SDLL117 - Beam subjected to multiple of excitations transverse fluid-elastics and random zones

Abstract

This case of validation is intended to calculate by frequential method (resorption of software FLUSTRU) the linear vibratory response of a tubular structure of standard beam subjected to a transverse external flow.

One calculates the effects of the coupling fluid-elastic (variation of the frequency and the damping of structure) according to the rate of flow, then the vibratory response of the beam with a turbulent fluid excitation.

The fluid excitation is distributed on several zones and can be of identical or different nature on each one of these zones. Thus, this case test compares the results got with only one excitation zone (the tube is subjected to a fluid excitation distributed over all its length), and with two excitation zones (the tube is subjected to two fluid excitations of comparable nature, distributed on each half of the tube). The comparisons are carried out for various profiles of velocity and various coefficients fluid-elastics.

For this case test, there is no strictly speaking reference solution. The results got with two excitation zones of the fluid are compared with the results got with only one excitation zone. The purpose of the case test is to check non regression data structures.

1 Problem of reference

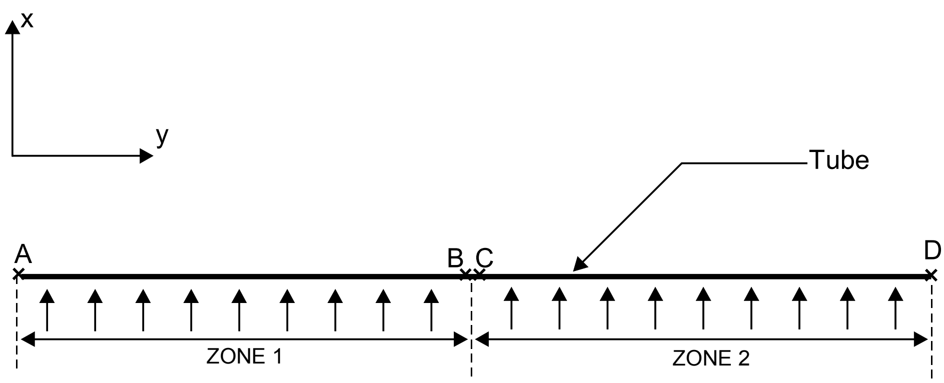
1.1 Geometry

the characteristics of the right tube of circular section digs are the following ones:

diameter external of the tube: $19{,}05\,mm$,
internal diameter of the tube: $16{,}87\,mm$.

The overall length of the tube is of $1{,}00\ m$, with:

the length of the part AB : $0{,}4975\,m$,
the length of the part CD : $0{,}4975\,m$.



Note:

The rates of flow are given to the nodes and not to the elements. Two adjacent zones of excitation must be separated by an element (BC in fact). However, the rate of flow is well defined in all the nodes and it is well the section $[AD]$ as a whole which is excited.

1.2 Properties of the materials

the values of the physical quantities characteristic of each element of structure are:

Tube out of brass: $E=1{,}22\,10^{11}\,N/m^2$ $\nu=0{,}3$ $\rho=8320\,kg/m^3$
Internal fluid: external $\rho_i=1000\,kg/m^3$
Fluid water: submerged tube in water over the entire length AD ,
transverse flow of water over the entire length AD
$\rho_e=1000\,kg/m^3$.

A coefficient of added mass for the computation of the equivalent density of structure to study is taken into account. The structure makes up of a beam, an internal fluid and an external fluid.

1.3 Boundary conditions and loadings

the beam is simply supported on the nodes A and D.
A random loading is distributed over the excited length (section $[AD]$ or sections $[AB]$ and $[CD]$) of the beam. The turbulent excitation is done thus by a transverse flow with the tube. The excitations are defined using a profile of velocity along the beam and an adimensional excitation spectrum. Each excitation zone of the fluid is implicitly defined by the portion of the tube on which the rate of flow is not null. In the case of multiple excitations, the excitation zones must be disjoined.

1.4 Initial conditions

The computation being frequential, one does not impose initial conditions.

2 Reference solution

2.1 Method of calculating used for the reference solution

the results got with two excitation zones of the fluid, of comparable nature, and distributed on each half of the tube, are compared with those obtained with only one excitation zone defined on the totality of the tube.

For the forces of coupling fluid-elastic, the comparisons are carried out on the variations of frequency and reduced damping of structure, according to the rate of flow. Several computations are carried out with uniform profiles velocity on $[AD]$, or in staircase (uniform on $[AB]$ and uniform on $[CD]$), and various types of network (configurations VISCACHE 1 and CLOTAIRE). The comparisons were carried out, for a rate of flow of $1,5 m/s$, for mode 2.

With regard to the turbulent excitations, they are the standard deviations of vibratory displacement calculated starting from the response sprectrums which were compared. These comparisons were also carried out for structures where the profiles velocities were uniform on $[AD]$, or in staircase (uniform on $[AB]$ and uniform on $[CD]$). They were carried out with the one of the two nodes located in the middle of the tube (node 100), where the differences are maximum.

3 Modelization A

3.1 Characteristic of the modelization

The model consists of beam elements right of Timoshenko: POU_D_T.

Cutting in 199 elements uniformly distributed on the group of the tube:

Section $[AB]$: 99 elements
Section $[BC]$: 1 element
Section $[CD]$: 99 elements

the nodes A and D are blocked following the directions:

X , Y and Z in translation
Y in rotation

3.2 Characteristics of the mesh

the nombre total of nodes used for this mesh is of 200.
Meshes (of type SEG2) are 199.
Mesh file is with the Aster format .

3.3 Stages of computation

the profile rate of flow fluid and the parameters taking into account the fluid coupling - structure are defined by operators DEFI_FONC_FLUI and DEFI_FLUI_STRU.
One then calculates the modal parameters of our structure in taking into account the elastic forces fluid - with CALC_FLUI_SRU.
The definition of the multiple zones of excitation is carried out by a call to the operator DEFI_SPEC_TURB, who allows to draw up the restrain between interspectral matrix and shape functions. The excitations are then projected on modal base using operator PROJ_SPEC_BASE and the interspectrums of modal response are calculated by the operator DYNA_SPEC_MODAL.
Lastly, one from of deduced the autospectrums from nodal stresses by a call to REST_SPEC_PHYS.
One can at the same time calculate spectral response only for one rate of flow, thus these three last stages (PROJ_SPEC_BASE, DYNA_SPEC_MODAL, REST_SPEC_PHYS) are carried out in a loop, in the command file, where one browses the list rates of flow.

3.4 Values tested

Identification	Reference *1 zones*	Computation *2 excitation zones*	% difference
Frequency Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) uniform Profile velocity ($1\,m/s$) Coefficients Viscache 1	32,28018 Hz	32,28018 Hz	0,0

Reduced damping Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) Profile velocity uniform ($1\,m/s$) Coefficients Viscache 1	8,960594E- 01%	8,960594E- 01%	0,0
Frequency Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) Profile velocity in staircase (et) $0{,}5$ $1\,m/s$ Coefficients Viscache 1	31,39222 Hz	31,39222 Hz	0,0
Reduced damping Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) Profile velocity in staircase (et) $0{,}5$ $1\,m/s$ Coefficients Viscache 1	9,170868E- 01%	9,170842E- 01%	0,0
Frequency Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) Profile velocity in staircase (et) $0{,}5$ $1\,m/s$ uniform Clotaire Coefficients	32,19244 Hz	32,19244 Hz	0,0
Reduced damping Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) Profile velocity in staircase (et) $0{,}5$ $1\,m/s$ uniform Clotaire Coefficients	5,947656E- 01%	5,947633E- 01%	0,0
Frequency Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) uniform Profile velocity ($0{,}5\,m/s$) Coefficients uniform Clotaire	32,28018 Hz	32,28018 Hz	0,0
Reduced damping Mode 2 Coupling fluid-elastic (velocity $1{,}5\,m/s$) Profile velocity uniform ($0{,}5\,m/s$) uniform Clotaire Coefficients	6,071243E- 01%	6,071211E- 01%	0,0
Value of **the RMS of displacement** for the rate of flow $0{,}7\,m/s$ Profile velocity uniform ($0{,}5\,m/s$) uniform Clotaire Coefficients	1,20960E-06 m	1,20953E-06 m	– 0,005
Value of **the RMS of displacement** for the rate of flow $1{,}1\,m/s$ uniform Profile velocity ($0{,}5\,m/s$) uniform Clotaire Coefficients	8,46330E-06 m	8,46290E-06 m	– 0,005
Value of **the RMS of displacement** for the rate of flow $1{,}5\,m/s$ uniform Profile velocity ($0{,}5\,m/s$) uniform Clotaire Coefficients	3,91328E-05 m	3,91308 E-05 m	– 0,005
Value of **the RMS of displacement** for the rate of flow $0{,}7\,m/s$ Profile velocity uniform ($1{,}0\,m/s$) Coefficients Viscache 1	2,83236E-06 m	2,83221E-06 m	– 0,005

Value of **the RMS of displacement** for the rate of flow $1,1\,m/s$ uniform Profile velocity ($1,0\,m/s$) Coefficients Viscache 1	1,36880E-05 m	1,36783E-05 m	– 0,005
Value of **the RMS of displacement** for the rate of flow $1,5\,m/s$ uniform Profile velocity ($1,0\,m/s$) Coefficients Viscache 1	3,24409E-05 m	3,24393E-05 m	– 0,005

4 Summary of the results

This case test makes it possible to check the behavior of the various operators of computation of fluid coupling - structure, in the case of multiple excitation zones. It is a case test of non regression operators concerned, and in particular, data structures.

In the case of the forces fluid-elastics (operators DEFI_FLUI_STRU and CALC_FLUI_STRU), when several excitation zones of the fluid are defined with identical characteristics, one obtains many rigorously equivalent results if there is only one zone.