

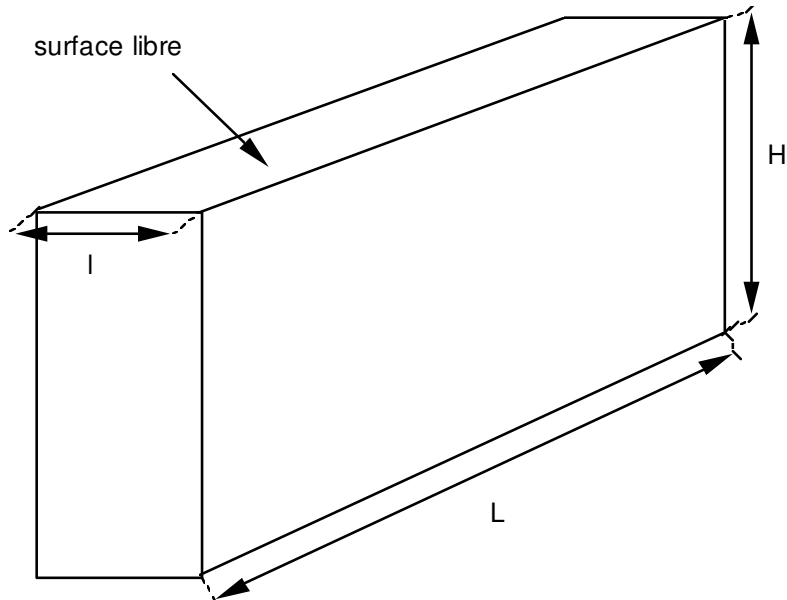
ADLV101 - Modes of shaking of a tank filled of water

Summary:

This test, of the acoustic and fluid field, relates to the research of the Eigen frequencies of a rectangular tank filled with a fluid including a free surface. The modal analysis thus determines the first modes of shaking of the surface of the fluid filling the tank. The first three Eigen frequencies are found with less than 1% of the analytically calculated frequencies.

1 Problem of reference

1.1 Geometry



dimensions of the tank:

height: $H = 0.3 \text{ m}$

length: $L = 0.8 \text{ m}$

width: $l = 0.1 \text{ m}$

1.2 Properties of materials

The modelled material is the fluid contained in the tank:

density: $\rho_c = 1000 \text{ kg/m}^3$

speed of sound: $c = 1400 \text{ m/s}$

1.3 Boundary conditions and loading

One imposes the field of gravity on the whole of the fluid model

```
load = AFFE_CHAR_MECA ( ...  
GRAVITY = (9.81, 0. , 0. , - 1.));
```

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference [bib3] provides the general formula of the modes of shaking in a parallelepipedic tank:

$$f_{ij} = \frac{1}{2\pi} \sqrt{\pi g \sqrt{\frac{i^2}{L^2} + \frac{j^2}{l^2}} th \left[\pi H \sqrt{\frac{i^2}{L^2} + \frac{j^2}{l^2}} \right]}$$

where i and j are the orders of the longitudinal and transverse modes (many nodal lines in each direction).

In the typical case or $-\frac{L}{l}$ is large, the formula is simplified for the longitudinal modes [bib1], [bib2].

2.2 Results of reference

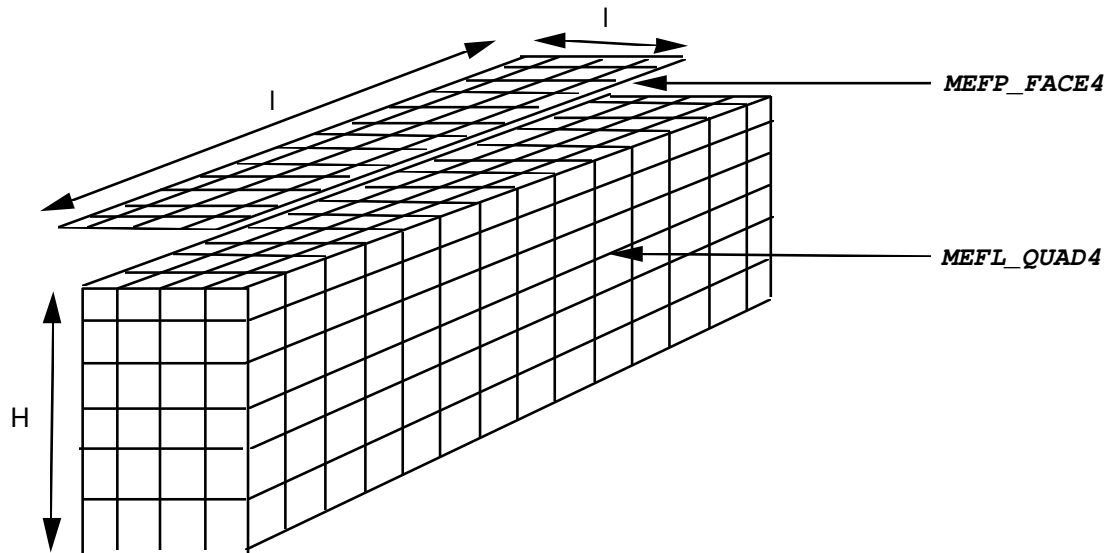
For $\frac{L}{l}=8$. and $h=0.3$ the first four modes are at frequencies 0.898,1.384,1.709 and 1,975.

2.3 Bibliographical references

- 1) WAECKEL F., LEPOUTERE C. Note internal EDF/DER "Effect of gravity on the free surface of a fluid coupled to a structure", HP-61/93/139.
- 2) MUTO, KASA, NAKAHARA, Experimental ISHIDA "tests one sloshing answer of has toilets pool with submerged blocks" - ASME, flight PVP 98, (1985).
- 3) BLEVINS R.D. Formulated for natural frequency and shape mode. Ed Krieger

3 Modeling A

3.1 Characteristics of modeling



- free surface is modelled by 57 elements MAFP_FACE4 (modeling 2D_FLUI_PESA) quadrangle with 4 nodes,
- fluid volume is modelled by 513 elements of fluid (modeling 3D_FLUIDE) cubic with 8 nodes.

3.2 Characteristics of the grid

The grid contains: 513 HEXA8
 57 QUAD4

3.3 Values tested

Identification	Reference
mode1	8.98250e-01
mode 2	1.38452e+00
mode 3	1.70952e+00
mode 4	1.97551e+00

4 Modeling B

4.1 Characteristics of modeling

This modeling differs from modeling A only by the type of element of free surface and by the type of element of fluid:

- free surface is modelled by 57 elements MEFP_FACE8 (modeling 2D_FLUI_PESA) quadrangle with 8 nodes,
- fluid volume is modelled by 513 elements of fluid (modeling 3D_FLUIDE) cubic with 20 nodes.

4.2 Characteristics of the grid

the grid contains: 513 HEXA20
 57 QUAD8

4.3 Values tested

Identification	Reference
mode1	8.98250e-01
mode 2	1.38452e+00
mode 3	1.70952e+00
mode 4	1.97551e+00

5 Modeling C

5.1 Characteristics of modeling

This modeling differs from modeling A only by the type of element of free surface and by the type of element of fluid:

- free surface is modelled by 57 elements MEFP_FACE9 (modeling 2D_FLUI_PESA) quadrangle with 9 nodes,
- fluid volume is modelled by 513 elements of fluid (modeling 3D_FLUIDE) cubic with 27 nodes.

5.2 Characteristics of the grid

the grid contains: 513 HEXA27
 57 QUAD9

5.3 Values tested

Identification	Reference
mode1	8.98250e-01
mode 2	1.38452e+00
mode 3	1.70952e+00
mode 4	1.97551e+00

6 Modeling D

6.1 Characteristics of modeling

This modeling differs from modeling A by the type of element used. Each mesh of modeling A is cut into two by a vertical plan.

- free surface is modelled by 114 elements MEFP_FACE3 (modeling 2D_FLUI_PESA) triangle with 3 nodes,
- fluid volume is modelled by 1026 elements of fluid (modeling 3D_FLUIDE) pentaedric with 6 nodes.

6.2 Characteristics of the grid

the grid contains: 1026 PENTA6
 114 TRIA3

6.3 Values tested

Identification	Reference
mode 1	8.98250e-01
mode 2	1.38452e+00
mode 3	1.70952e+00
mode 4	1.97551e+00

7 Modeling E

7.1 Characteristics of modeling

This modeling differs from modeling B by the type of element used. Each mesh of modeling B is cut by a vertical plan.

- free surface is modelled by 114 elements MEFP_FACE6 (modeling 2D_FLUI_PESA) triangle with 6 nodes,
- fluid volume is modelled by 1026 elements of fluid (modeling 3D_FLUIDE) pentaedric with 15 nodes.

7.2 Characteristics of the grid

the grid contains: 1026 PENTA15
 114 TRIA6

7.3 Values tested

Identification	Reference
mode 1	8.98250e-01
mode 2	1.38452e+00
mode 3	1.70952e+00
mode 4	1.97551e+00

8 Summary of the results

Modeling A implements elements of fluid of the type `HEXA8` and of the elements of free surface of the type `QUAD4`. The got result reveals a maximum error of 1.52% compared to the analytical solution.

Modeling B utilizes elements of fluid of the type `HEXA20` and of the elements of free surface of the type `QUAD8`. The results correlate perfectly with the analytical solution.

Elements fluid of the type `HEXA27` and of fluid weighing of type `QUAD9` are used for modeling C. the got results are identical to the reference solution.

Modeling D makes it possible to validate elements fluid of the type `PENTA6` and of the elements of free surface of the type `TRIA3`. The got results reveal a relative error of 1,479% compared to the reference solution.

Modeling E makes it possible to validate the elements of free surface of the type `TRIA6`. They are connected to elements of fluid of the type `PENTA15`. There is perfect coincidence of the results with the analytical solution.

Generally, it is observed that results got by elements with quadratic interpolation (`HEXA20`, `HEXA27`) are in excellent agreement with the analytical results. Nevertheless the elements with linear interpolation have an acceptable precision on the results.