

## ADLV101 - Modes of shaking of a tank filled of water

---

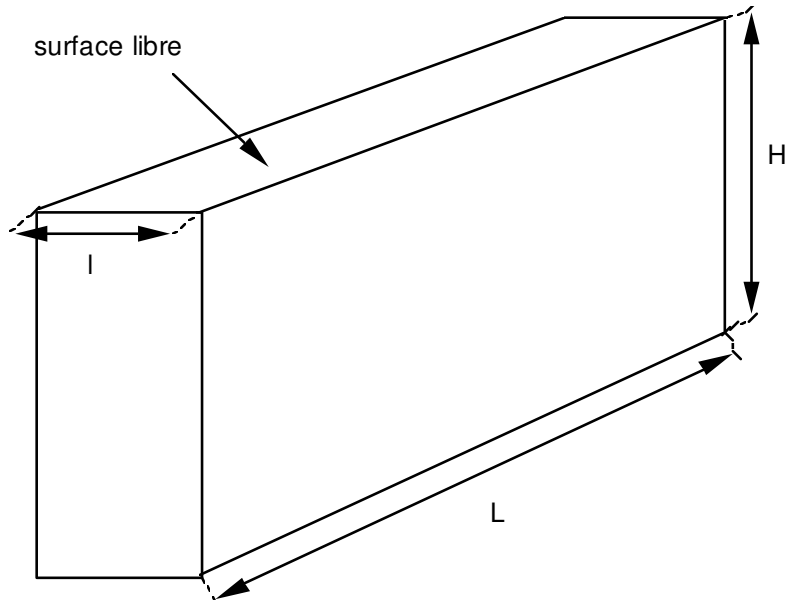
### Summary:

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

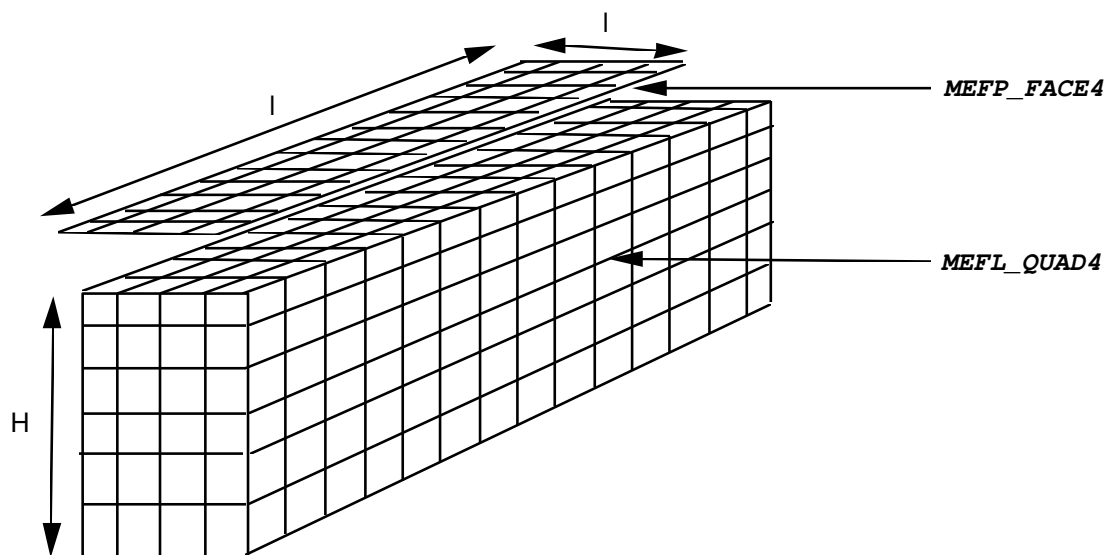
For  $\frac{L}{l}=8$ . and  $h=0.3$  the first four modes are at frequencies 0.898,1.384,1.709 and 1,975.

### 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 MEFP\_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











## 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.