ADLV312 – Flexible cylindrical tank filled with water

Summary:

This test relates to the modal analysis of a tank filled with water. Fluid volume has a free surface. The tank is modelled by elements of plate DKT and fluid by elements vibroacoustic 3D.

It is a question of calculating the hydroelastic clean modes; one is not interested particularly in the modes of shaking whose deformation energy is weak with respect to that of the hydroelastic modes.
In order to improve the identification of these modes, one calculates the masses generalized after having imposed the standard on a given degree of freedom.
The values of reference of the Eigen frequencies are obtained numerically starting from modelings 3D and from Fourier in software the SAMCEF software.

1 Problem of reference

1.1 Geometry

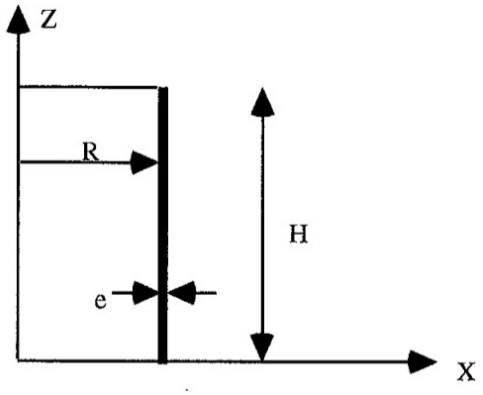

Figure 1.1 Geometry of the problem

Dimensions of the tank:

- height: $\mathrm{H}=0.3048\ \mathrm{m}$
- average radius: $\mathrm{R}=0.076073\ \mathrm{m}$
- thickness of hull: $\mathrm{e}=0.254\times10^{-3}\ \mathrm{m}$

The surfacel ibre is located at the ordinate $Z=\mathrm{H}$. It is perpendicular to the axis Z .

1.2 Properties of material

The properties of the fluid filling the cavity are the following ones:

Speed of sound	$c_F=1400\,\mathrm{m.s}^{-1}$
Density	$\rho_F=1000\,\mathrm{kg.m}^{-3}$

The properties of the hull are the following ones:

Young modulus	$E=2.06\times10^{11}\mathrm{Pa}$
Poisson's ratio	$\nu=0.3$
Density	$\rho_S=7850.0\,\mathrm{kg.m}^{-3}$

1.3 Boundary conditions and loadings

Embedding at the base:

In any point such as $Z=0$	$DX=0$, $DY=0$, $DZ=0$, $DRX=0$, $DRY=0$, $DRZ=0$

Fluid subjected to a field of gravity:

In any point of the fluid	Gravity $g=9.81\,\mathrm{m/s^2}$ according to Z

2 Reference solution

2.1 Method of calculating used for the reference solution

The values of reference of the Eigen frequencies are obtained numerically: one carries out the average of the results coming from an analysis of Fourier and two analyses 3D. The formulation for the fluid is the same one in the three cases: it is about an incompressible fluid, discretized by a potential of displacement. The hull of Fourier is of Reissner type, the models of hulls 3D are respectively of Mindlin type (3D-1) and hybrid (3D-2). The analyses were carried out by means of software the SAMCEF software. In each case, the grids are refined until obtaining a stable solution.

In order to improve the identification of these modes, one locates in the SAMCEF software the degree of freedom normalized and one imposes the same one in the tests. One will be able to thus compare the generalized masses.

2.2 Results of reference

The table below provides the values of reference for the first mode of harmonics 2 to 7 (harmonic “N” is in $\cos(n\theta)$). The relative variation is calculated compared to the digital result furthest away from the reference.

Harmonic	Fourier (Hz)	Model 3D-1 (Hz)	Model 3D-2 (Hz)	Reference (Hz)	Variation (%)
4	71.2	71.5	70.8	71.2	1.0
3	77.5	77.7	77.0	77.4	0.9
5	98.8	99.6	98.3	98.9	1.3
2	133.6	133.6	132.9	133.4	0.5
6	147.3	149.4	146.6	147.8	1.9
7	211.4	216.0	210.4	212.6	2.7

2.3 Uncertainty on the solution

Uncertainty varies from one frequency to another. The relative variation more deep east lower than 3 % (see table above).

3 Modeling A

3.1 Characteristics of modeling A

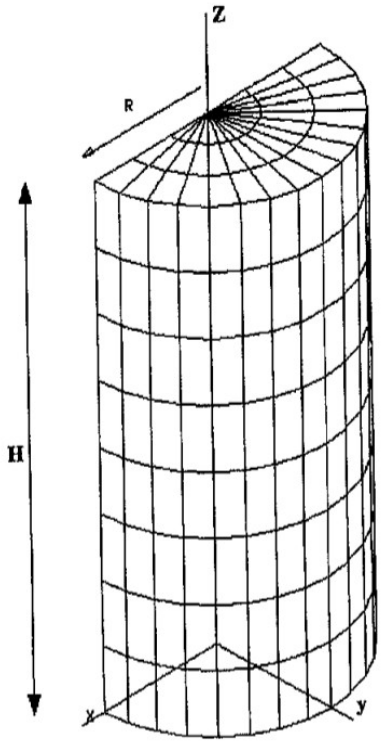

Figure 3.1. Grid of modeling A

Only half of tank is with a grid. This model perhaps used to calculate the modes of torsion around the axis Z .
The tank is with a grid regularly by elements of quadrangular plate (modeling DKT). The fluid is with a grid by voluminal elements of fluid (modeling 3D_FLUIDE), the upper part is covered with a layer of elements with free surface (modeling 2D_FLUI_PESA). The interface fluid-structure is papered quadrangular elements of coupling (modeling FLUI_STRU).

3.2 Characteristics of the grid

Many nodes: 2822
Many meshs and types: 64 TRIA3, 1280 QUAD4, 512 PENTA6 and 2048 HEXA8

3.3 Sizes tested and results

Identification	Value of reference	Type of reference	Tolerance (%)
Mode 1	71.2	'SOURCE_EXTERNE'	4.6

Mode 2	77.4	'SOURCE_EXTERNE'	3.5
Mode 3	98.8	'SOURCE_EXTERNE'	5.4
Mode 4	133.4	'SOURCE_EXTERNE'	2.0
Mode 5	147.8	'SOURCE_EXTERNE'	6.5
Mode 6	212.6	'SOURCE_EXTERNE'	7.7

4 Summary of the results

In this test, only the frequencies of structure are tested; one is not interested in the frequencies of free surface.
The got results are in concord with those obtained by the SAMCEF software since the maximum variation with the reference solution reached 7.5 %.
It should be noted that a relatively fine grid was also used in order to get results close to the reference solution (5 meshs according to the ray, 16 meshs on the height and 32 on the circumference).