Urban Physics

7S0X0, 2020-2021 Quartile 3

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Urban Physics

Week 5 Urban noise control

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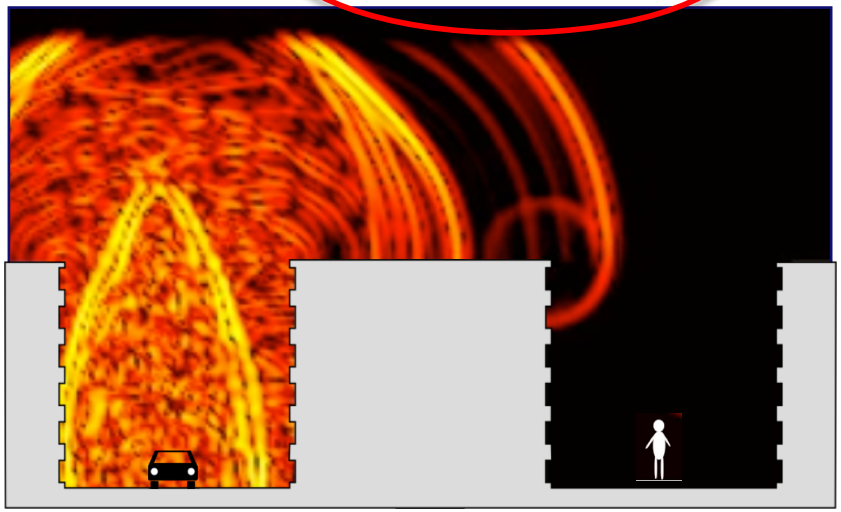
Overview Urban Acoustics

Physics/Mech.Engineering

Built Environment

IE&IS / psychology



Source measures

TABLE 7.3 Source-Based Noise Mitigation Measures

Measure
Legislation
Low-noise road surfaces and maintenance
Traffic management
Low-noise tyres
Low-noise vehicles
Driver Behaviour

Source measures

Legislation

- Most cost-effective and efficient in terms of reducing environmental noise
- In the EU, road traffic noise reductions at the source are mandated by limiting the permissible sound level of motor vehicles
- In 1970, the Motor Vehicle Directive (70/157/EEC) established permissible sound levels for motor vehicles
- Directive 70/157/EEC has been substantially amended several times, in an effort to account for the changing fleet composition in Europe.

Source measures

Low noise road surface (road traffic)

- Important for reducing noise from tyre-road mechanisms:
  - porous surface reduces air pumping
  - smooth surface reduces vibrations of the tyre that radiate noise
- Low noise road surfaces reduces noise at all locations
- 6 dB reduction can be achieved for most absorptive porous pavements compared to dense asphalt (Kropp et al. 2007).
- An average reduction of 3-4 dB(A) on highways can be achieved by single layer porous pavement (Ripke et al. 2005).

Source measures

Low noise tyres

- Different tyres produce noise in a range of 6-8 dB
- EU tyre labelling includes its noise production

1 black wave =

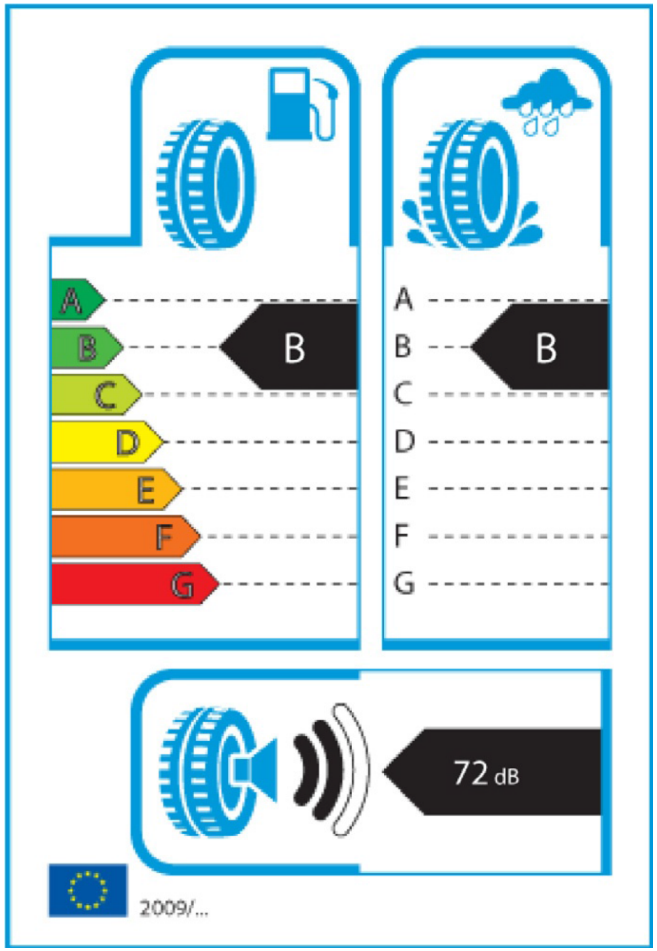
Quiet (3 dB or more below the future European limit);

2 black waves =

Moderate (between the future European limit and 3 dB below);

3 black waves =

Noisy (above the future European limit).



Source measures

Driver behaviour

- Promoting more passive and less aggressive driving styles can reduce noise by an average of 5 dB(A) for cars and commercial vehicles and by 7 dB(A) for motorcycles
- Low RPM driving is favourable
- Automatic gearing systems would be better

Source measures

Traffic management

- Reducing heavy vehicles in city centers (thereby reducing the peak level)
- Reducing traffic volume
- Lowering driving speeds

http://www.independent.ie/irish-news/truck-stuck-under-bridge-in-dublin-city-centre-29481596.html

Source measures

Traffic management

TABLE 7.4 The Effect of Speed Reduction on Noise

Reduction in Actual Driving Speed [km/h]	Noise Reduction (LAE[a], dB) – Light Vehicles	Noise Reduction (LAE, dB) – Heavy Vehicles
130 to 120	1.0	–
120 to 110	1.1	–
110 to 100	1.2	–
100 to 90	1.3	1.0
90 to 80	1.5	1.1
80 to 70	1.7	1.2
70 to 60	1.9	1.4
60 to 50	2.3	1.7
50 to 40	2.8	2.1
40 to 30	3.6	2.7

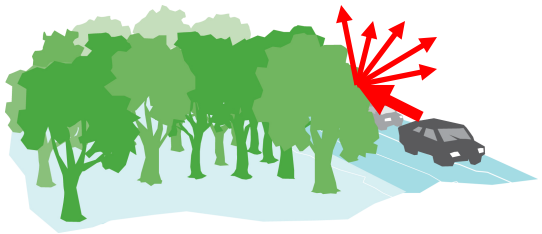
[a] *LAE is the A-weighted sound exposure level (SEL).*

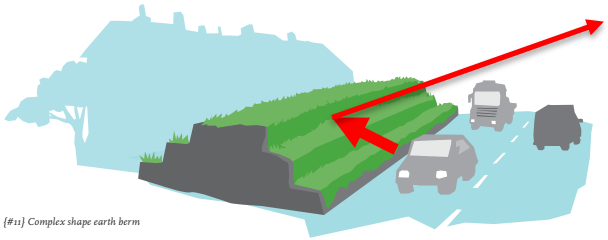
Andersen (2003).

Murphy, E., & King, E. (2014). *Environmental noise pollution: Noise mapping, publ... policy*. Newnes.

Propagation path measures

Screening	Barriers Buildings
Diffusion	Ground effects Building effects
Absorption	Ground treatments Green treatments





{#11} Complex shape earth berm

Propagation path measures

Screening: Barriers

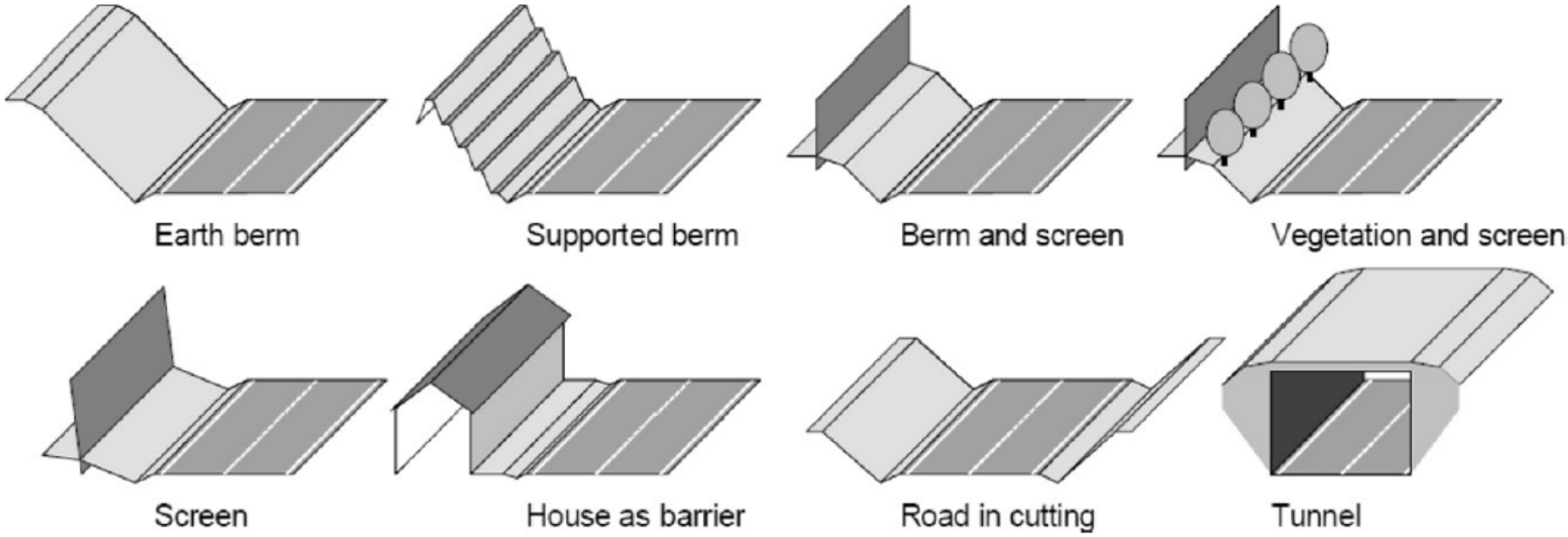


FIGURE 7.8 Range of potential noise barriers. *Source:* *Paikkala et al. (2002).*

Murphy, E., & King, E. (2014). *Environmental noise pollution: Noise mapping, public health, and policy*. Newnes.

Propagation path measures

Screening: Barriers

- In practice, a noise barrier will reduce noise levels by 3–7 dB, depending on their design and height (Arenas, 2008)
- Important, barriers should:
  - Block line of sight between source and receiver
  - Cover an horizontal angle of at least 160° from the receiver
  - Be made of a solid material, without openings or breaks
  - Be placed as close as possible to source or receiver

Propagation path measures

Screening: Barriers

Beneficial:

- Absorption at source side (reduce possible multiple reflections)
- Capped barriers (next slide)
- Angled barriers (to reflect sound upwards)
- Earth berms (3 dB increased reduction compared to thin screen with same height)

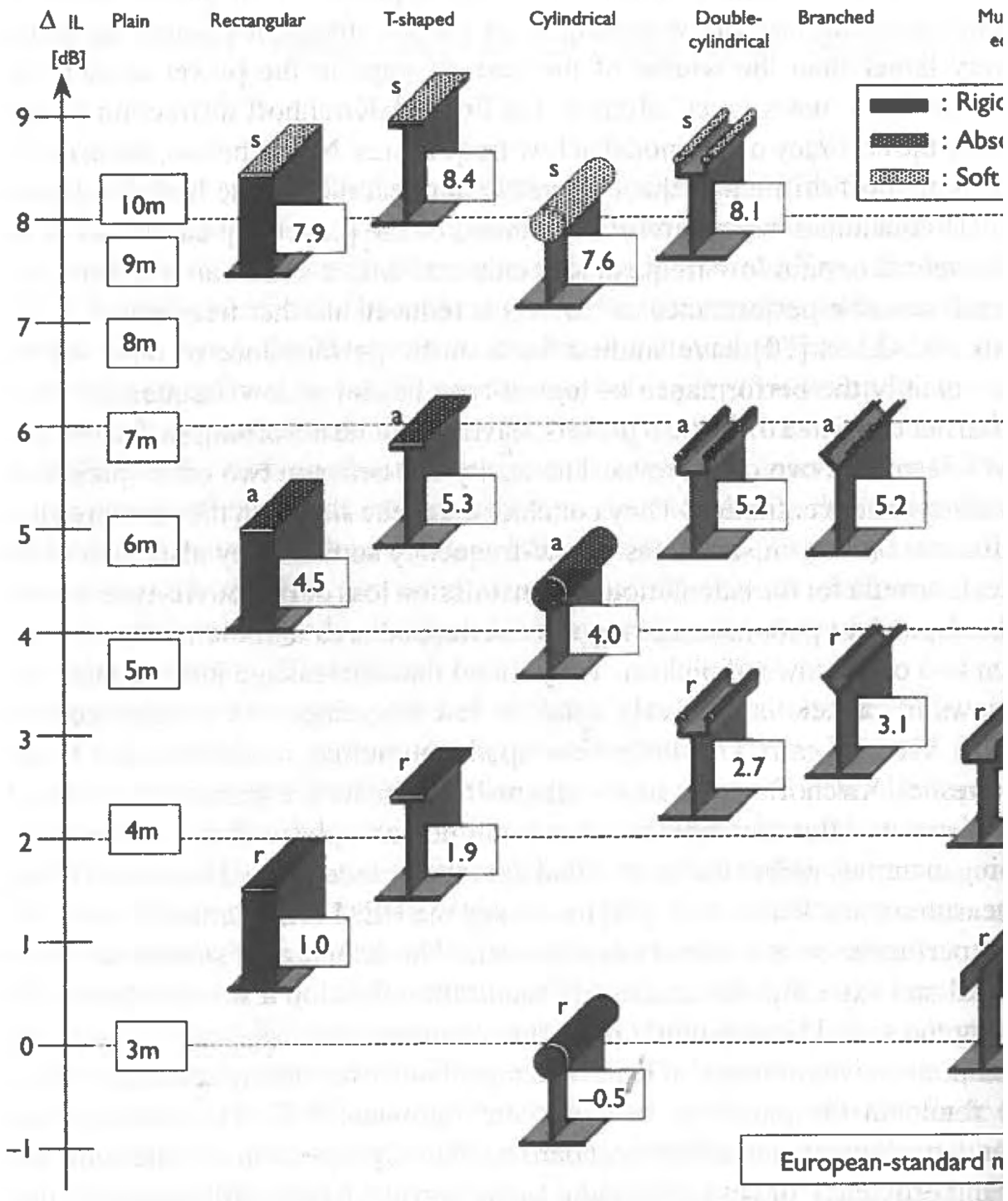
http://www.whisper-wall.com

Propagation path measures

FIGURE 7.9 Example of a capped barrier. *Courtesy: Douglas Barrett, Sanchez Industrial Design, Inc.*

Screening: Barriers

Predicted acoustic performance of traffic noise barriers of various shapes assuming a standard traffic noise spectrum. The figures indicate the relative change in the mean insertion loss relative to a 3 m plane screen



K. Attenborough et al., Predicting Outdoor Sound

Propagation path measures

Screening: Buildings

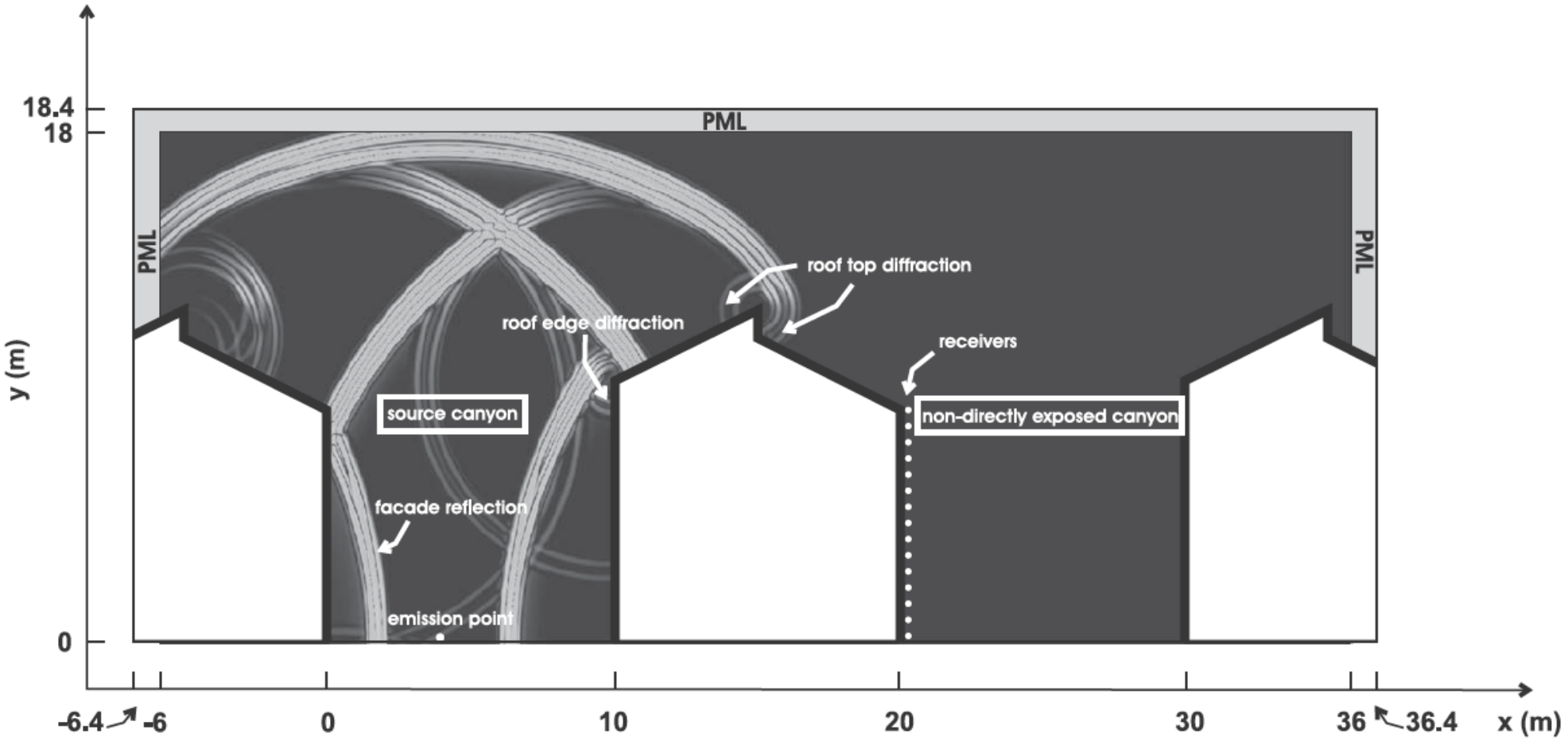
- Use buildings to shield residential buildings against noise

www.hollandscherm.nl/

Propagation path measures

Screening: Buildings influence of roof shape

Van Renterghem T, Botteldooren D. The importance of roof shape for road traffic noise shielding in the urban environment. J Sound Vibration 2010;329: 1422-34.

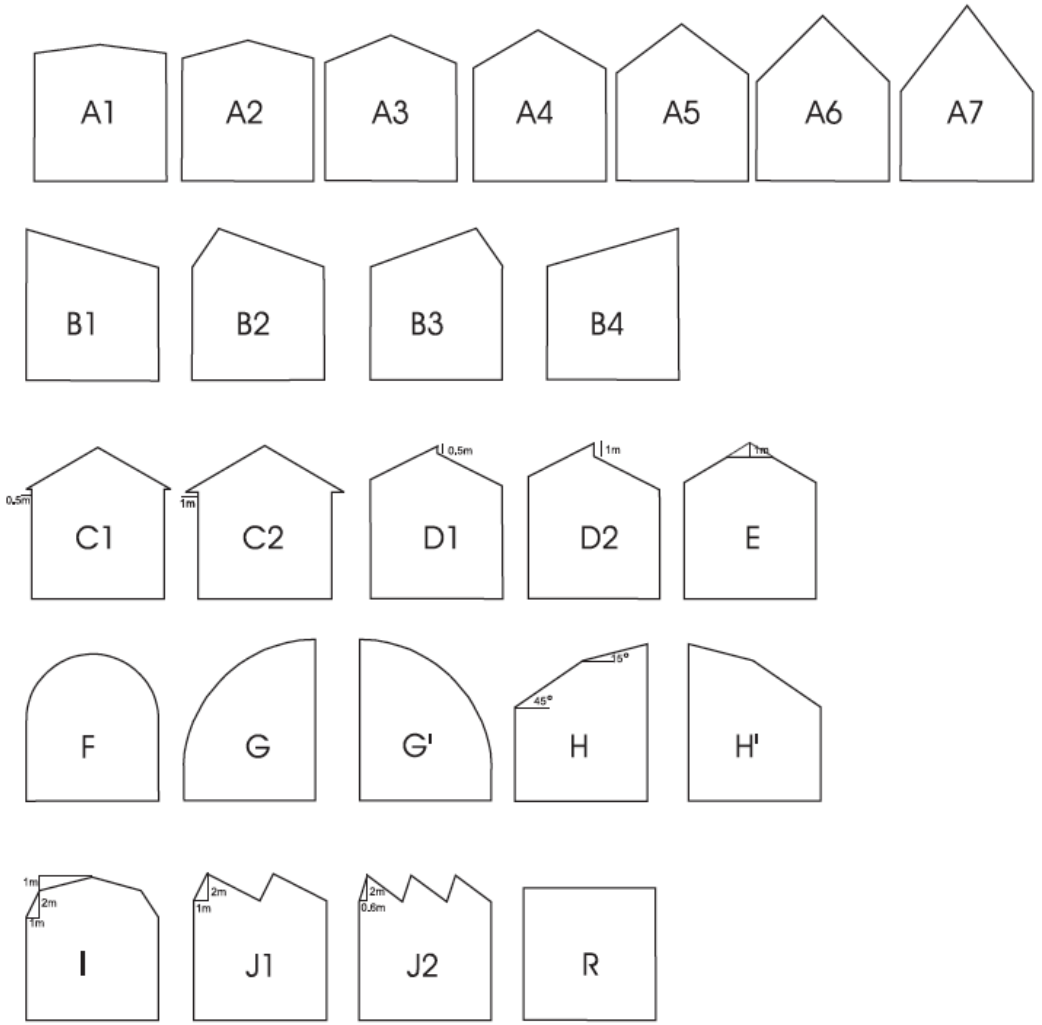


Propagation path measures

Screening: Buildings influence of roof shape

Van Renterghem T, Botteldooren D. The importance of roof shape for road traffic noise shielding in the urban environment. J Sound Vibration 2010;329: 1422-34.

Studied buildings

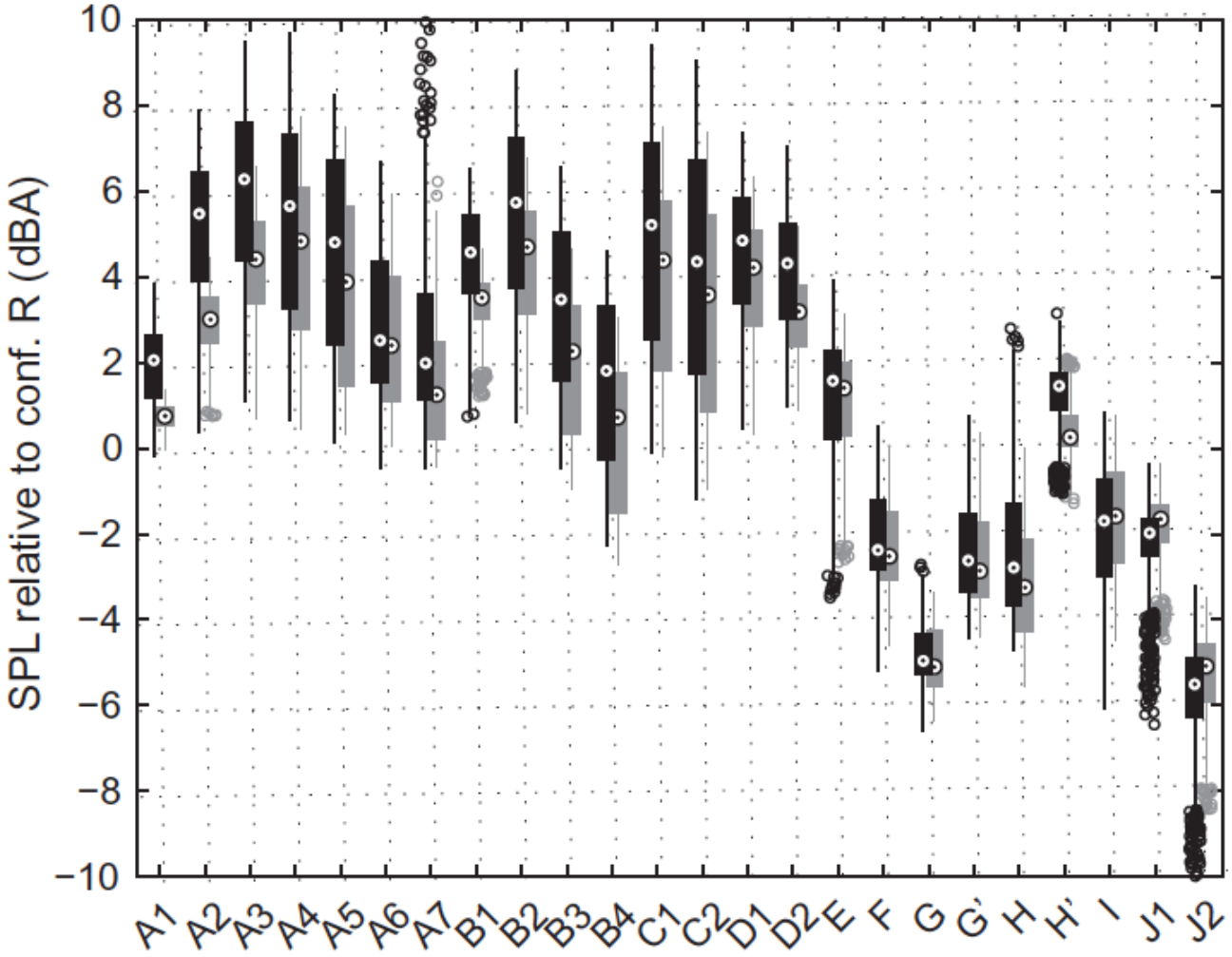


Propagation path measures

Screening: Buildings influence of roof shape

Van Renterghem T, Botteldooren D. The importance of roof shape for road traffic noise shielding in the urban environment. J Sound Vibration 2010;329: 1422-34.

Results relative to flat roof



Propagation path measures

Screening: Buildings

- Use non-residential buildings to shield residential buildings against noise
- Room-layout in buildings (bedrooms located away from noise)
- Prevent multiple reflections to increase noise levels (see next slide)
- Prevent direct exposure of façades by wing walls and balconies (see second next slide)

Propagation path measures

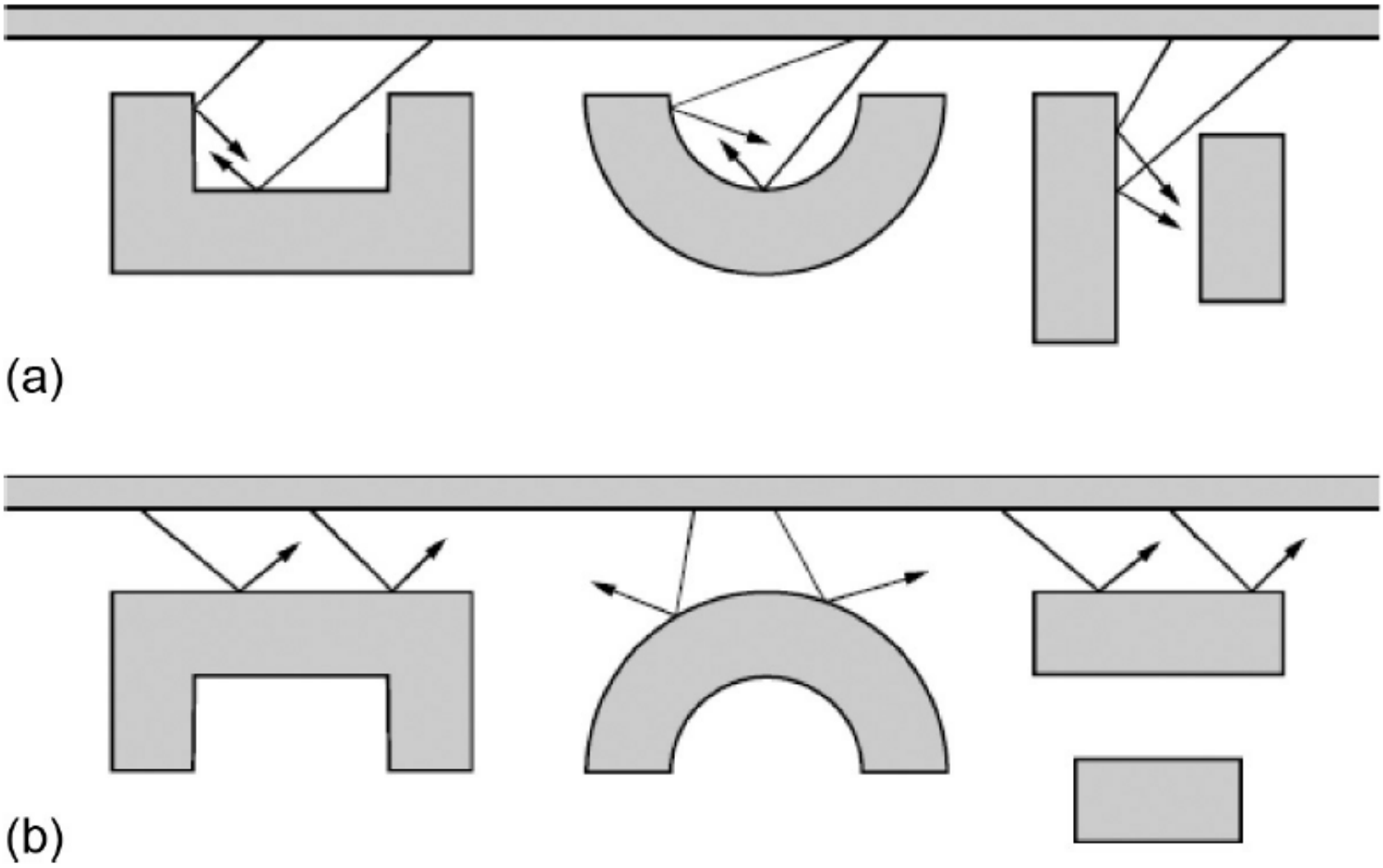


FIGURE 7.6 Noise reflection at buildings: (a) to be avoided and (b) preferred. *Source: Nelson (1987).*

Murphy, E., & King, E. (2014). *Environmental noise pollution: Noise mapping, public health, and policy*. Newnes.

Propagation path measures

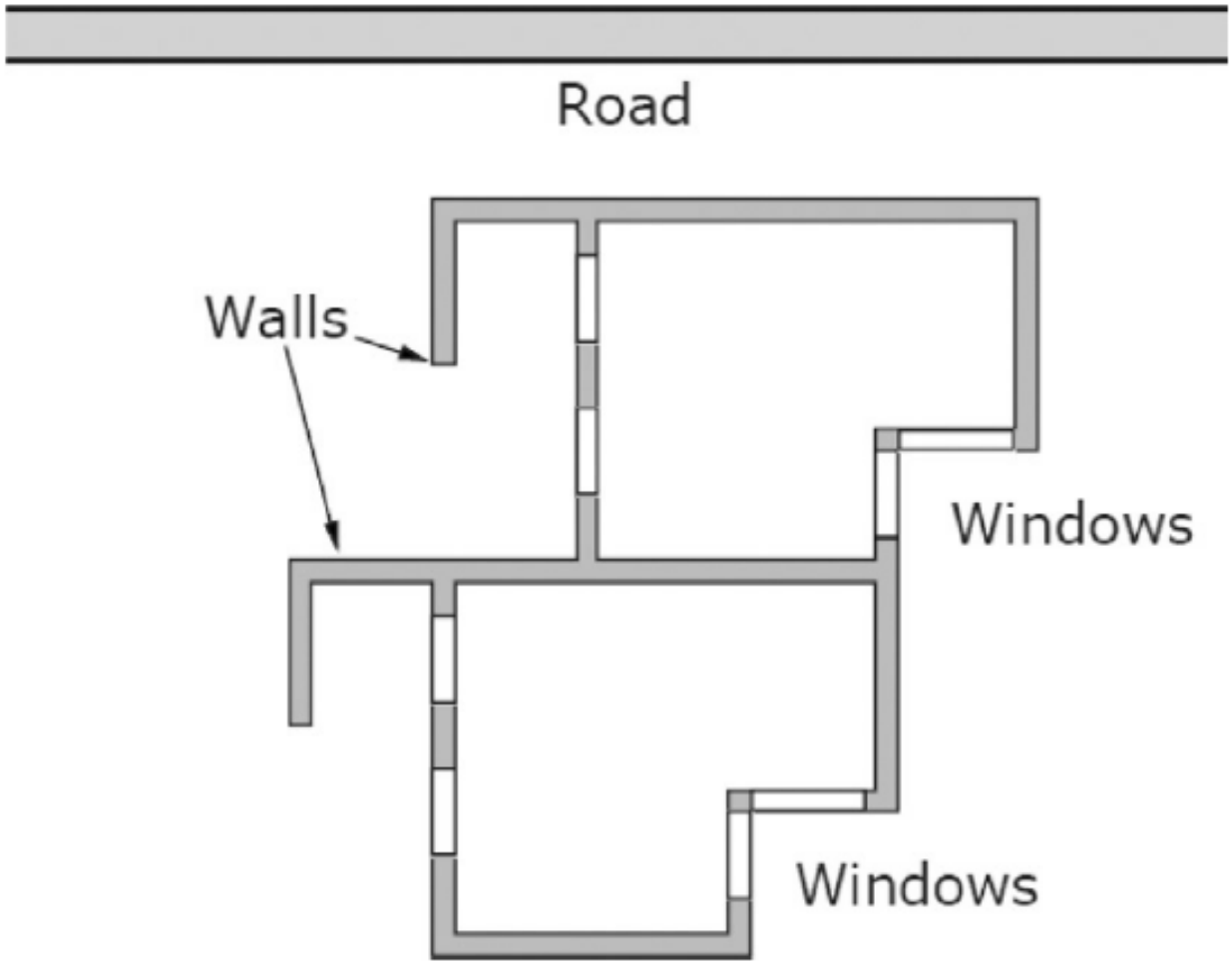


FIGURE 7.7 Illustration of how wing walls can be used to prevent noise immission. *Source:* Nelson (1987).

Murphy, E., & King, E. (2014). *Environmental noise pollution: Noise mapping, public health, and policy*. Newnes.

Propagation path measures

Diffusion: Ground effect

Brick lattice along road

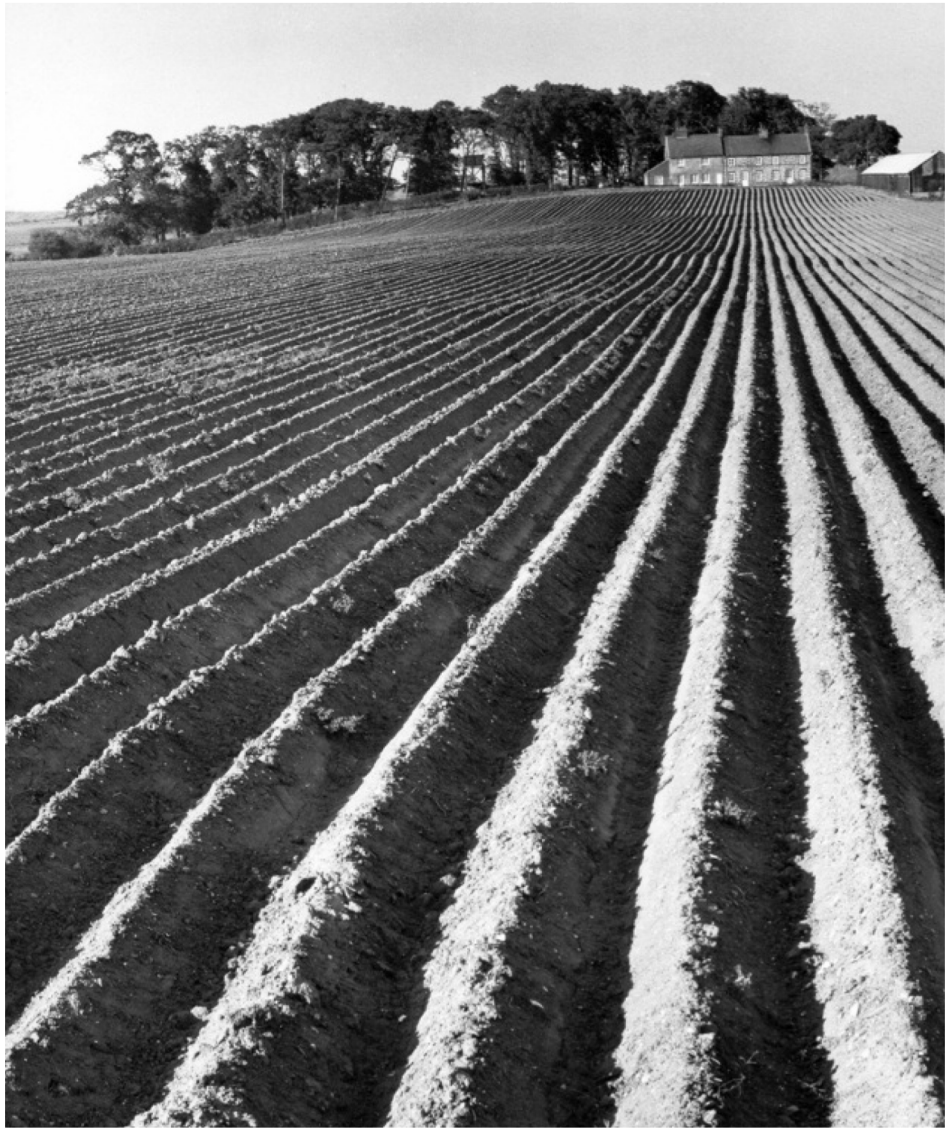
Lattice: 0.3 m high square lattice	Insertion loss (dB) – 2 lane road
1.65 m Wide	6.2
3.05 m Wide	7.2
5.85 m Wide	8.7
12.05 m Wide	10.5

Bashir, I., Hill, T., Taherzadeh, S., Attenborough, K., Hornikx, M. (2014). Reduction of Surface Transport Noise by Ground Roughness. Applied Acoustics, **83**, 1-15.

Propagation path measures

Diffusion: Ground effect

Ploughed ground: up to 10 dB more noise reduction compared to flat soft surface



http://www.beetlesandhuxley.com/gallery/all-stock/newly-ploughed-field-holkham-norfolk-1970.html

K. Attenborough, T. Waters-Fuller, K.M. Li, J.A. Lines: Acoustical properties of Farmland, J. Agric. Eng. Res. 76, 183–195 (2000)

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Propagation path measures

Diffusion: Building façades

Diffuse facades

Propagation path measures

Diffusion: Building façades Diffuse facades

- Building Correction (BC) factor
- Diffusion coefficient d = 0

$$BC = (2.4)\frac{d_{sr}}{w}$$

- Diffusion coefficient d = 0.2

$$BC = \left(3.0 + 1.3\log_{10}\left(\frac{h}{w}\right)\right)\frac{d_{sr}}{w}$$

- Diffusion coefficient d = 0.8

$$BC = \left(3.5 + 2.5\log_{10}\left(\frac{h}{w}\right)\right)\frac{d_{sr}}{w}$$

Additional effect of façade openings

- d_{sr} = source – receiver distance
- w = street width
- h = street height

Heutschi, K., Applied Acoustics, 44, 259-274.

Propagation path measures

Diffusion: Building façades Diffuse facades, courtyards

- The effect of diffuse reflection facades compared to flat façades for noise propagation from the street to an adjacent courtyard can be estimated to 5 dB

Hornikx and Forssén, Acta Acustica united with Acustica 94, 265-281.

Propagation path measures

Absorption: Ground treatments

- Ground treatment: crop, grass, gravel, asphalt…
  - Increasing absorption with softer materials
  - Reduction depends on interference effect (see lecture slides week 4)

Propagation path measures

Absorption: Ground treatments Helmholtz resonators in asphalt

3 dB reduction possible

Propagation path measures

Absorption: Green treatments

(literature: Noise Solutions for quieter and greener cities)

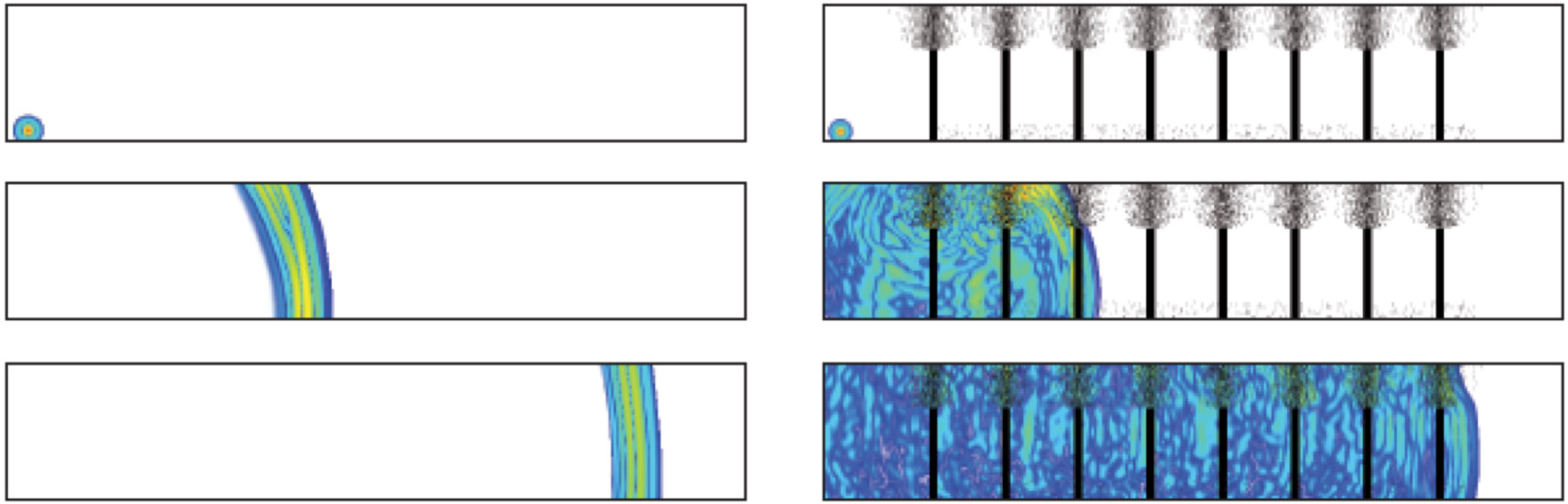
- Low-height barrier: 3–12 dB(A) noise reduction for an urban road

Thomas *et al*. Auralisation of a car pass-by behind a low finite-length vegetated noise barrier, Euronoise 2012, 10-13 June, Prague, Czech Republic.

Propagation path measures

Absorption: Green treatments

- 15 m vegetation belts can replace a thin noise screen with a height of 1-1.5 m, up to 6 dB(A) reduction at 50 m from the road

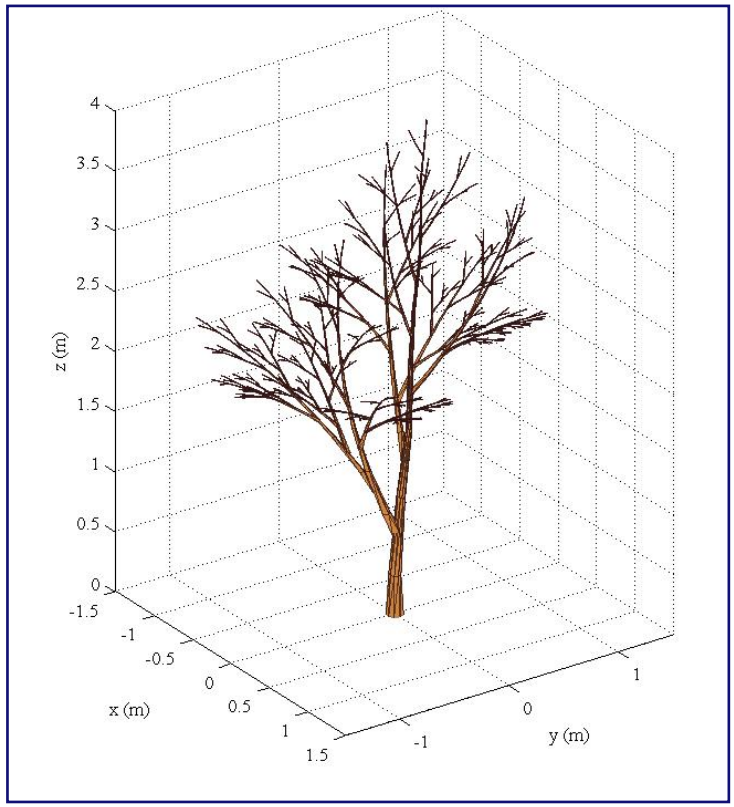


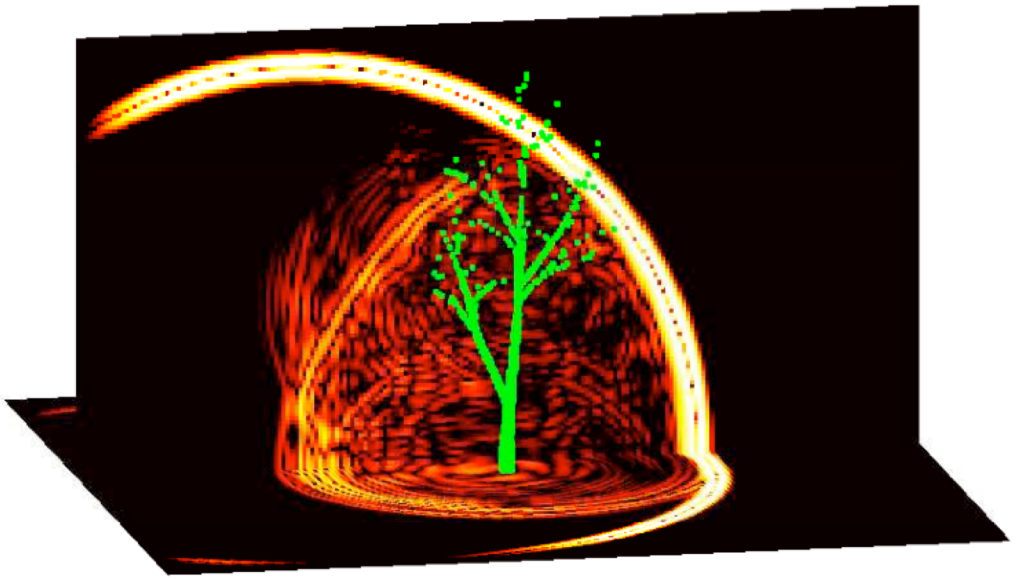
Van Renterghem, T.,. Botteldooren, D., Verheyen, K., Road traffic noise shielding by vegetation belts of limited depth. J. Sound Vib., 331, p. 2404-2425, (2012).

Propagation path measures

Absorption: Green treatments

- No more than 2 dB(A) for close positioning of trees in an urban street configuration

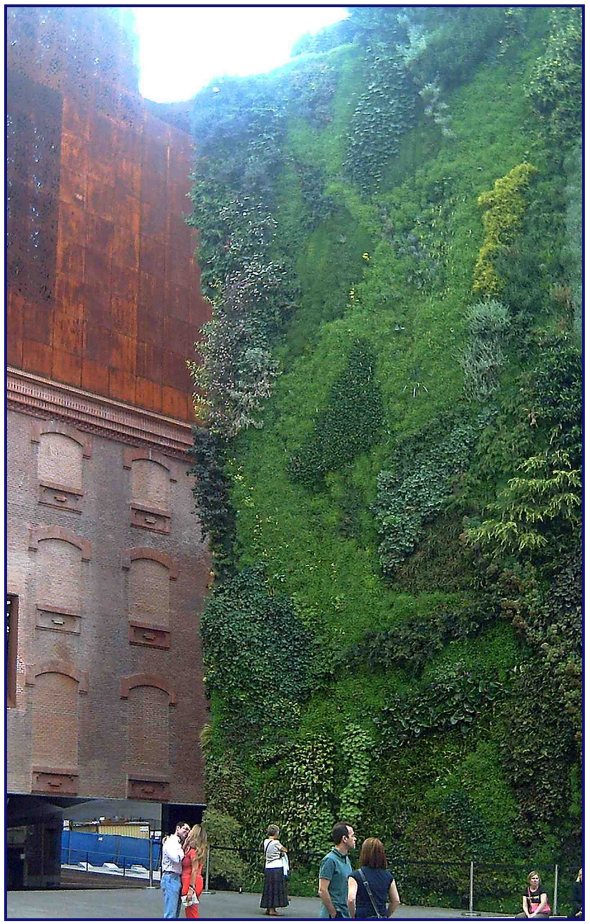




Hornikx, M., Botteldooren, D., Van Renterghem, T., Forssén, J., (2011). Modelling of scattering of sound from trees by the PSTD method. Forum Acusticum, 26 June to - 1 July, Aalborg, Denmark. Invited.

Propagation path measures

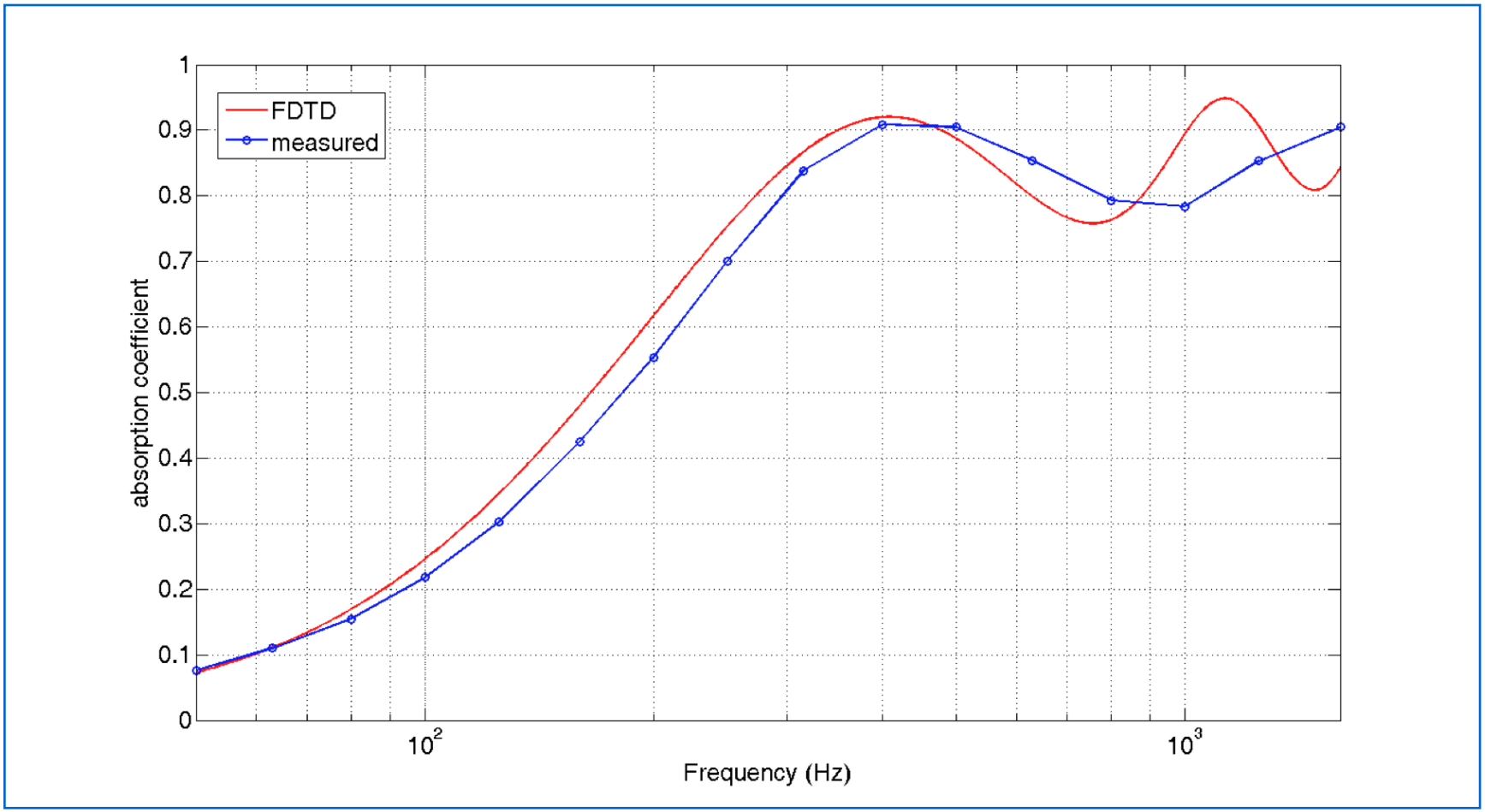
Absorption: Green treatments vegetated walls



Propagation path measures

- Vegetated walls and barriers: Canevaflor vegetated wall system

  FDTD = predicted



*Van Renterghem, T., Hornikx, M., Forssen, J., Botteldooren, D., (2013), The potential of building envelope greening to achieve quietness. Build. Environ., **61**, 34-44.

Propagation path measures

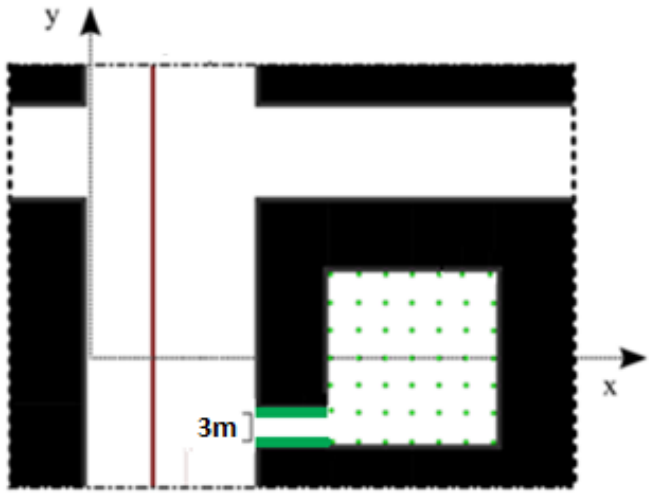
Absorption: Green treatments green facades

- Noise reduction
  - 3 to 4 dB(A) reduction in courtyard*
  - 2 to 3 dB(A) in trafficked street

*Van Renterghem, T., Hornikx, M., Forssen, J., Botteldooren, D., (2013), The potential of building envelope greening to achieve quietness. Build. Environ., **61**, 34-44.

Propagation path measures

Absorption: Green treatments green façade opening



- Noise reduction in courtyard 4.5 dB(A)

Veisten et al., Environ. Res. Public Health, 9(10), 3770-3788.

Propagation path measures

Absorption: Green treatments

Propagation path measures

Absorption: Green treatments

Propagation path measures

Absorption: Green treatments green roof

- Noise reduction only in courtyard:
  - 2.5 dB(A) for flat roofs and
  - 8 dB(A) for angled roofs

Propagation path measures