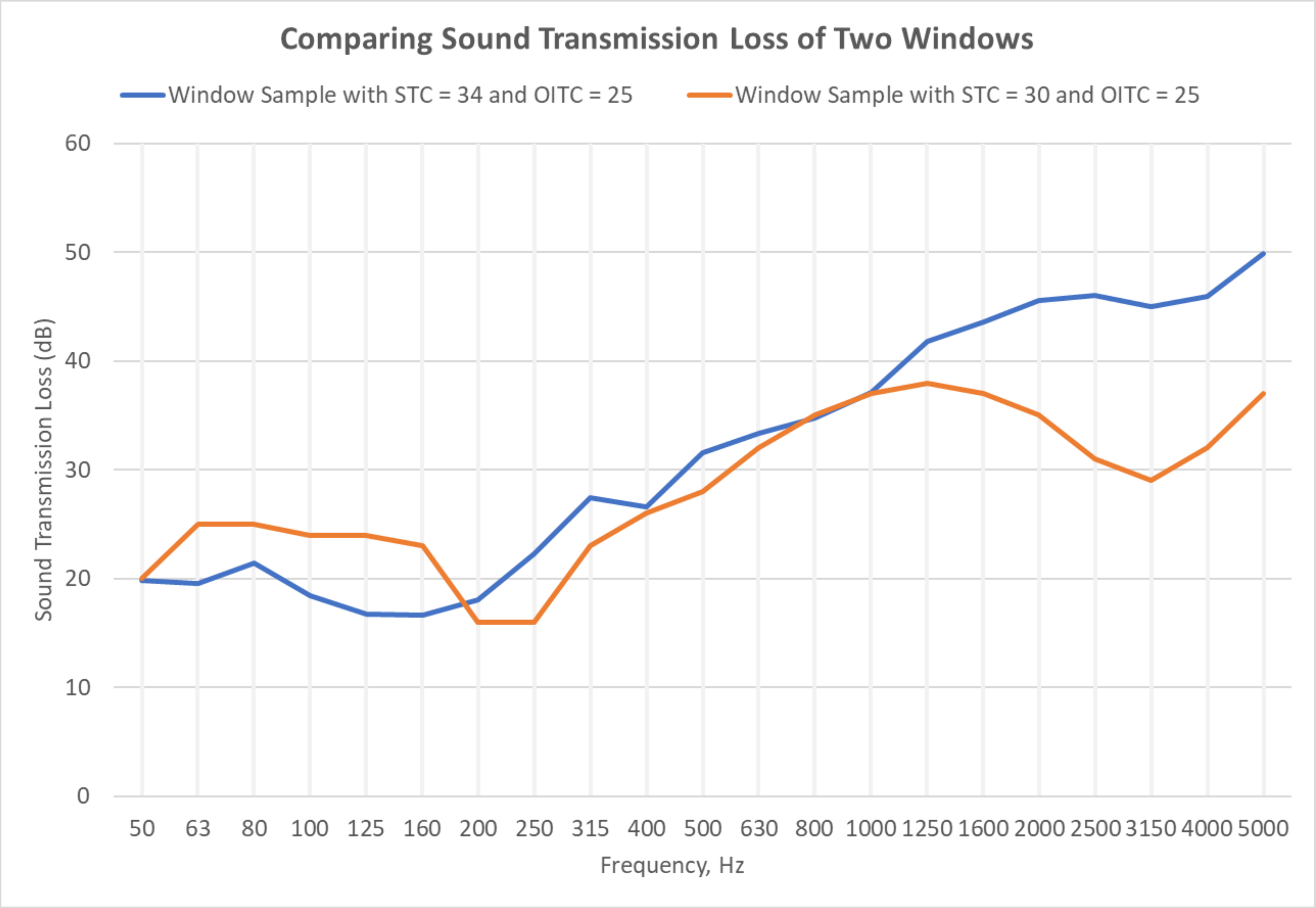
- Increase mass of exterior partition
- Break the vibration transmission paths whenever possible
- Increase the cavity size
- Use sound absorption material inside the cavity
- Improve air tightness and seal any leakage points
- Increase damping (e.g. laminated glass)
- Use smaller window panels whenever possible

Common Misconceptions

- STC and OITC can be used interchangeably
- Thermal insulation performance = sound Isolation performance
- Good sound absorption = good sound isolation
- Triple leaf glazing is better than double glazing
- Laminated glass has the same acoustical performance as tempered safety glass

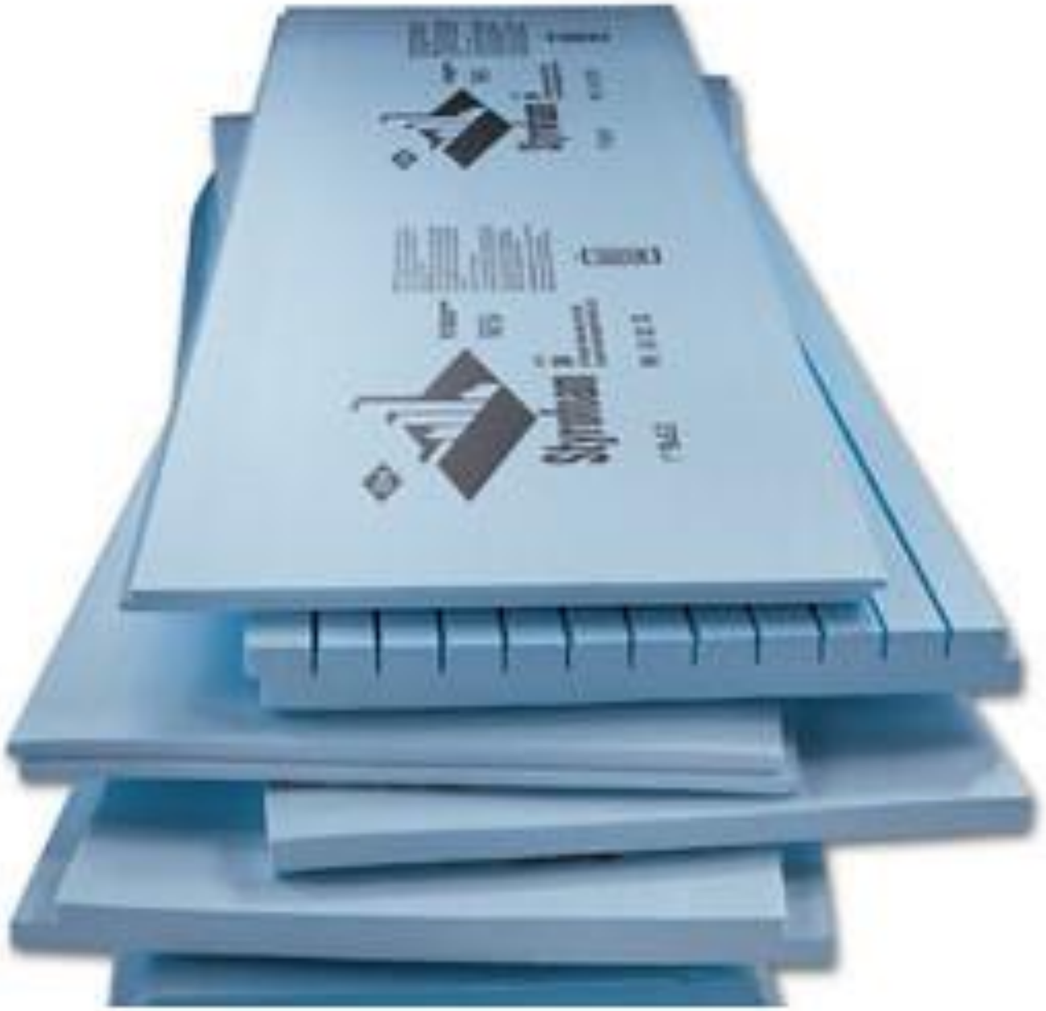
STC and OITC Cannot Be Used Interchangeably

- OITC also includes transmission loss data at frequency of 80 Hz and 100 Hz
- Different products with the same STC rating may not have the same OITC rating and vice versa



Thermal and Sound Isolation are Different

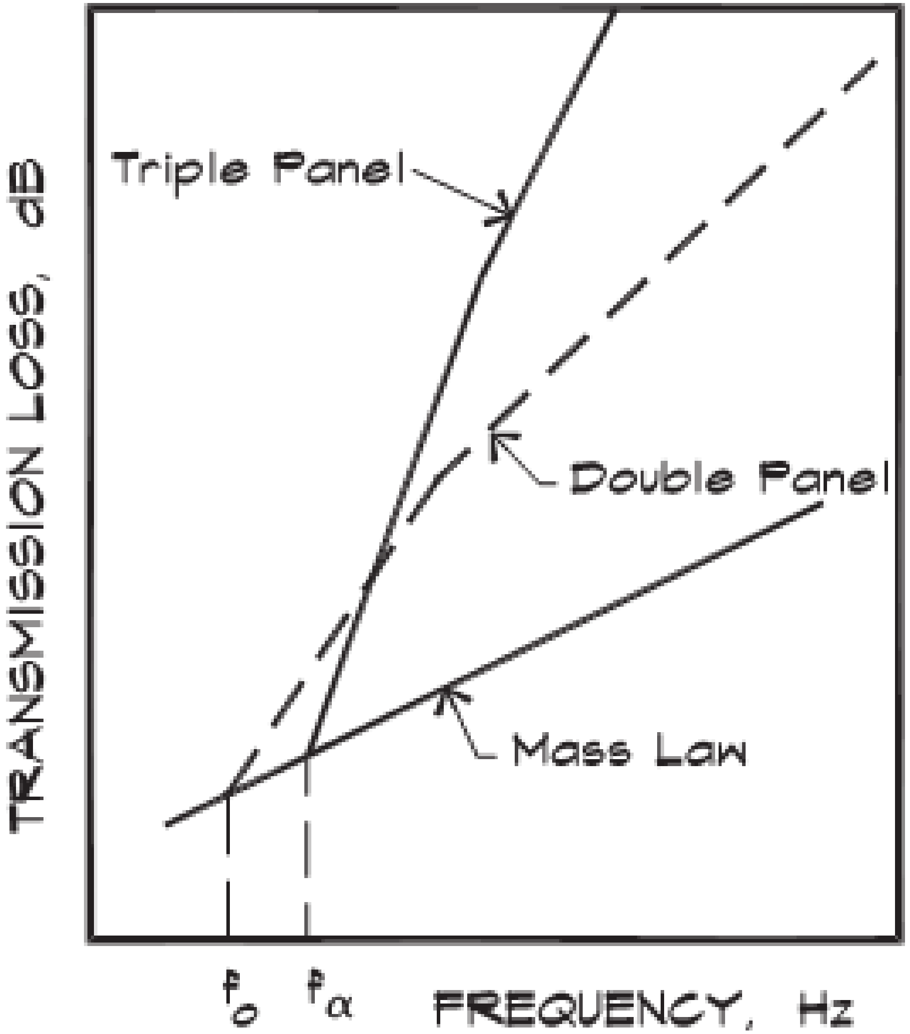
- It is crucial to conduct acoustical analysis on the building envelope to ensure that the design meet the noise criteria
- Closed-cell thermal insulation material (EPS, closed-cell foam, etc.) doesn’t provide any acoustical benefits
- To improve the sound isolation performance, heavier cladding is more preferable



Good Sound Absorption Doesn't Mean Good Sound Isolation

- Sound absorption materials themselves don't block sound

Triple Glazing Can Be Worse Than Double Glazing



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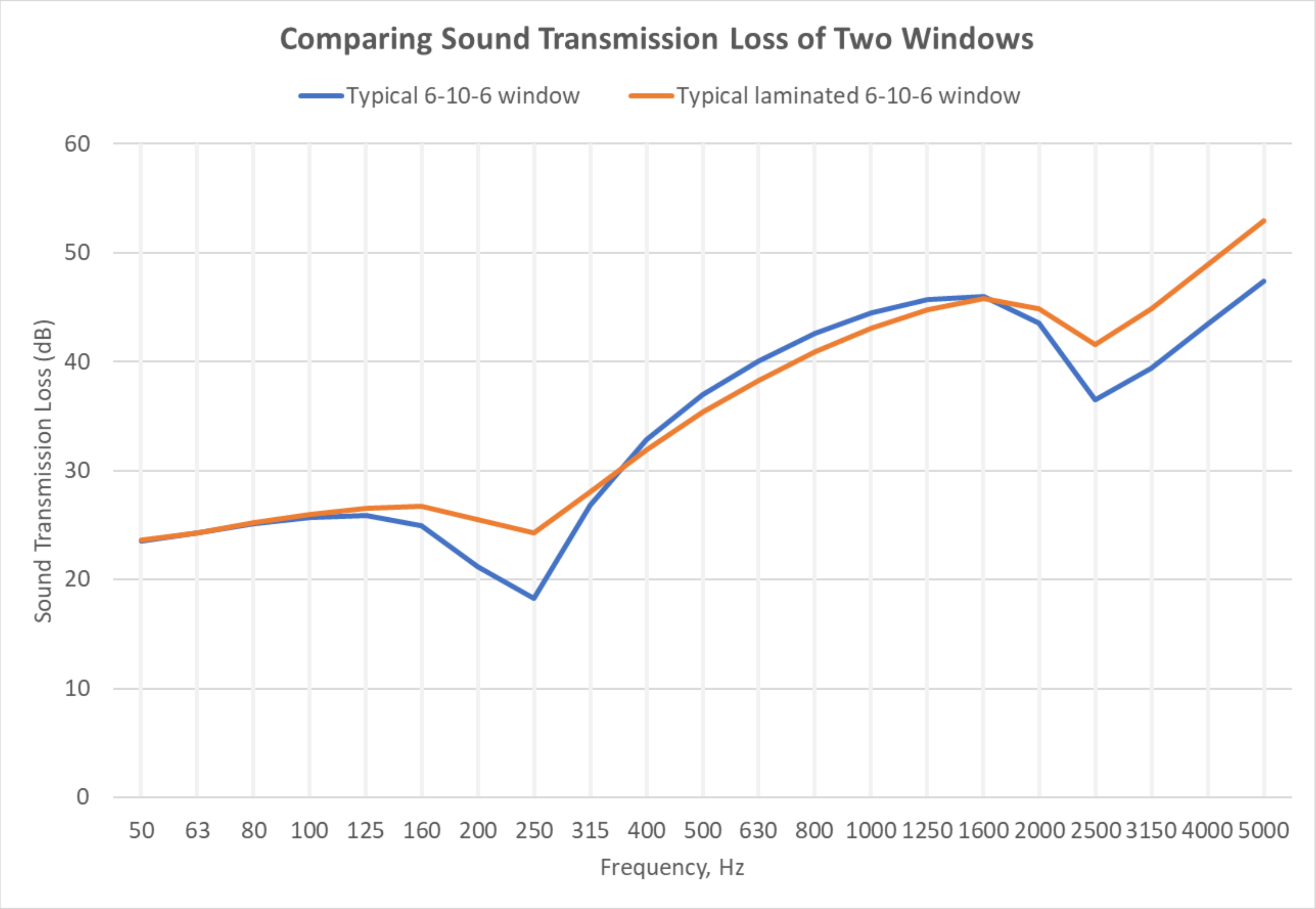

Laminated Glass is Acoustically Superior to Tempered Safety Glass

Thank You!

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