FDLV103 - Concentric spheres separated by a Summarized incompressible

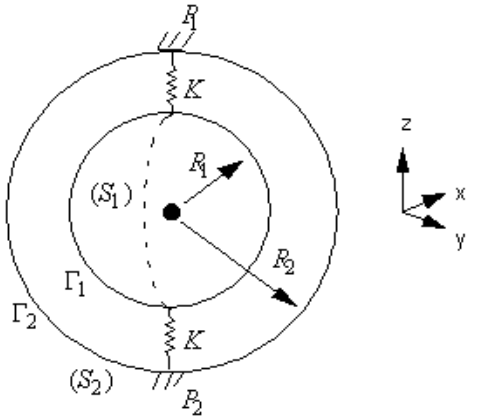
fluid:

This test relates to the field of the fluids in the aspect inertial coupling. One carries out a modal analysis of a rigid sphere connected to the solid mass by springs and diving in an incompressible volume of fluid of spherical form.

The test validates the computation of added mass in 3D as well as modal computation for a system fluid-structure coupled in 3D.

1 Problem of reference

1.1 Geometry



the sphere intérieurea (S_1) a radius $R_1=0.35\,m$.
The interior sphere (S_2) has a radius $R_2=0.45\,m$.

1.2 Material properties

the sphere intérieureest (S_1) out of steel:

$$\rho_s=7\,800\,kg/m^3$$
$$E=2.110^{11}\,Pa$$
$$\nu=0.3$$

The fluid filling out volume understood enters (S_1) and (S_2) is water of density $\rho_f=1\,000\ kg/m^3$ (equivalent thermal characteristics: $\lambda=1$, $\rho_f C_p=1\,000$).

One passes to model the fluid by a thermal modelization 3D.

1.3 Boundary conditions and loadings

One null supposes a temperature in a point of the fluid mesh.

One embeds springs on the level of the solid mass at the points P_1 and P_2 .

2 Reference solution

2.1 Method of calculating used for the reference solution

One is based on result analytical [bib1]:

In the case of two concentric spheres immersed in the same fluid, it is shown that the added mass induced by the fluid confined on the internal sphere (S_1) is worth:

$$m_a = \frac{2}{3}\rho_f \pi \left[\frac{1+2\left(\frac{R_1}{R_2}\right)^3}{1-\left(\frac{R_1}{R_2}\right)^3} \right] R_1^3$$

If it is supposed that the sphere has one following degree of freedom Oz, the eigen mode of translation of the sphere (S_1) according to Oz is given by:

$$f = \frac{1}{2\pi}\sqrt{\frac{2\mathrm{K}}{m+m_a}}$$

Numerical application:

$K = 10^5\, N/m$

$m = 12\, kg$

$m_a = 329.17\, kg$

$F = 3.8534\, Hz$

2.2 Bibliographical references

1.R.D. BLEVINS, “Formulated for natural frequency and mode shape”, ED. KRIEGER

3 Modelization A

3.1 Characteristic of the modelization

The modelization understand:

side structure:

2 discrete elements of the type K_TR_L (mesh SEG2)
1316 shell elements of the type DKT (mesh TRIA3)

fluid side:

1316 thermal elements of face of the type 3D (mesh TRIA3)
14454 thermal elements of volume of the type 3D (mesh TETRA4)

the nodes of the inner shell are blocked according to all their degrees of freedom of rotation, like their two degrees of freedom of translation DX and DY (GROUP_NO: NOINT).

Springs are embedded with the solid mass at the points $P1$ and $P2$ (GROUP_NO: ENCAST).

The shells are of thickness $1\ mm$.

3.2 Characteristics of the mesh

Number of meshes and types: 2632 TRIA3, 2 SEG2, 14454 TETRA4.

3.3 Values tested

Identification	Reference
Order of the eigen mode: 1	3.8534

4 Summary of the results

One finds the values of the analytical results well.

The small variation observed on the added mass can come:

of a discretization not rather fine of the surface of the sphere,
or of a discretization not fine enough of fluid volume.