SDLL117 - Beam subjected to multiple zones excitations fluid-rubber bands and random transverses

Summary

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

One calculates the effects of the coupling fluid-rubber band (variation of the frequency and the damping of the structure) according to the rate of the flow, then the vibratory response of the beam to 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 zones excitation (the tube is subjected to a fluid excitation distributed over all its length), and with two zones of excitation (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 speed and various coefficients fluid-rubber bands.

For this case test, there is no strictly speaking reference solution. The results got with two zones of excitation of the fluid are compared with the results got with only one zones excitation. The objective of the case test is to check to it not regression of the structures of data.

1 Problem of reference

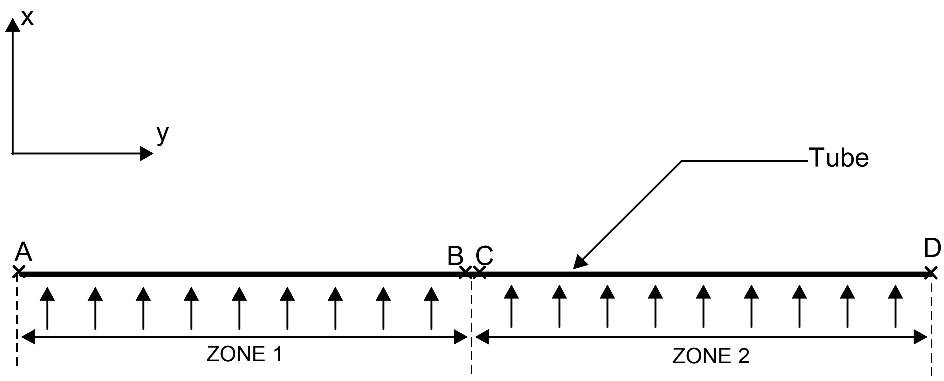
1.1 Geometry

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 materials

The values of the physical sizes characteristic of each element of the structure are:

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

A coefficient of mass added for the calculation of the equivalent density of the structure to study is taken into account. The structure consists 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 $[CD]$) beam. The turbulent excitation is done thus by a transverse flow with the tube. The excitations are defined using a profile of speed along the beam and an adimensional spectrum of excitation. Each zone of excitation of the fluid is implicitly defined by the portion of the tube on which the rate of flow is not worthless. In the case of multiple excitations, the zones of excitation must be disjoined.

1.4 Initial conditions

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

For the forces of coupling fluid-rubber band, the comparisons are carried out on the variations of frequency and reduced damping of the structure, according to the rate of flow. Several calculations are carried out with uniform profiles speed 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 displacement calculated starting from the spectra of vibratory answer which were compared. These comparisons were also carried out for structures where the profiles speeds 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 Modeling A

3.1 Characteristics of modeling

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

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

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

Nodes A and D following the directions are blocked:

X , Y and Z in translation
Y in rotation

3.2 Characteristics of the grid

The full number of nodes used for this grid is of 200.
Meshs (of type SEG2) are 199.
The file of grid is with the format ASTER.

3.3 Stages of calculation

The profile rate of flow fluid and the parameters taking of account the fluid coupling - structure are defined by the operators DEFI_FONC_FLUI and DEFI_FLUI_STRU.
One then calculates the modal parameters of our structure by taking of 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, which makes it possible to establish the link between matrix interspectrale and functions of form. The excitations are then projected on the modal basis using the operator PROJ_SPEC_BASE and the interspectres of modal answer are calculated by the operator DYNA_SPEC_MODAL.
Lastly, one from of deduced the autospectres from constraints to the nodes by a call to REST_SPEC_PHYS.
One can at the same time calculate spectral response only for one rate of the flow, thus these three last stages (PROJ_SPEC_BASE, DYNA_SPEC_MODAL, REST_SPEC_PHYS) are realized in a loop, in the command file, where one traverses the list rates of the flow.

3.4 Values tested

Identification	**Reference** *1 zone*	**Calculation** *2 zones of excitation*	**% difference**
Frequency Mode 2 Coupling fluid-rubber band (speed $1,5 m/s$) Uniform profile speed ($1 m/s$) Coefficients Viscache 1	32.28018 Hz	32.28018 Hz	0.0

Reduced damping Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Uniform profile speed ($1\,m/s$) Coefficients Viscache 1	8,960594E- 01%	8,960594E- 01%	0.0
Frequency Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Profile speed in staircase ($0{,}5$ and $1\,m/s$) Coefficients Viscache 1	31.39222 Hz	31.39222 Hz	0.0
Reduced damping Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Profile speed in staircase ($0{,}5$ and $1\,m/s$) Coefficients Viscache 1	9,170868E- 01%	9,170842E- 01%	0.0
Frequency Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Profile speed in staircase ($0{,}5$ and $1\,m/s$) Uniform Clotaire coefficients	32.19244 Hz	32.19244 Hz	0.0
Reduced damping Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Profile speed in staircase ($0{,}5$ and $1\,m/s$) Uniform Clotaire coefficients	5,947656E- 01%	5,947633E- 01%	0.0
Frequency Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Uniform profile speed ($0{,}5\,m/s$) Uniform Clotaire coefficients	32.28018 Hz	32.28018 Hz	0.0
Reduced damping Mode 2 Coupling fluid-rubber band (speed $1{,}5\,m/s$) Uniform profile speed ($0{,}5\,m/s$) Uniform Clotaire coefficients	6,071243E- 01%	6,071211E- 01%	0.0
Value of **RMS of displacement** for the rate of flow $0{,}7\,m/s$ Uniform profile speed ($0{,}5\,m/s$) Uniform Clotaire coefficients	1,20960E-06 m	1,20953E-06 m	– 0.005
Value of **RMS of displacement** for the rate of flow $1{,}1\,m/s$ Uniform profile speed ($0{,}5\,m/s$) Uniform Clotaire coefficients	8,46330E-06 m	8,46290E-06 m	– 0.005
Value of **RMS of displacement** for the rate of flow $1{,}5\,m/s$ Uniform profile speed ($0{,}5\,m/s$) Uniform Clotaire coefficients	3,91328E-05 m	3.91308 E– 05 m	– 0.005
Value of **RMS of displacement** for the rate of flow $0{,}7\,m/s$ Uniform profile speed ($1{,}0\,m/s$) Coefficients Viscache 1	2,83236E-06 m	2,83221E-06 m	– 0.005

Value of **RMS of displacement** for the rate of flow $1,1 m/s$ Uniform profile speed ($1,0 m/s$) Coefficients Viscache 1	1,36880E-05 m	1,36783E-05 m	– 0.005
Value of **RMS of displacement** for the rate of flow $1,5 m/s$ Uniform profile speed ($1,0 m/s$) 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 fluid calculation of coupling - structure, in the case of multiple zones of excitation. It is a case test of nonregression of the operators concerned, and in particular, structures of data.

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