

AHLV302 – Guide of anechoic wave at vibro-absorbing entry

Summary:

The objective of this CAS-test is to calculate the fields of pressure in a guide of wave at anechoic exit and whose acoustic excitation is provided by a boundary condition speed imposed on a panel absorbing defined in the section of entry.

This test uses the vibroacoustic finite elements:

- modeling With : 3D_FLUIDE ;
- modeling B : 2D_FLUIDE ;
- modeling C : AXIS_FLUIDE .

An exact analytical solution exists. This CAS-test thus makes it possible to validate the features of definition of material properties for a not-deadened fluid, of definition of boundary conditions of speed and impedance as well as the tools of creation and assembly of the matrices of mass, stiffness and acoustic damping. In addition, it allows the validation of the acoustic calculation of pressure.

1 Problem of reference

1.1 Geometry

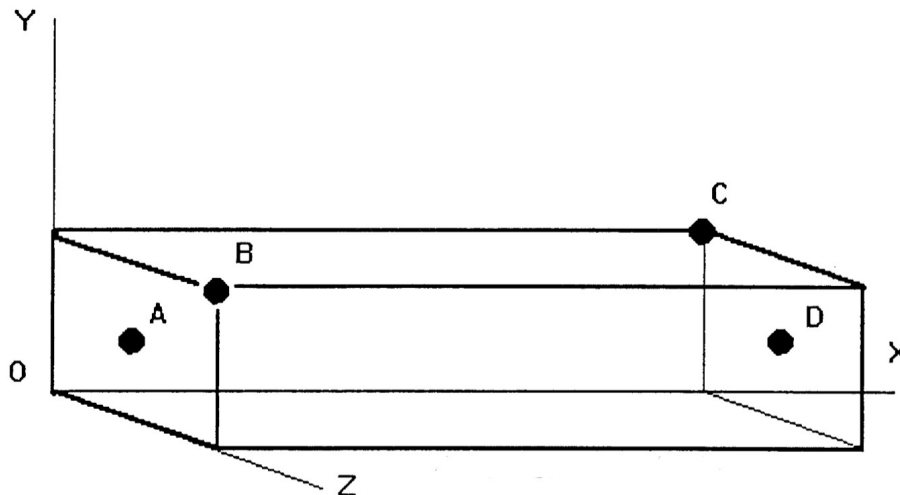


Figure 1.1 Geometry of the problem and system of loading

Parallelepipedic cavity:

- length: $L=l_x=1.0\text{ m}$
- height: $h=l_y=0.1\text{ m}$
- width: $l=l_z=0.2\text{ m}$

Coordinates of the points:

- A : $x=0.$, $y=0.05$, $z=0.1$
- B : $x=0.$, $y=0.1$, $z=0.2$
- C : $x=1.$, $y=0.1$, $z=0.0$
- D : $x=1.$, $y=0.05$, $z=0.1$

1.2 Properties of material

The material properties are those of the air:

$c=340\text{ m}\cdot\text{s}^{-1}$	Speed of sound
$\rho=1.2\text{ kg}\cdot\text{m}^{-3}$	Density

1.3 Boundary conditions and loadings

Unit uniform speed and impedance:

Section of entry $x=0$	$V_n=-1\text{ m}\cdot\text{s}^{-1}$ à 500 Hz $Z_n=-1000\text{ kg}\cdot\text{m}^{-2}\cdot\text{s}$
Section of entry $x=1$	$Z_n=-408\text{ kg}\cdot\text{m}^{-2}\cdot\text{s}$

2 Reference solution

2.1 Method of calculating used for the reference solution

The field of pressure p check the equation of Helmholtz according to the axis x :

$$\frac{d^2 p}{dx^2} + k^2 p = 0, \quad x \in [0, L]$$

In $x=0$, one finds boundary conditions speed V_n^s and of impedance Z_{n0} imposed:

$$p(x=0) = Z_{n0} (V_n(x=0) - V_n^s)$$

what gives in terms of imposed admittance:

$$V_n(x=0) = V_n^s + A_{n0} p(x=0)$$

In $x=L$, impedance Z_{nL} (or its reverse, the admittance A_{nL}) is imposed:

$$\frac{-\frac{dp}{dx}}{-i\rho\omega} = A_n p$$

The pressure in the guide of wave has the following form:

$$p(x) = C_1 e^{-ikx} + C_2 e^{ikx}$$

Thus, one can express the derivative of the pressure:

$$\frac{dp(x)}{dx} = -ikC_1 e^{-ikx} + ikC_2 e^{ikx}$$

Boundary conditions in $x=0$ allow to write:

$$-ikC_1 + ikC_2 = -i\rho\omega V_n^s - i\rho\omega A_{n0} (C_1 + C_2)$$

The boundary condition in $x=L$ allows to write:

$$ikC_1 e^{-ikL} - ikC_2 e^{ikL} = -i\rho\omega A_{nL} (C_1 e^{-ikL} + C_2 e^{ikL})$$

These two last relations make it possible to write a system of equations of which the resolution makes it possible to determine the constants C_1 and C_2 and thus pressure and particulate speed in any point of the guide of wave.

By preoccupation with a simplicity, the analytical expression of the coefficients C_1 and C_2 is not here well informed.

2.2 Results of reference

One calculates the pressure at the points A , B , C and D .

2.3 Uncertainty on the solution

Analytical solution.

3 Modeling A

3.1 Characteristics of modeling A

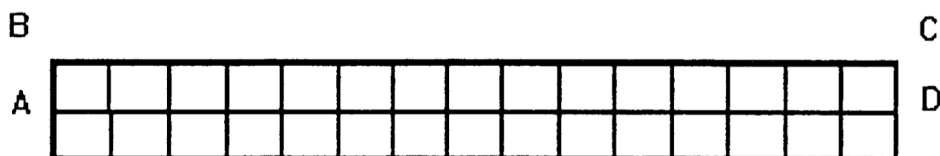


Figure 3.1. Grid of modeling A

Modeling 3D_FLUIDE

Cutting: 15 elements along axis X;
2 elements along the axis there;
2 elements along axis Z.

3.2 Characteristics of the grid

Many nodes: 471
Many meshes and types: 60 HEXA20 and 8 QUAD8

3.3 Sizes tested and results

Position	Value of reference	Tolerance (%)
<i>A</i>	$-289.77+0. i$	0.1
<i>B</i>	$-289.77+0. i$	0.1
<i>C</i>	$284.14-53.246 i$	0.3
<i>D</i>	$284.84-53.246 i$	0.3

4 Modeling B

4.1 Characteristics of modeling B

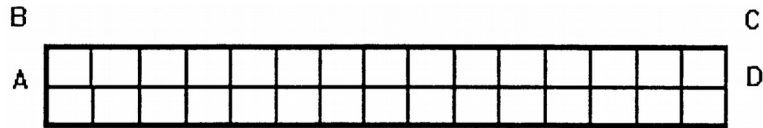


Figure 4.1. Grid of modeling B

Modeling 2D_FLUIDE

Cutting: 15 elements along axis X;
2 elements along axis Y.

4.2 Characteristics of the grid

Many nodes: 125
Many meshes and types: 30 QUAD8 and 4 SEG3

4.3 Sizes tested and results

Position	Value reference	Tolerance (%)
<i>A</i>	$-289.77+0. i$	0.1
<i>B</i>	$-289.77+0. i$	0.1
<i>C</i>	$284.14-53.246 i$	0.3
<i>D</i>	$284.84-53.246 i$	0.3

5 Modeling C

5.1 Characteristics of modeling C

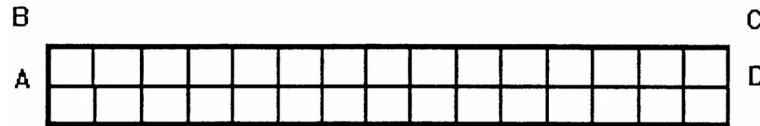


Figure 5.1. Grid of modeling C

Modeling `AXIS_FLUIDE`

Cutting: 15 elements along axis X;
2 elements along axis Y.

5.2 Characteristics of the grid

Many nodes: 125
Many meshes and types: 30 `QUAD8` and 4 `SEG3`

5.3 Sizes tested and results

Position	Value reference	Tolerance (%)
<i>A</i>	$-289.77+0. i$	0.1
<i>B</i>	$-289.77+0. i$	0.1
<i>C</i>	$284.14 - 53.246 i$	0.3
<i>D</i>	$284.84 - 53.246 i$	0.3

6 Summary of the results

The results are satisfactory and identical for three modelings.