Benchmark case: Duct

Description

This benchmark is the same example as in reference [1,3], see Figure 1. The 3D model consists of an air–filled duct of length $l = 3.4$ m with a 0.2m×0.2m square cross section. Since the solutions of the three–dimensional method should be compared with the analytical solution of the corresponding one–dimensional problem, it is necessary to apply zero boundary conditions for the boundary admittance, i.e. $Y = 0$, and the particle velocity on the entire surface, with the exception of $Y(l) = (\rho c)^{-1}$. Furthermore, for the particle velocity at $x = 0$, $v_x(0) = 1\,\mathrm{m/s}$ has been used. The sound pressure magnitude is constant in the duct and over the entire frequency range. The solution may be considered as waves traveling through the duct. The boundary condition at $x = l$ ensures that the wave is fully absorbed. Although a smooth solution is expected over the entire frequency range, the numerical solution may be unstable if modes perpendicular to the traveling waves occur. For the above given cross section, these modes occur for frequencies of 850, 1700, 2550, 3400 Hz and higher. This benchmark case has been used in reference [2], which provides an analytical solution of the 1D duct problem including the solution of the eigenvalue problem with arbitrary admittance boundary conditions at both ends. Furthermore, it gives the 1D finite element system matrices, studies the eigenvalue distribution of the finite element solution with respect to Shannon's sampling theorem and critically discusses the accuracy of mode superposition for reconstruction of the solution in frequency domain.	
Name	Duct
Field	Linear Acoustics
Code	*Assigned by Associate Editors*
Categories	
Bounded or Unbounded problems	Bounded
Dimensionality of the case	3D
Scattering or Radiation problem	Scattering
Time–domain or Frequency–domain problem	Frequency domain
Description	
PDE	Helmholtz Equation
Geometry	Length $l = 3.4$ m with a 0.2m×0.2m square cross section, see Fig. 1
Propagation medium	Air ($\rho = 1.3$ kg/m^3, $c = 340$ m/s)
BCs	$Z = \infty$ at walls $Z(l, y, z) = \rho c$
Source	$v_x = 1$ m/s at $x = 0$
Receiver	$(x, y, z) = (l, 0, 0)$
Quantity to compute	Acoustic pressure Frequencies for computation: 850 to 3400 Hz, with 425 Hz increment

References

[1] S. Marburg. Six boundary elements per wavelength. Is that enough? *Journal of Computational Acoustics*, 10(1):25–51, 2002.

[2] S. Marburg. Normal modes in external acoustics. part i: Investigation of the one–dimensional duct problem. *Acta Acustica united with Acustica*, 91(6):1063–1078, 2005.

[3] S. Marburg and S. Schneider. Influence of element types on numeric error for acoustic boundary elements. *Journal of Computational Acoustics*, 11(3):363–386, 2003.

Geometrical details

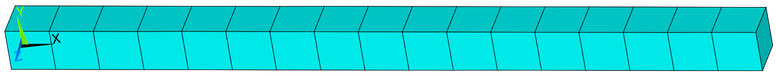

Figure 1: Benchmark case 'Duct'

Computational Details

Computational technique	
Computed results	
Programming details	
Code accessibility	
Processing details	
Computational complexity	
Notes	
References	
Contributing institute	Associate Editors benchmark cases

Results

Frequency (Hz)	**Acoustic Pressure (Pa)**
XX	$xx + jyy$