FDLV102 - Added mass calculated on one modele generalized

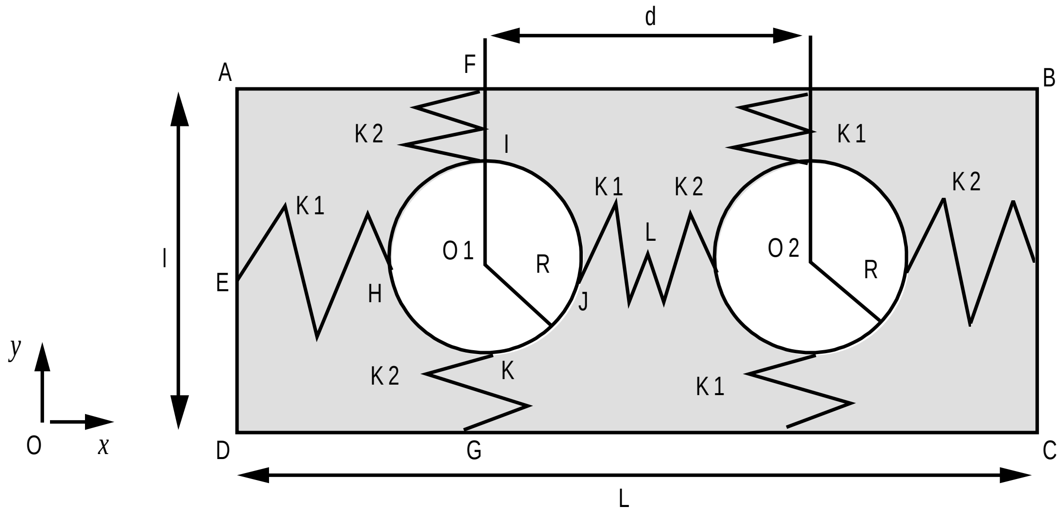
Summarized:

This test belongs to the field of the fluid interaction/structure, in its aspect inertial coupling: it is a question of calculating an added mass matrix, from one modele generalized resulting from a computation by dynamic substructuring. One carries out a modal analysis on the fluid coupled system/structure from a computation by substructuring, and one compares result with a direct fluid modal computation. One tests thus, for a two-dimensional fluid problem, the possibility of calculating the terms of added auto--mass and added mass of coupling between substructures deduced between them by rotation and translation (these “deduced” substructures not being with a grid).

There is currently only one modelization, which consists in assigning to the fluid mesh plane thermal elements.

1 Problem of reference

1.1 Geometry



Line of cylinders with circular section connected by springs to a fixed solid mass:

length:	$L=l_x=2.0\,m$
width	$l=l_y=1.0\,m$
radius of the cylinders:	$R=0.25\,m$
outdistance between centers of the tubes:	$d=1.0\,m$

Coordinates of the points (in m):

	$O1$	$O2$	A	B	C	D		
x	0.	1.00	– 0.50	1.50	1.50	– 0.50		
y	0.	0.	0.50	0.50	– 0.50	– 0.50		
	E	F	G	H	I	J	K	L
x	-0.50	0.	0.	– 0.25	0.	0.25	0.	0.50
y	0.	0.50	-0.50	0.	0.25	0.	– 0.25	0.

1.2 Properties of the materials

Fluid: Solid

$$\rho_0=1000.0\,Kg.m^{-3}$$

water: Steel

$$\rho_S=7800.0\,Kg.m^{-3} \qquad E=2.\text{E}11\,Pa \qquad \nu=0.3$$

Springs connecting the cylinder (substructure n°1 with a grid) to the solid mass:

Discrete element of the type `K_T_D_L`:

$$K_1=(1.\text{E}7\;1.1.\text{E}7)\,N/m$$

$$K_2=(1.1.\text{E}8\;1.\text{E}8)\,N/m$$

1.3 Boundary conditions and loading

Without object for the computation of added mass.

1.4 Initial conditions

Without object for the computation of added mass.

2 Reference solution

2.1 Method of calculating used for the reference solution

direct Modal computation (without dynamic substructuring)

Computation of the eigen modes in air:

One calculates with the option BANDAGES of operator MODE_ITER_SIMULT the first 4 eigenfrequencies of the system in air (spring-mass system):

mode 1: vibration of the two cylinders in phase according to Ox
mode 2: vibration of the cylinder n°2 according to Oy (on the right)
mode 3: vibration of the two cylinders in opposition of phase according to Ox
mode 4: vibration of the cylinder n°1 according to Oy (on the left)

These modes can be analytically given [bib1].

The computation Code_Aster provides for the eigenfrequencies in air:

mode 1: $f_1 = 17.3555\,Hz$ mode 2: $f_2 = 18.2034\,Hz$
mode 3: $f_3 = 42.6760\,Hz$ mode 4: $f_4 = 57.5418\,Hz$

Computation of the mass matrix added on modal base:

On this modal base, one calculates the added mass matrix of order 4 with operator CALC_MATR_AJOU [U4.55.10] option "MASS_AJOU" key word MODE_MECA (terms of triangular the inferiors):

$m11 = 300.67\,kg/m$ $m12 = 0.001\,kg/m$
$m13 = 269.98\,kg/m$ $m14 = 0.009\,kg/m$
$m22 = 269.98\,kg/m$ $m23 = 0.009\,kg/m$
$m24 = 31.05\,kg/m$ $m33 = 301.71\,kg/m$
$m34 = -0.011\,kg/m$ $m44 = 269.86\,kg/m$

Addition of this matrix to the generalized mass matrix:

One adds the matrix thus determined to the generalized mass matrix (operator COMB_MATR_ASSE [U4.53.01]) then one calculates the eigenfrequencies of structure immersed with operator MODE_ITER_SIMULT option PLUS_PETITE [U4.52.01].

The computation finds the eigenfrequencies following:

mode 1: $f'_1 = 15.8782\,Hz$ mode 2: $f'_2 = 16.7811\,Hz$
mode 3: $f'_3 = 39.0389\,Hz$ mode 4: $f'_4 = 53.0488\,Hz$

2.2 Results of reference

Eigenfrequencies determined by Code_Aster in a direct computation.

2.3 Bibliographical references

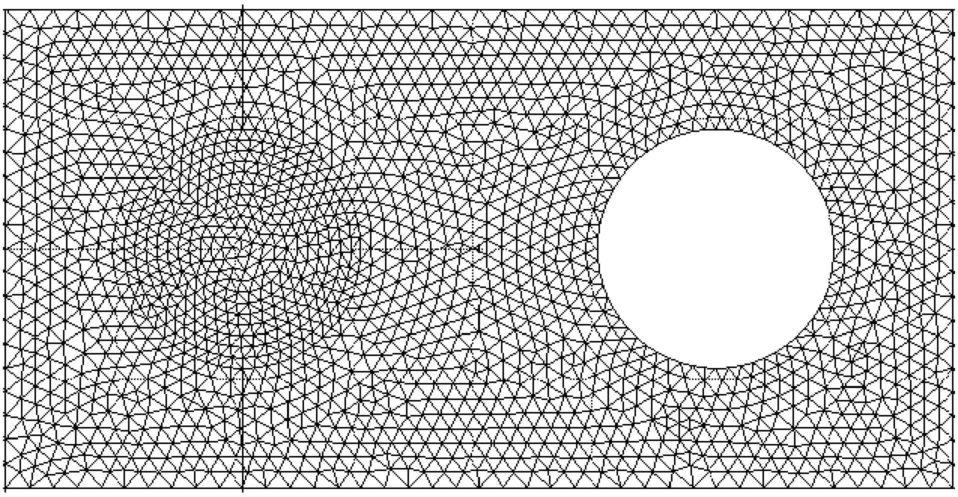
1.R.J GIBERT - Vibrations of Structures. Interactions with fluids. Eyrolles (1988).

3 Modelization A

3.1 Characteristic of the thermal

modelization Formulation planes for fluid (TRIA3 and SEG2)

Formulation plane strain and discrete for solid (TRIA3 and SEG2)



Cutting = 40 meshes TRIA3 according to the axis of x
the 20 meshes TRIA3 according to the axis of y
the 120 meshes SEG2 on the contour of the two cylinders
4 meshes SEG2 on the contour of the two cylinders representing meshes springs

Boundary conditions:

```
DDL_IMPO: (GROUP_NO: PBLOC1 DX: 0. DY: 0. DZ: 0.)
DDL_IMPO: (GROUP_NO: PBLOC2 DX: 0. DY: 0. DZ: 0.)
DDL_IMPO: (GROUP_NO: PBLOC3 DX: 0. DY: 0. DZ: 0.)
DDL_IMPO: (GROUP_NO: PBLOC4 DX: 0. DY: 0. DZ: 0.)
```

Name of the nodes: $E=PBLOC1$ $L=PBLOC2$
$F=PBLOC3$ $G=PBLOC4$

3.2 Characteristics of the mesh

Many nodes: 1.881
Number of meshes and types: 3.580 TRIA3, 124 SEG2

3.3 Values tested

Identification	Reference direct computation	*Aster* computation with under - structuring	% difference
Order of the eigen mode i : 1	15.8782	15.8782	+0.0000
Order of the eigen mode i : 2	16.7811	16.7815	+0.00002
Order of the eigen mode i : 3	39.0389	39.0289	– 0.0002

Order of the eigen mode i : 4	53.0488	53.0586	– 0.0002

3.4 Remarks

Computations of modes carried out by:

```
MODE_ITER_SIMULT     option: “tape”     List_freq: (2.  70. )
```

4 Recall

Course of the computation of added mass per modal synthesis

Computation of the eigen modes of the substructure 1 (cylinder of left with a grid) with interfaces blocked by MODE_ITER_SIMULT

Definition of two dynamic interfaces type CRAIG-BAMPTON (imposed unit displacement):

"EAST": corresponds to the " $PBLOC2=L$
SOUTHERN" point: corresponds to the point $PBLOC4=G$

Definitions of 2 modal bases associated with these interfaces: operator DEFI_INTERF_DYNA [U4.55.03]:

$BAMO1$: two dynamic modes and a constrained mode: unit displacement on $PBLOC2=L$
$BAMO2$: two dynamic modes and a constrained mode: unit displacement on $PBLOC4=G$

Definitions of 2 macro-elements associated with these modal bases: operator MACR_ELEM_DYNA [U4.55.05]

Definition of modele generalized: operator DEFI_MODELE_GENE [U4.55.06]:

Sous_structure_1: $CYLINDR0$: corresponds to the cylinder of left (with a grid)
Sous_structure_2: $CYLINDR1$: corresponds to the cylinder of right (nonwith a grid)
This second substructure is deduced from the first by rotation of -90°.
ANGL_NAUT: (- 90. , 0. , 0.)
Connection: EST and SUD
This definition of two substructures makes it possible DEFI_MODELE_GENE to calculate the translation between two substructures.

Creation of a full profile sky line from modele generalized definite: operator NUME_DDL_GENE [U4.55.07]

Assembly of the generalized stiffness matrixes and mass: operator ASSE_MATR_GENE [U4.55.08]

Computation of the mass matrix added from Generalized model definite:

The modal bases attached to each of two substructures define fields at nodes of displacement in the site of 1st substructure in the mesh. Operator CALC_MATR_AJOU [U4.55.10] transports the field at nodes substructure corresponding to the modal base of the second via the translation and rotation defined higher substructure to assign it to the site of the second in the mesh. The computation of the added mass is thus carried out following this displacement of field at nodes: one can thus calculate the added mass on 1st substructure, the added mass over the second substructure as well as the term of coupling between two substructures, taking into account the fluid environment of each substructure.

Summation of the assembled mass matrix generalized with the added mass matrix: COMB_MATR_ASSE [U4.53.01]

Computation of the eigen modes of immersed total structure: MODE_ITER_SIMULT [U4.52.02].