

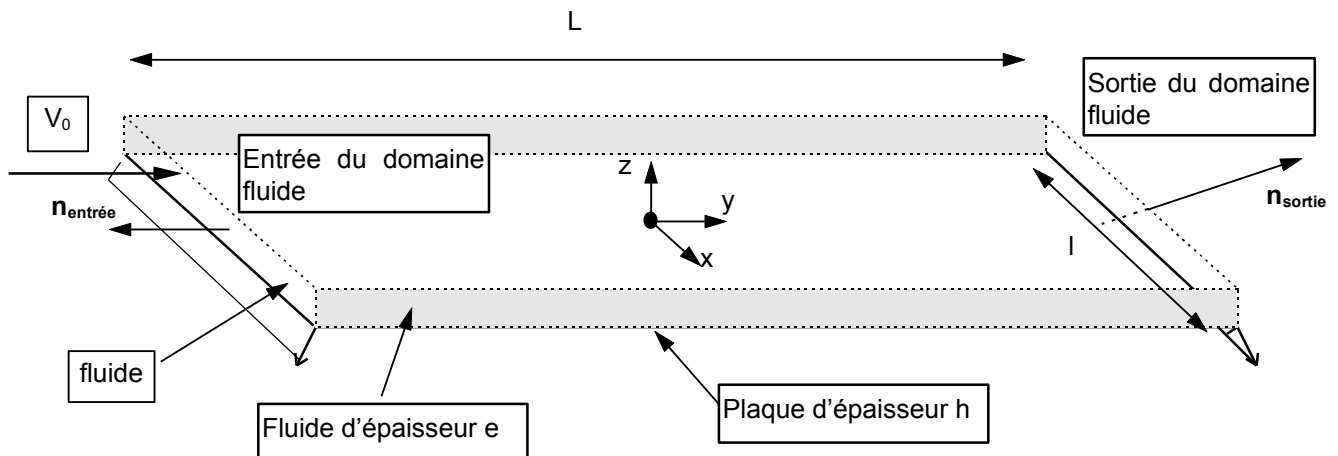
SDLS105 - Plane plate subjected to a turbulence homogeneous

Summary

This test of the field of the linear dynamics of the hulls and the plates implements the calculation of acceptance, a function intended to calculate the modal DSP of effort starting from a DSP of pressure. This precise test implements a modeling of the type plates with elements of fluid coupling/structure to test the method of Corcos whose function of correlation is appropriate to flows drawn up turbulent plans.

1 Problem of reference

1.1 Geometry



$$L = 50 \text{ m}$$

$$l = 5 \text{ m}$$

thickness of fluid $e = 0.5 \text{ m}$

thickness of the plate $h = 0.5 \text{ m}$

1.2 Properties of materials

Fluid: density $\rho = 1000 \text{ kg.m}^{-3}$ (water).

Structure: $\rho_s = 7800 \text{ kg/m}^3$, $E = 2.1 \cdot 10^{11} \text{ Pa}$, $\nu = 0.3$ (steel).

1.3 Boundary conditions and loadings

Fluid:

- to simulate steady flow, one forces on the face of entry of the fluid a normal speed of -4 m/s , the speed of entry \vec{V}_0 fluid being of opposite direction to the normal of entry (by analogy with the thermal analysis, one imposes a normal heat flow equivalent of -4),
- to calculate the fluid disturbance brought by the movement of the plate one forces a boundary condition of Dirichlet in a node of the fluid.
- one imposes in $x = \frac{e}{2}$ the condition $\phi_1 = \phi_2 = 0$ who corresponds to a null flow through the higher fluid wall.

Structure:

- the plate is subjected to a displacement imposed correspondent on a first mode of inflection [bib2]:

$$X_1 = \sin \frac{py}{L}$$

2 Reference solution

2.1 Method of calculating used for the reference solution

For the calculation of the added coefficients, one returns to the case test FDLV109.

One did a calculation of damping added to the rate of flow ($V_0 = 4 \text{ m.s}^{-1}$).

The added mass brought by the flow is worth:

$$M_{11}^a = 0.625 \cdot 10^5 \text{ kg},$$

$$M_{22}^a = 0.625 \cdot 10^5 \text{ kg},$$

$$M_{12}^a = 0.$$

Added damping is worth with $V_0 = 4 \text{ m.s}^{-1}$:

$$C_{11}^a = 0,$$

$$C_{22}^a = 0,$$

$$C_{12}^a = 0.266 \cdot 10^5 \text{ N.m}^{-1}.$$

The added stiffness is worth with $V_0 = 4 \text{ m.s}^{-1}$:

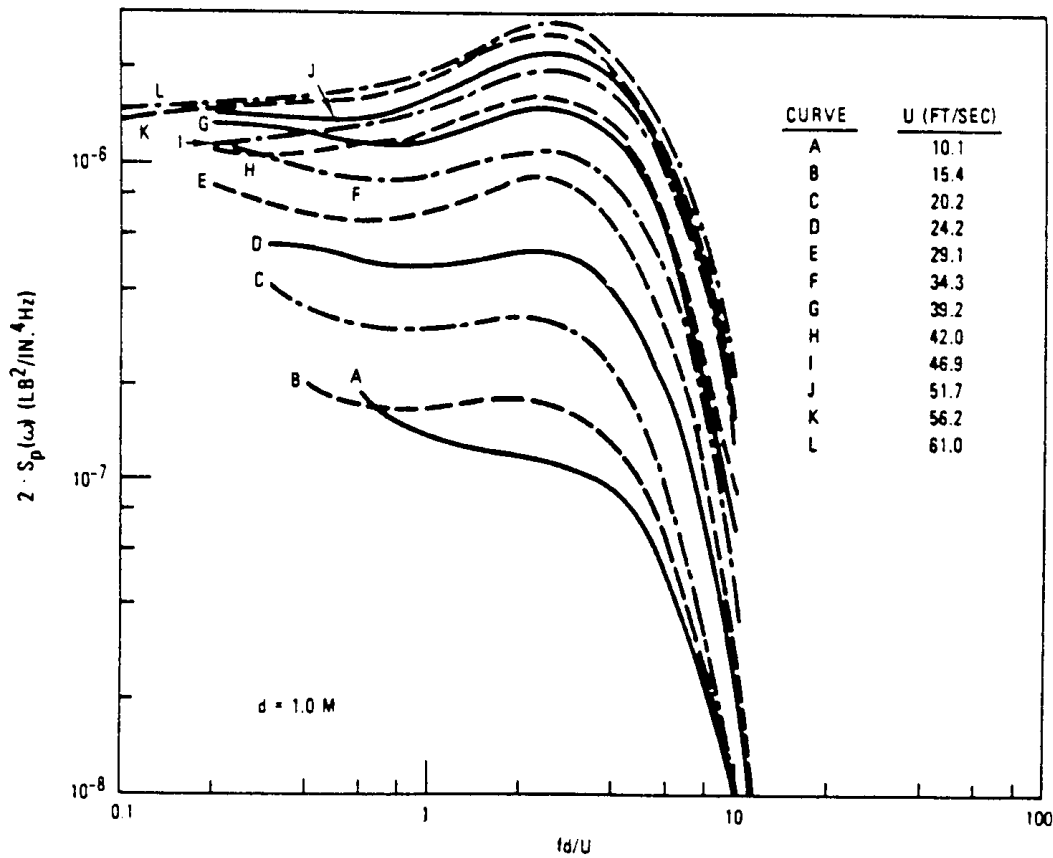
$$K_{11}^a = -0.3943 \cdot 10^4 \text{ N.m}^{-1} \cdot \text{rad}^2,$$

$$K_{22}^a = -0.1577 \cdot 10^5 \text{ N.m}^{-1} \cdot \text{rad}^2,$$

$$K_{12}^a = 0.$$

The interest of the test is here to calculate and test the autospectre of modal effort obtained starting from a spectrum of pressure characteristic of established turbulent flows.

The spectrum chosen here is constant then null starting from a cut-off frequency:



One has for DSP of pressure:

$$F_{R_p}^{(s)}(w) = K^2 (\rho U^2)^2 d^3 \text{ for } 0,1 < \frac{wd}{2pU} < 10$$

The function of coherence chosen in the case of this plate subjected to parallel flow, is resulting from a model of Corcos:

$$r^{(s)}(x-x', w) = e^{-k_L(x-x')} e^{-k_T(y-y')} \cos(w(x-x')/U_c).$$

Parameters k_T and k_L parameters of Bakewell are called and are worth according to the pulsation:

$$k_L = 0.1 \frac{w}{U_c} \text{ and } k_T = 0.55 \frac{w}{U_c}$$

The function acceptance, defined in any general information by

$$J_{A_s}^2(w) = \int_A \int_A r(x-x', w) f_{i_\alpha}(x) f_{j_\alpha'}(x') n_\alpha(x) n_{\alpha'}(x') dA dA'$$

acceptance

is worth in our case:

$$J_{A_m}^2(w) = \int_A \int_A e^{-k_T|y-y'|} e^{-k_L|x-x'|} \underbrace{\cos\left(\frac{w(x-x')}{U_c}\right) \sin\left(\frac{k_n x}{L}\right) \sin\left(\frac{k_m x'}{L}\right)}_{\text{acceptance}} dx dy dx' dy'$$

$$= \int_{-l/2}^{l/2} \int_{-l/2}^{l/2} e^{-k_T|y-y'|} dy dy' \cdot \int_0^L \int_0^L e^{-k_L|x-x'|} \cos\left(\frac{w(x-x')}{U_c}\right) \sin\left(\frac{k_n x}{L}\right) \sin\left(\frac{k_m x'}{L}\right) dx dx'.$$

The first integral in factor has an analytical expression and is worth:

$$\int_{-l/2}^{l/2} \int_{-l/2}^{l/2} e^{-k_T|y-y'|} dy dy' = \frac{2l}{k_T} - 2 \left(\frac{1 - e^{-k_T l}}{k_T^2} \right).$$

One gives in table Ci after values of this integral:

ω (rad/s)	$I_T(\omega)$
0.01	24.9121
0.1	24.1414
1.	18.0988
2.	13.8102
10.	4.2803

The other factor is more complex to evaluate. One thus numerically calculated this integral using the software Maple V.5:

ω (rad/s)	$I(\omega)$
0.01	1006.601
0.1	815.3964
1.	14,319
2.	6.5836
10.	1,288

Thus, for the pulsation 0.01 rad/s and 1 rad/s , the modal DSP of effort is worth respectively:

ω (rad/s)	DSP(ω)
0.01	7.28848E8
1.	7.53237E6

2.2 Results of reference

Analytical result.

2.3 References bibliographical

- [1] ROUSSEAU G., LUU H.T. : Mass, damping and stiffness added for a vibrating structure placed in a potential flow - Bibliography and establishment in *Code_Aster* - HP-61/95/064.
- [2] BLEVINS R.D: Formulated for natural frequency and shape mode. ED. Krieger 1984.
- [3] ROUSSEAU G. Specification of the calculation of acceptance in *Code_Aster*. Spectral response of structures with a turbulent excitation random HP51/97/027/A

3 Modeling A

3.1 Characteristics of modeling

For the system 3D on which one calculates the added coefficients:

For the solid:	160 meshes QUAD4 elements of hulls MEDKQU4
For the fluid:	160 meshes QUAD4 elements thermics THER_FACE4 on the plane surface
	184 meshes QUAD4 thermal elements THER_FACE4 on the faces of entry and exit of fluid volume
	480 meshes HEXA8 thermal elements THER_HEX8 in fluid volume

3.2 Features tested

Orders

DEFI_SPECT_TURB	SPEC_CORR	METHOD	'CORCOS'
	_CONV_1		

PROJ_SPEC_BASE	MODE_MECA	MODELE_INTERFACE	
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3.3 Sizes tested and results

Identification	frequency	Reference	Aster	% difference
$SFIFI(\omega)\omega=1$	1.59155e-01	7.53237e+06	7.59109e+06	0,780
$SFIFI(\omega)\omega=0.01$	1.59155e-03	7.28848e+08	7.28121e+08	0,100

4 Modeling B

4.1 Characteristics of modeling

Compared to modeling A, one modifies only the values of the densities, which are multiplied by 30:

- Fluid: $\rho = 30000 \text{ kg.m}^{-3}$ (water),
- Structure: $\rho_s = 23400 \text{ kg/m}^3$ (steel).

One thus proceeds so as to decrease the cut-off frequency of the problem.

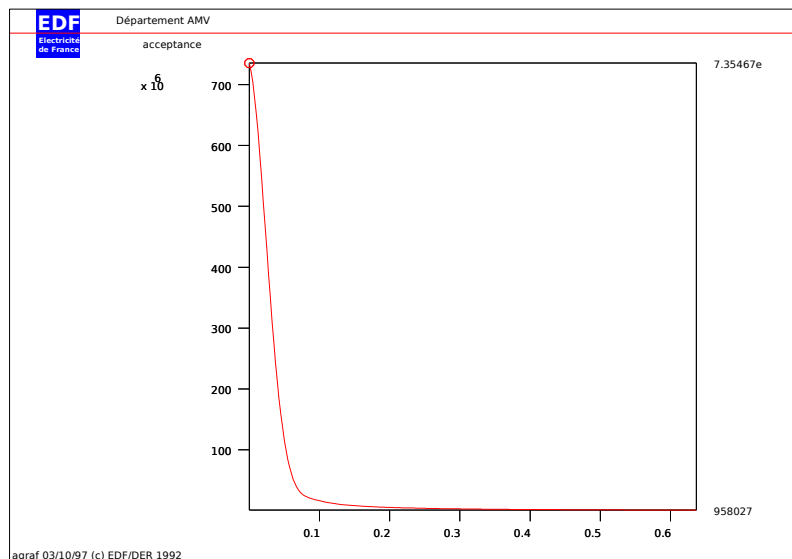
4.2 Sizes tested and results

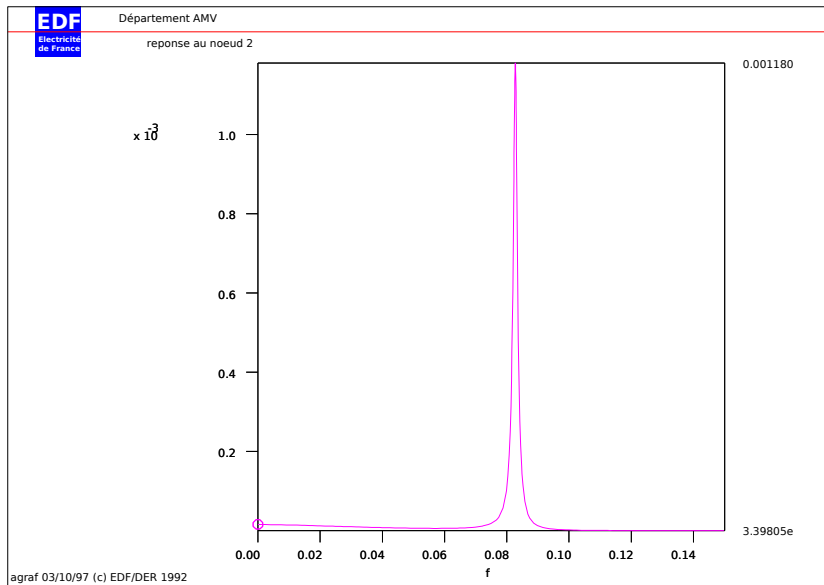
It is a question of testing the spectral response of the structure with the turbulent excitation previously defined in modeling A but calculated for 128 points of frequency. One tests for various frequencies the value of the spectral response to node 2 of the board which is with 13.75 m center of the board.

The theoretical answer was evaluated with software MAPLE version 5.

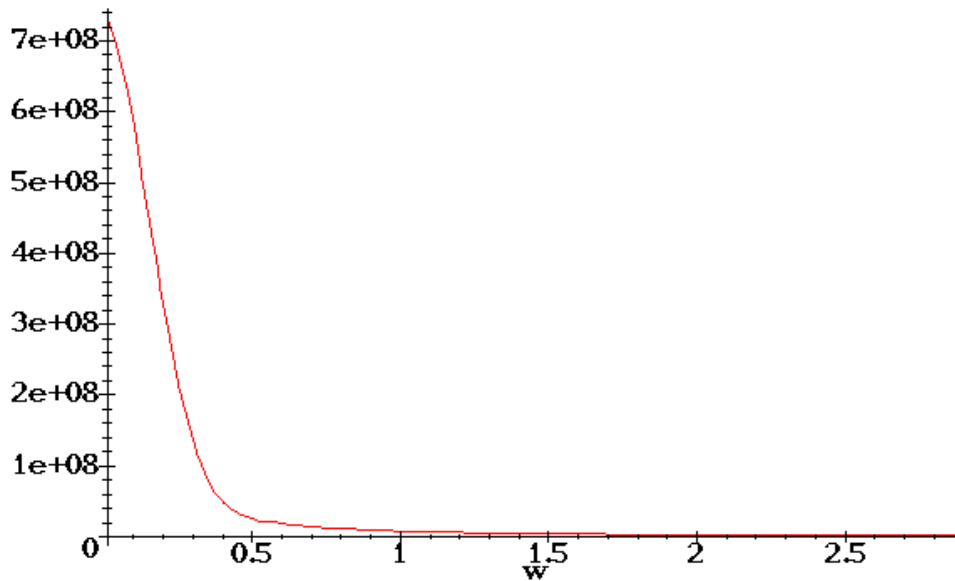
Identification	frequency (Hz)	Reference	Aster	% difference
$S_U(\omega) f=0.025$	2.50000e-02	1.09850e-05	1.09799e-05	0,046
$S_U(\omega) f=0.05$	5.00000e-02	6.09100e-06	6.09255e-06	0,025
$S_U(\omega) f=0.08275$	8.27500e-02	1.17770e-03	1.18010e-03	0,204

Curves of acceptance and answer given by Code_Aster are given below:





The curve of acceptance given by the software Maple V is represented below:



5 Summary of the results

The computational tool of acceptance in the case of a homogeneous turbulence on a plane plate was validated.