RIVAS Training Workshop: "Reducing railway induced ground vibration by interventions on the transmission path", Berlin, 23 May 2013

Mitigation of vibration by sheet pile walls

Results of numerical simulations

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Trafikverket

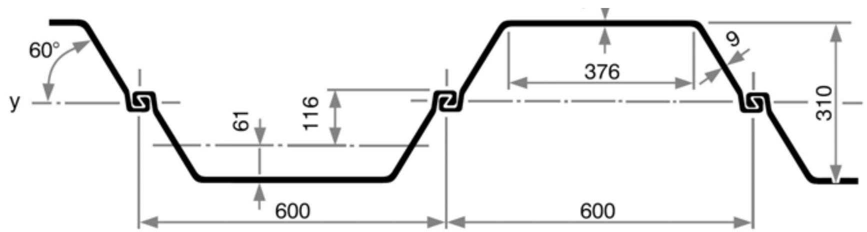
Contents

- Numerical analysis
  - Two-and-a-half dimensional methodology
  - Sheet pile wall model
  - Output
- Results for homogeneous halfspace
- Results for Furet test site
- Conclusions

Numerical analysis

- Sheet pile wall: VL 603-K profiles
  - Depth of 12 m with every fourth pile extended to 18 m

Mass	$m_w = 113.5\,\mathrm{kg/m^2}$
Sectional area	$A_w = 144.8\,\mathrm{cm^2/m}$
Moment of inertia	$I_w = 18900\,\mathrm{cm^4/m}$
Width	$t_w = 0.310\,\mathrm{m}$



Numerical analysis

- Sheet pile wall: VL 603-K profiles
  - Depth of 12 m with every fourth pile extended to 18 m

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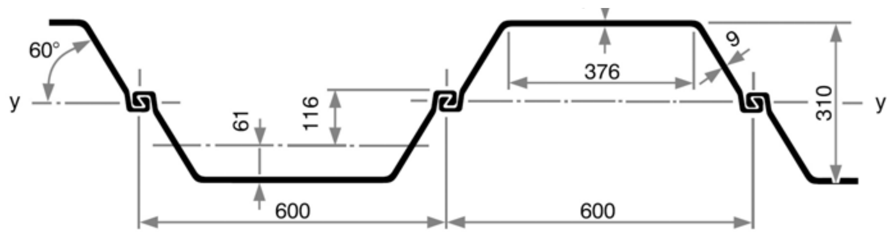
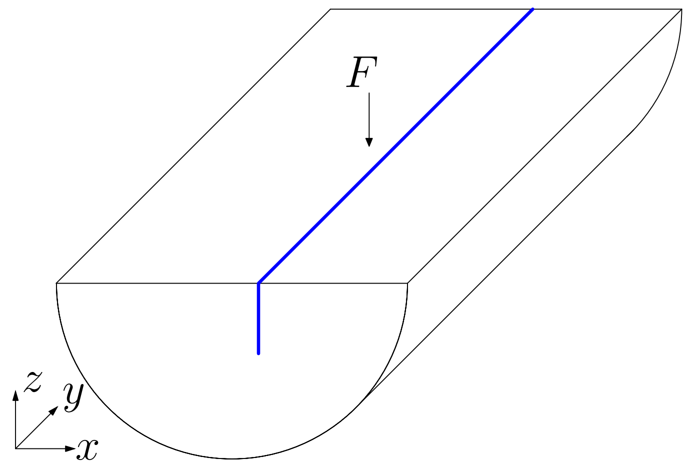
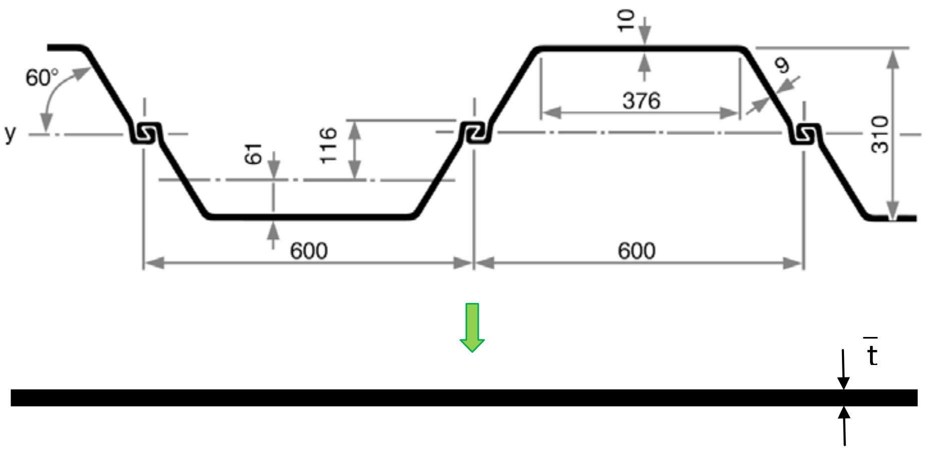


- 2.5D methodology
  - Longitudinally invariant geometry
    - Two models: depth $12\,\mathrm{m}$ and $18\,\mathrm{m}$
    - Profiling



Numerical analysis

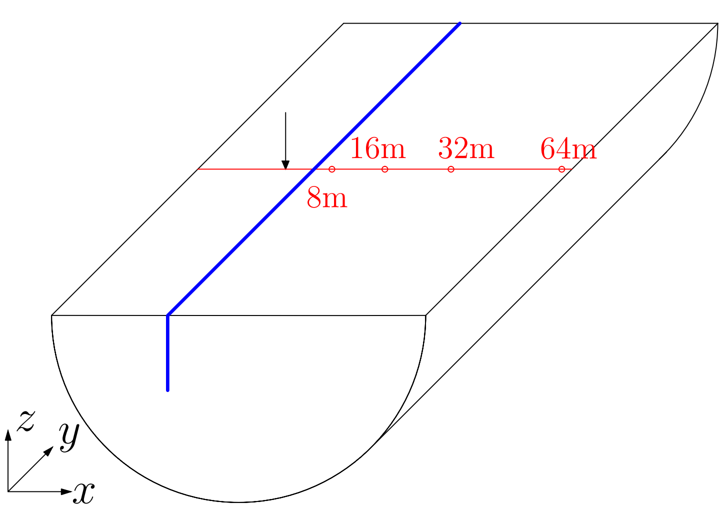
- Equivalent plate model
  - Bending stiffness along the profiles B_z is much larger than bending stiffness perpendicular to the profiles B_y
  - Equivalent orthotropic plate with same mass, axial stiffness and bending stiffness in both directions as the sheet pile wall

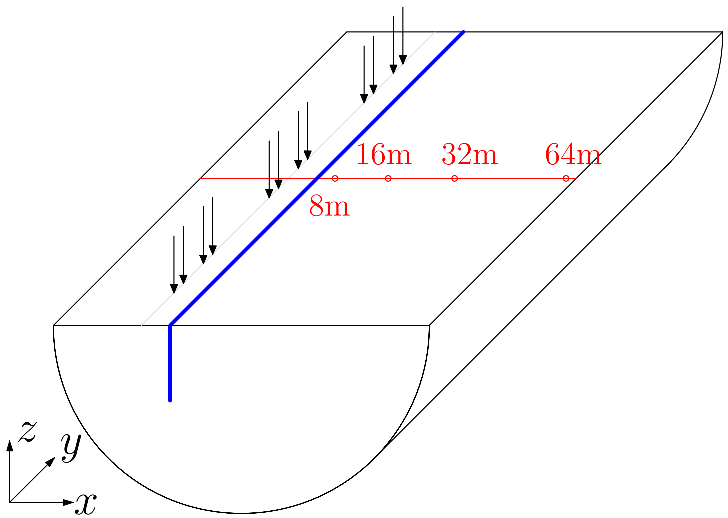


Thickness	$\bar{t} = 0.396\,\mathrm{m}$
Young's modulus	$\bar{E}_y = 2.47 \times 10^6\,\mathrm{N/m^2}$
Young's modulus	$\bar{E}_z = 7.68 \times 10^9\,\mathrm{N/m^2}$
Shear modulus	$\bar{\mu}_{yz} = 6.89 \times 10^7\,\mathrm{N/m^2}$
Poisson's ratio	$\bar{\nu}_{yz} = 0.0$
Poisson's ratio	$\bar{\nu}_{zy} = 0.0$
Mass density	$\bar{\rho} = 286.6\,\mathrm{kg/m^3}$

Numerical analysis

- Output
  - The presence of the track is disregarded
  - Transfer mobilities and insertion loss values at several distances for
    - a vertical harmonic point force
    - a ’line’ load consisting of 36 incoherent point forces (representing an IC train)





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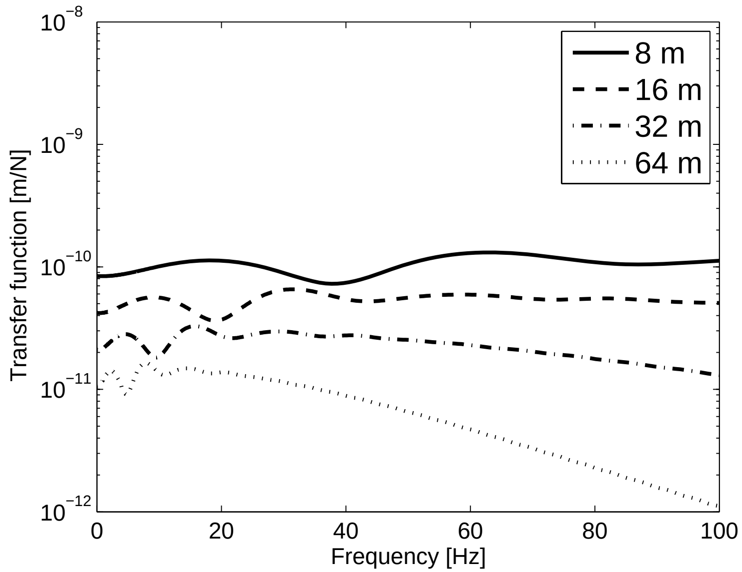
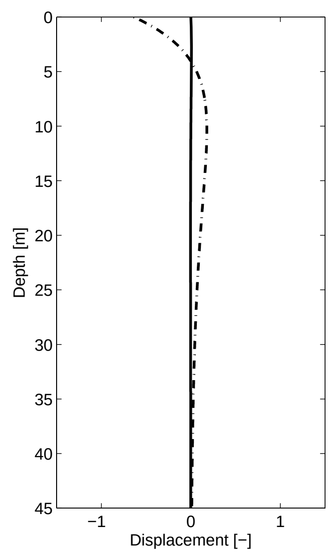
Homogeneous halfspace

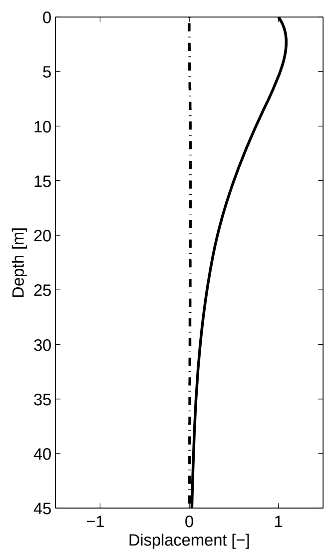
- Dynamic soil characteristics (Horstwalde)

Layer	h [m]	C_s [m/s]	C_p [m/s]	β_s [-]	β_p [-]	ρ [kg/m^3]	ν [-]
1	∞	250	1470	0.025	0.025	1945	0.485

- Transfer functions and fundamental Rayleigh wave at 10 Hz



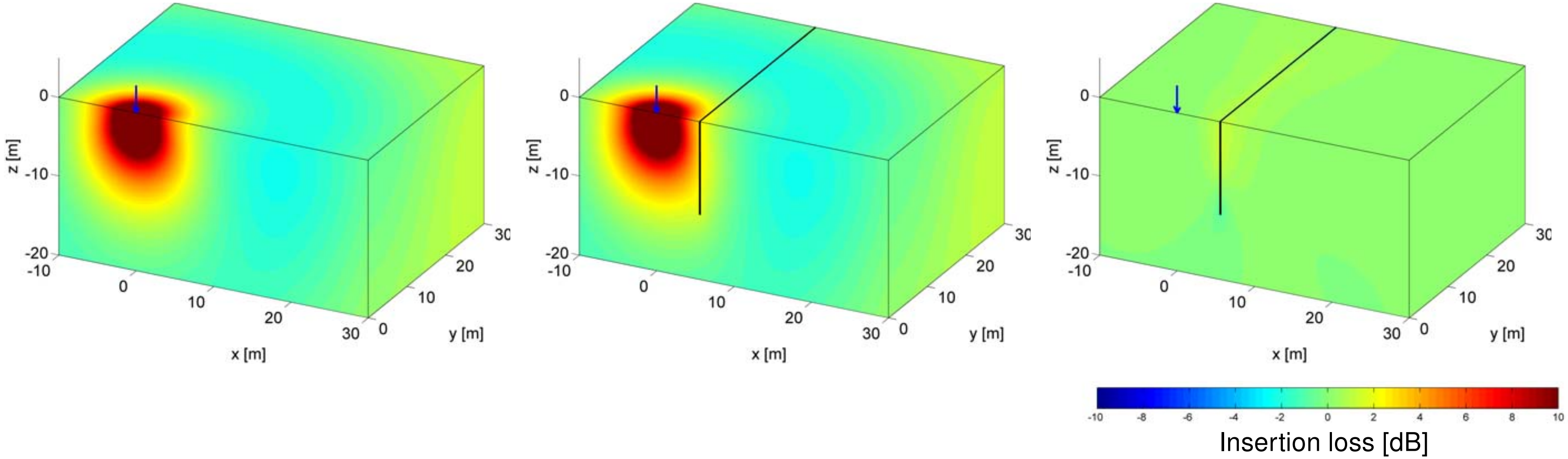




Homogeneous halfspace

- Vertical displacement and corresponding IL

5 Hz

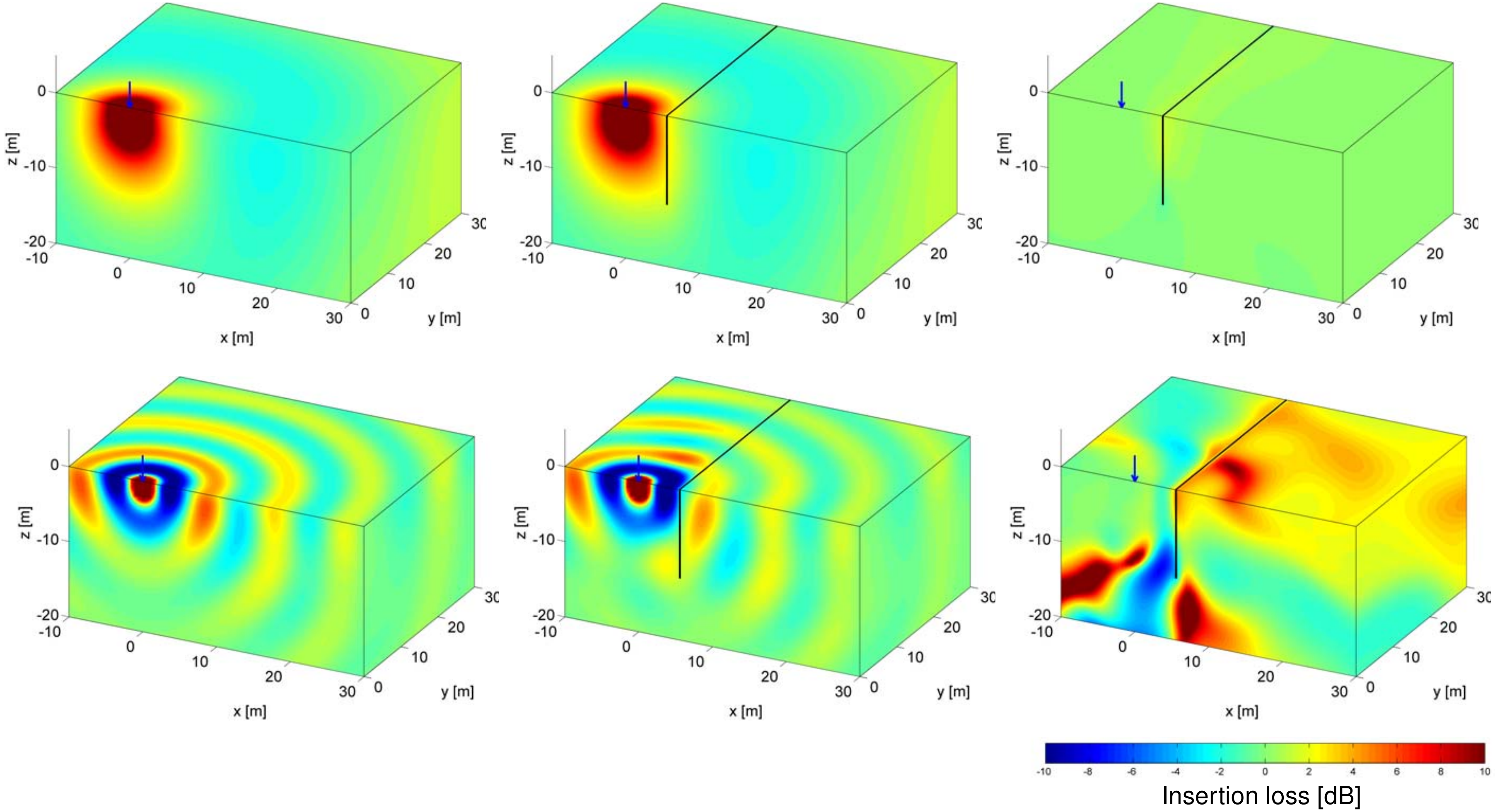


Homogeneous halfspace

- Vertical displacement and corresponding IL

5 Hz

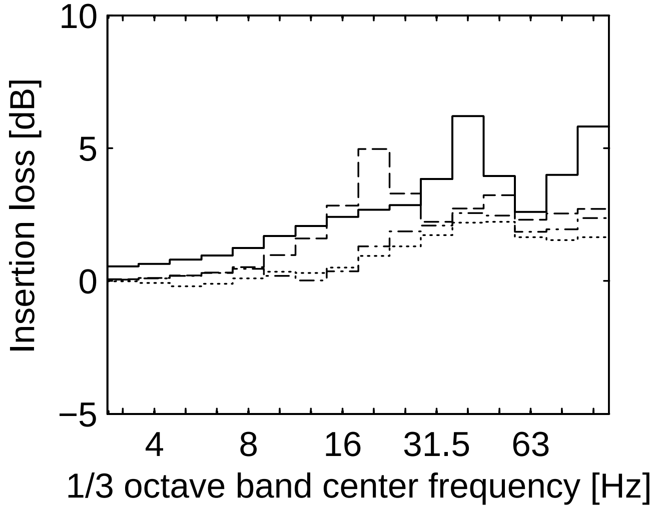
25 Hz



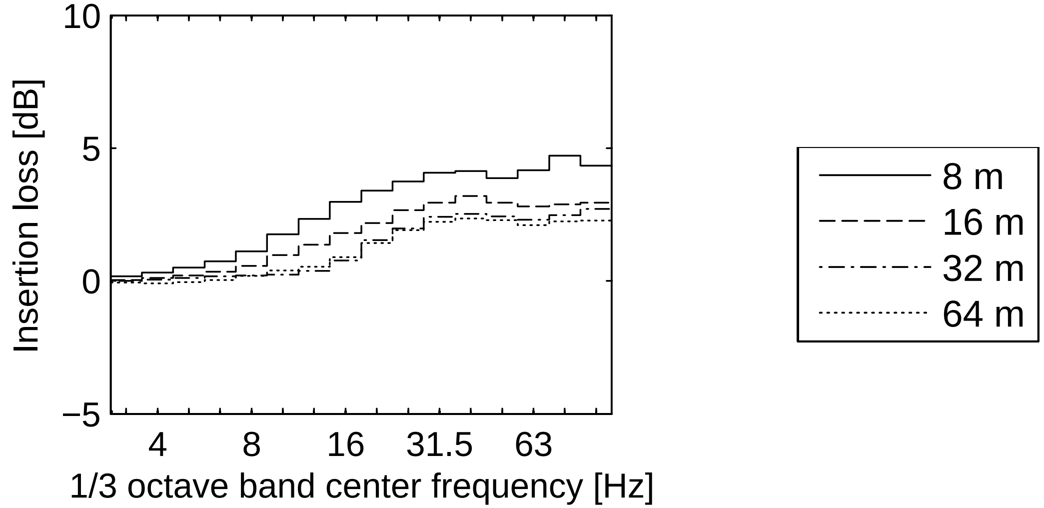
Homogeneous halfspace

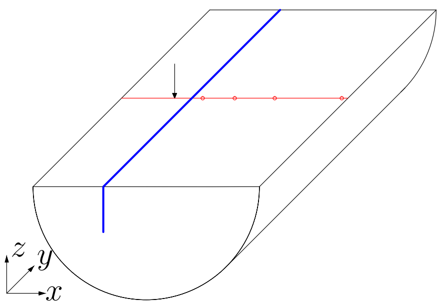
- Vertical insertion loss for the $12\,\mathrm{m}$ deep sheet pile wall

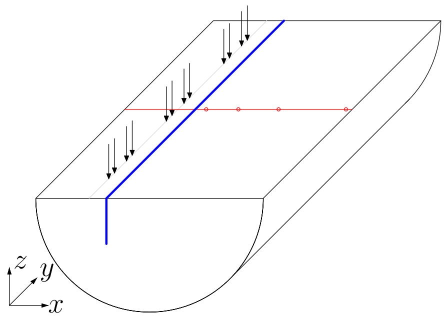
Point load



Line load







Homogeneous halfspace

- Influence of orthotropic behaviour
  - Comparison with isotropic plate model

	$\bar{E}_z$ [Pa]	$\bar{E}_y$ [Pa]	$\bar{\nu}$ [-]	$\bar{\rho}$ [kg/m^3]
Orthotropic wall	7.68×10^9	2.47×10^6	0.0	286.6
Isotropic wall	6.99×10^9	6.99×10^9	0.3	286.6

Homogeneous halfspace

- Influence of orthotropic behaviour
  - Comparison with isotropic plate model

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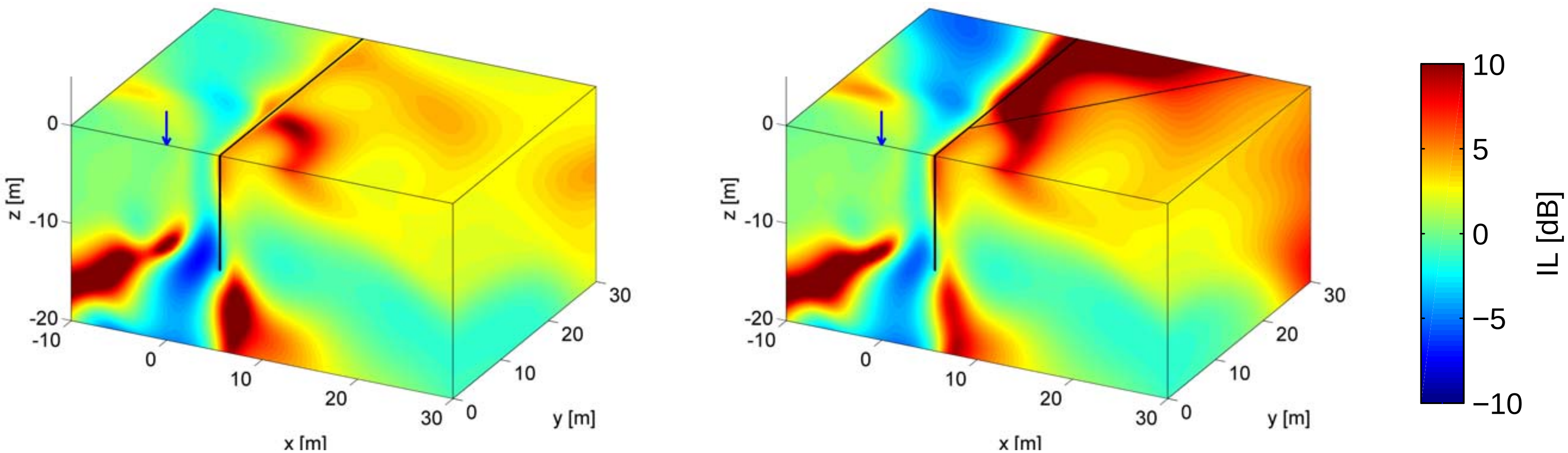
  - Vertical insertion loss at $25\,\mathrm{Hz}$ for a point load

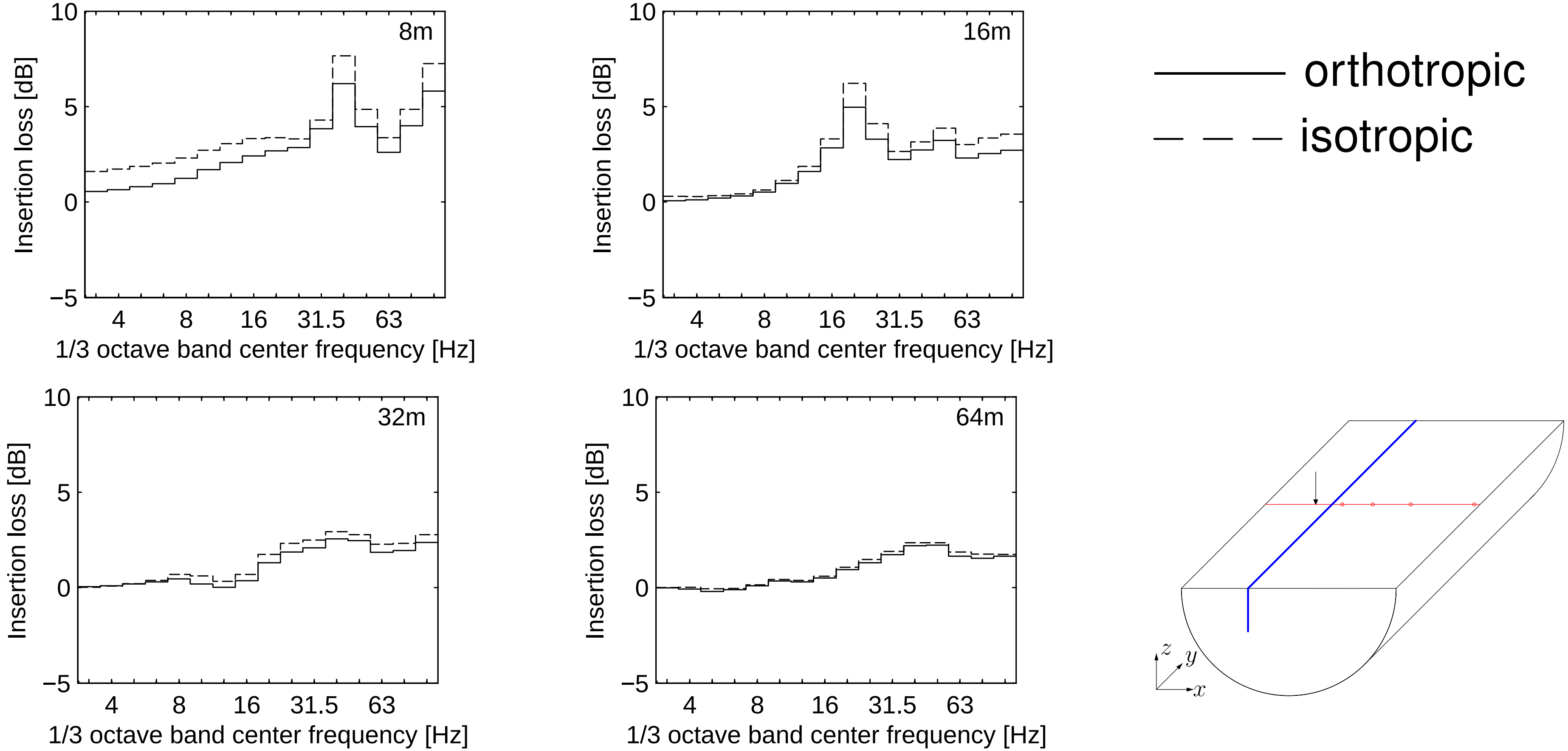
Orthotropic wall

Isotropic wall



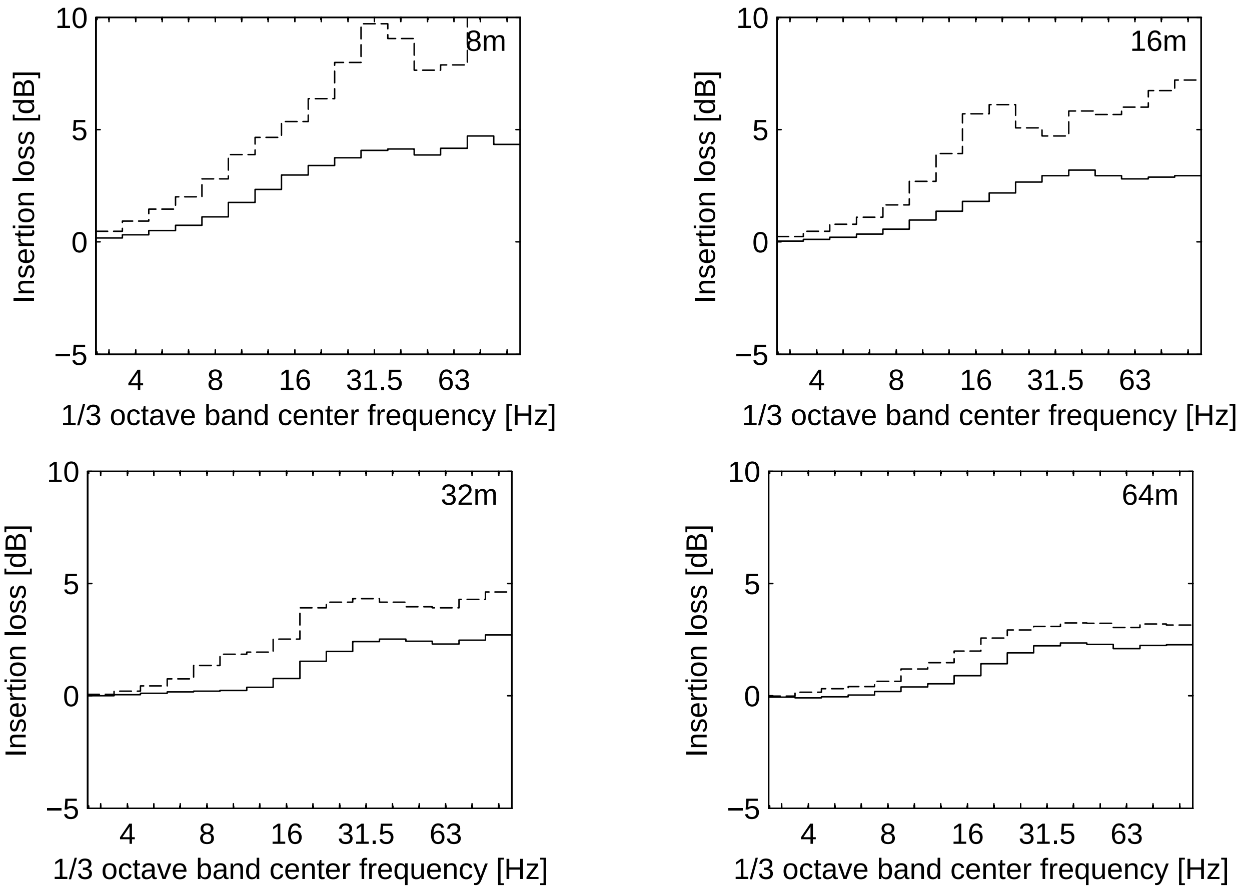
Homogeneous halfspace

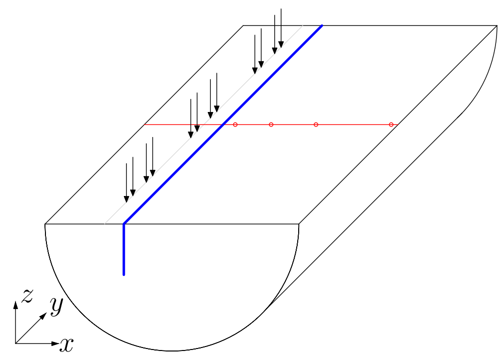
- Influence of orthotropic behaviour
  - Vertical insertion loss for a point load



Homogeneous halfspace

- Influence of orthotropic behaviour
  - Vertical insertion loss for a line load





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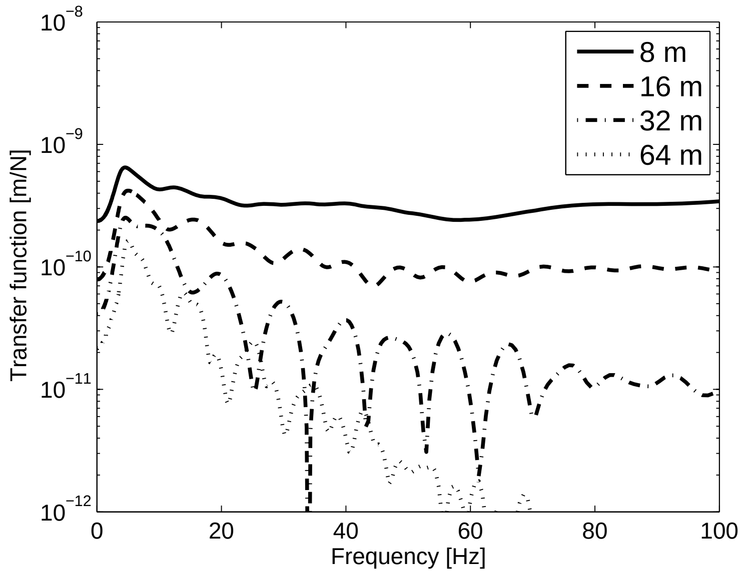
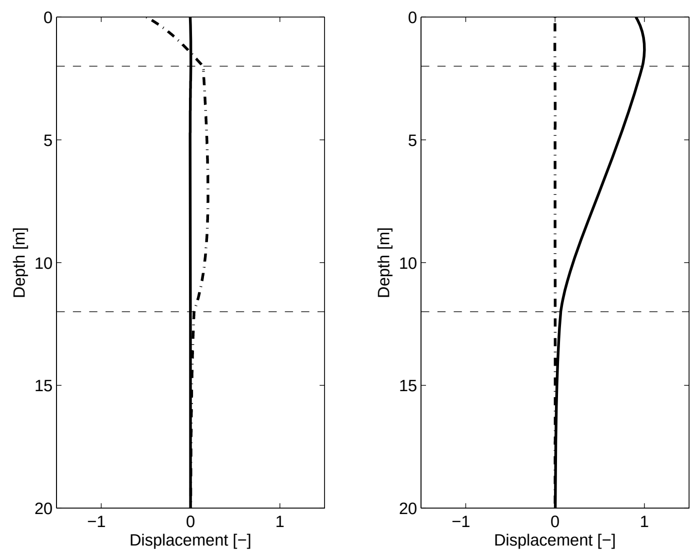
Furet test site

- Dynamic soil characteristics

Layer	h [m]	C_{s} [m/s]	C_{p} [m/s]	β [-]	ρ [kg/m^3]	ν [-]
1	2	154	375	0.025	1800	0.40
2	10	119	290	0.025	1850	0.40
3	∞	200	490	0.025	1710	0.40

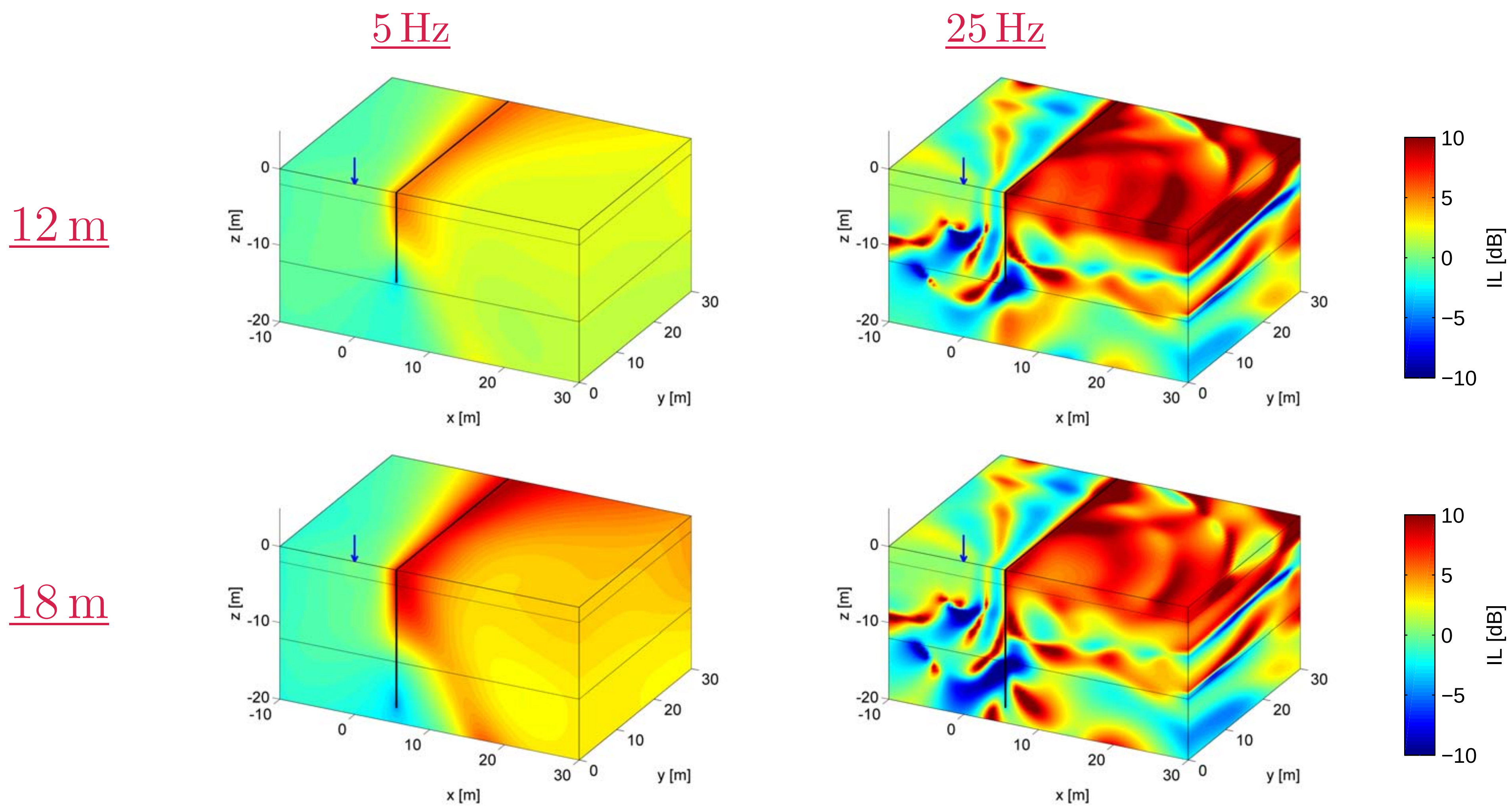
- Transfer functions and fundamental Rayleigh wave at 10 Hz





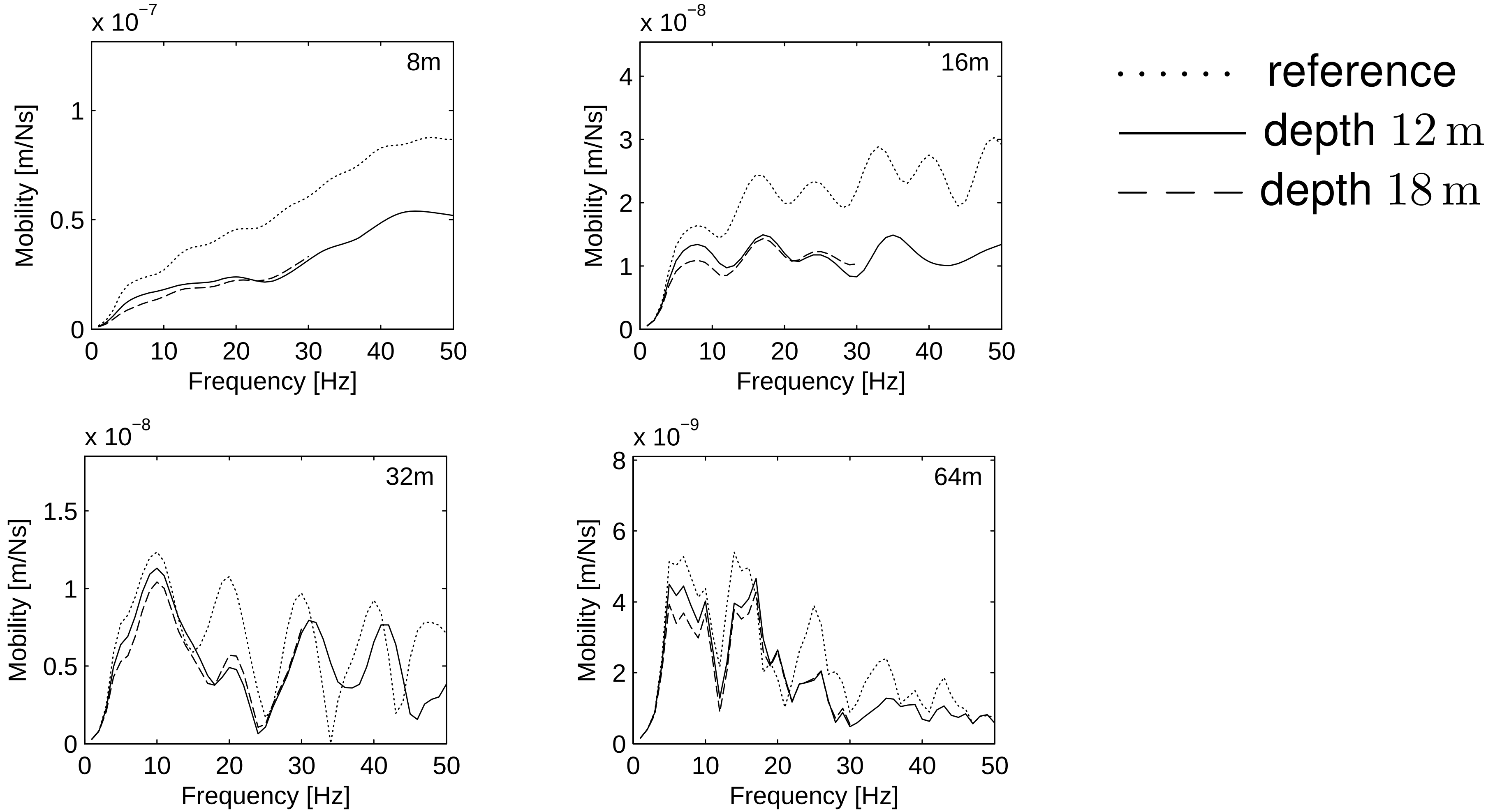
Furet test site

- Vertical insertion loss for the orthotropic sheet pile wall



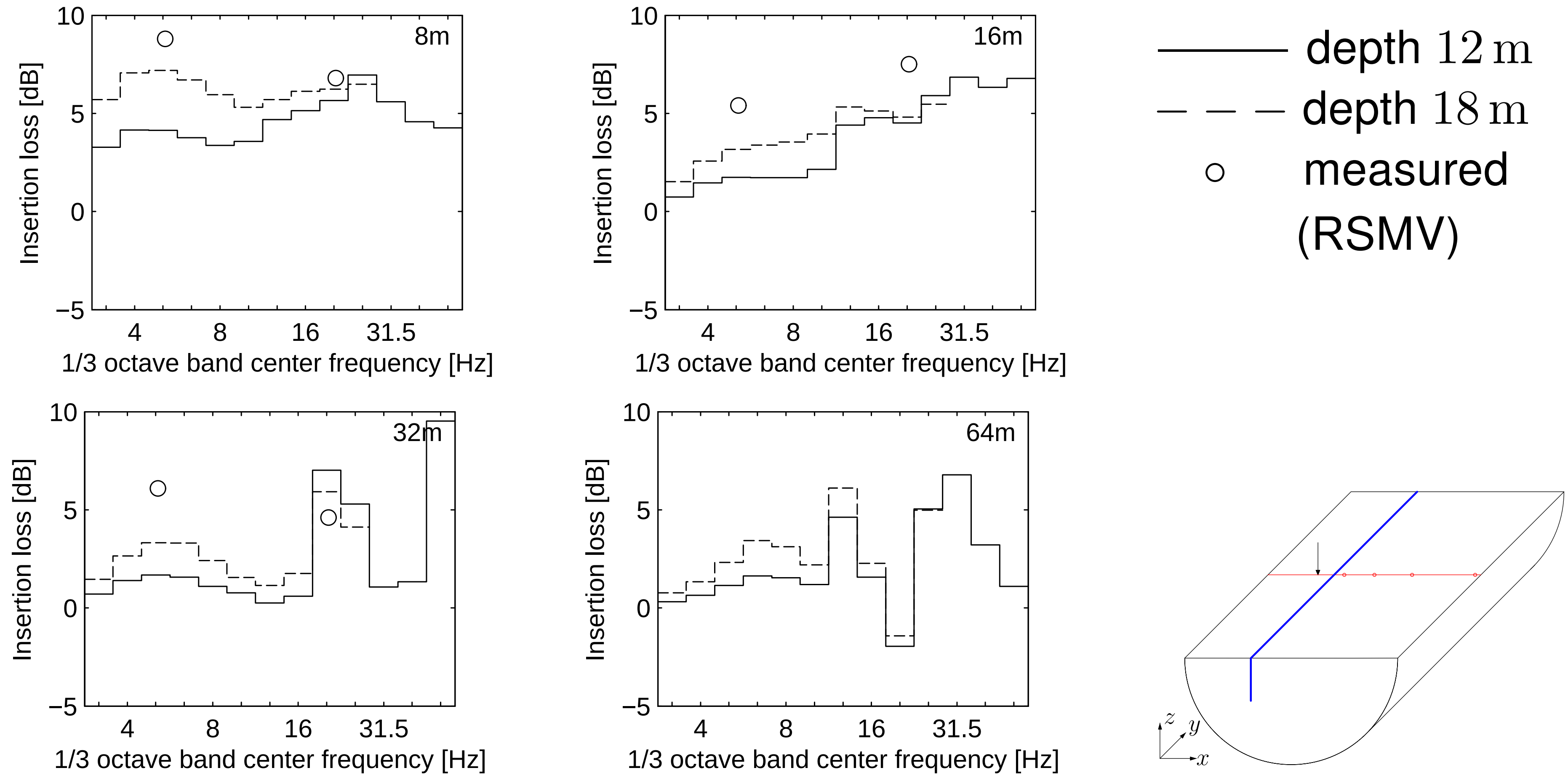
Furet test site

- Transfer mobility for a vertical point load



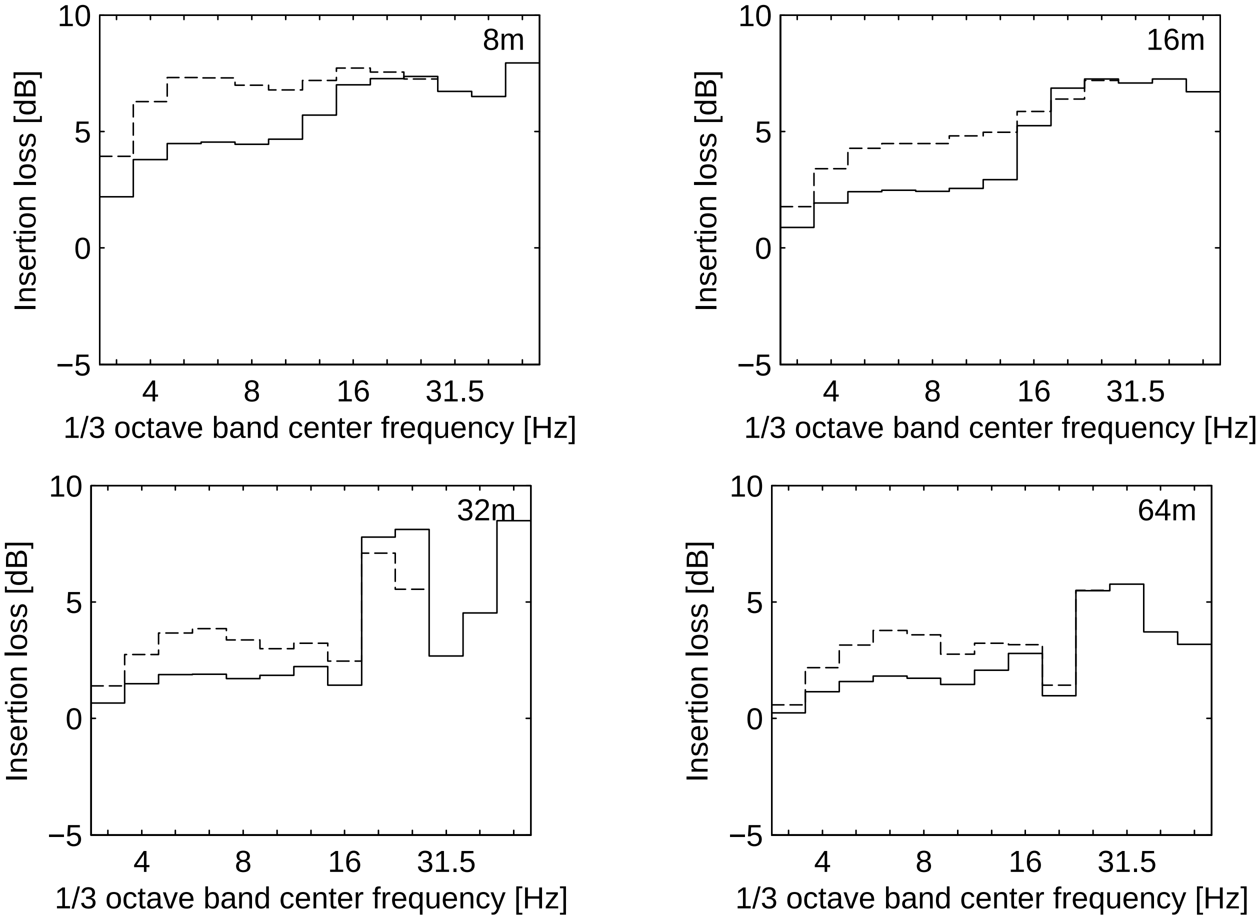
Furet test site

- Vertical insertion loss for a point load

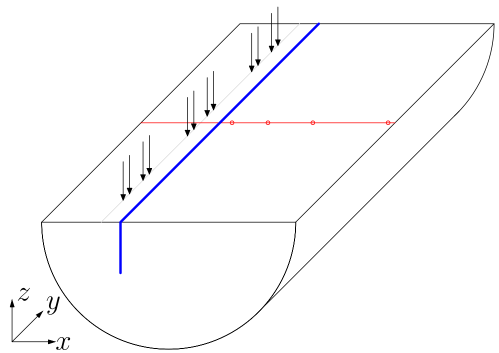


Furet test site

- Vertical insertion loss for a line load



—— depth 12 m
– – – depth 18 m



Contents

Conclusions

- Numerical analysis
  - Sheet pile wall acts as a stiff wave barrier
  - Only effective if the depth of the sheet pile wall is sufficiently large compared to the Rayleigh wavelength
  - Reduction at higher frequencies due to axial stiffness and vertical bending stiffness, longitudinal bending stiffness too low to affect vibration transmission
  - Important to take into account the orthotropic behaviour: isotropic model overestimates the insertion loss for a train passage
- Measurements at Furet test site
  - Train passages
  - RSMV (stationary excitation)

Thank you for your attention

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