SDLL04 - Beam hurled on two supports, coupled to a system mass-arises

Summary:

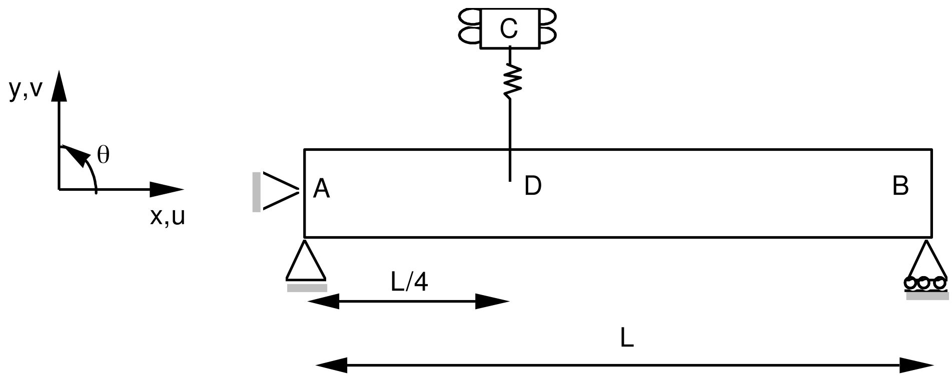
This problem plan consists in seeking the frequencies of vibration of a mechanical structure made up of a beam embed-slide and a mass connected to the beam by a spring. The stiffness of the spring and the mass depend on a variable parameter, which will make it possible to highlight the displacement of the Eigen frequencies for a small disturbance of the model. This test of Mechanics of the Structures corresponds to a dynamic analysis of a linear model having a linear behavior. It understands only one modeling.

This problem makes it possible to test the element of beam of Timoshenko in inflection, the calculation of the Eigen frequencies by the method of the iterations opposite and the method of Lanczos, the discrete elastic connection between a specific mass and a node of a beam.

The got results are in concord with the results given in guide VPCS. One observes well the unfolding of the Eigen frequencies induced by the disturbance of the initial model (beam hurled on two supports).

1 Problem of reference

1.1 Geometry



Length: $L=10$ $(a=\bar{AD}\quad b=\bar{DB})$ $m_e = lmabda\,\rho\,A\,L = 780\,\lambda\,kg$
$k_e = \pi^4 m_e = 780\,\lambda\pi^4\,N/m$

Cross-section:

surface $A=1.10^{-2}\,m^2$
moment of inertia $Iz=3.9\,10^{-6}\,m^4$

3 cases studied:

$\lambda=0.$
$\lambda=0.001$
$\lambda=0.01$

Coordinates of the points (meters):

	A	B	C	D
x	0.	10.	2.5	2.5
y	0.	0.	$qcq \neq 0$	0.

1.2 Material properties

$E=2.10^{11}\,Pa$

$\rho=7\,800.\,kg/m^3$

1.3 Boundary conditions and loadings

Not A : $u=v=0.$
Not B : $v=0.$
Not C : $u=0.$ $\theta=0.$ vertical slide

1.4 Initial conditions

Without object for the modal analysis.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is that given in card SDLL04/89 of the guide VPCS which presents the method of calculating in the following way:

The equation with the own pulsations of the complete system is written:

$$\lambda r_i L\left[\frac{\sin(r_i a)\sin(r_i b)}{\sin(r_i L)}-\frac{sh(r_i a)sh(r_i b)}{sh(r_i L)}\right]=2(\omega_i^2-\omega_c^2)/\omega_c^2$$

with:

$$\lambda=\frac{m_e}{\rho A L}\quad r_i^4=\omega_i^2\frac{\rho A}{E I}\quad \omega_C=\frac{k_e}{m_e}\quad a+b=L$$

In secondary absence of system, $k_e, m_e=0$, one finds well the Eigen frequencies of the beam hurled on two supports.

$$f_i=i^2\frac{\pi}{2}\frac{1}{L^2}\sqrt{\frac{EI}{\rho A}}=i^2\frac{\pi}{2}$$

When the secondary system is granted exactly on the first mode of this beam, the new Eigen frequencies of the system can be obtained by the approximate formulas:

$$f_{1,2}^*=\left(1\pm 0.5\sqrt{\frac{m_e}{M_1}}\right)f_1=(1\pm 0.5\sqrt{\lambda})f_1\quad f_3^*\simeq f_2$$

with M_1 modal mass of the beam without secondary system for an own standard mode to 1 at the point D .

2.2 Results of reference

The first two Eigen frequencies for $\lambda=0.$

The first three Eigen frequencies for $\lambda=0.001$ and $\lambda=0.01$.

2.3 Uncertainty on the solution

Lower than $4\lambda\%$ for the first modes if the system is granted to the first mode.

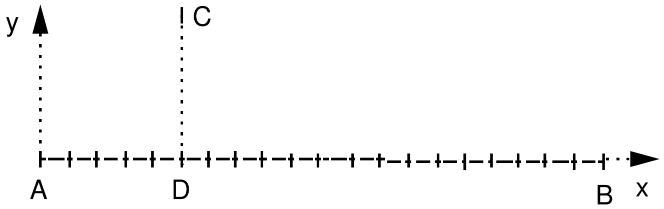
2.4 Bibliographical references

• NOUR-OMID, SACKMAN, KIUREGHIAN. Modal characterisation of equipment continous structure system. Newspaper of Sound and Vibration, V.88 n°4, p. 459.472 (1983).

3 Modeling A

3.1 Characteristics of modeling

One uses right beams of Timoshenko POU_D_T and of the discrete elements DIS_T.



Cutting:

AD : 5 meshs SEG2
DB : 15 meshs SEG2
CD : 1 mesh SEG2

Modeling:

POU_D_T for all the meshs of the beam AB
DIS_T for the mesh CD and the point C
For all the structure $DZ=DRX=DRY=0$

Limiting conditions:

in all the nodes of the beam AB : DDL_IMPO: (GROUP_NO: NPOUTRE DZ: 0. , DRX: 0, DRY MARTINI: 0.)

with the nodes ends: (GROUP_NO: WITH DX: 0. , DY: 0.) (GROUP_NO: B DY: 0.)

in C : (GROUP_NO: C DX: 0. , DZ: 0.)

Names of the nodes:

Not $A=N1$ Not $C=N22$
Not $B=N21$ Not $D=N6$

3.2 Characteristics of the grid

Many nodes: 22
Many meshs and types: 21 meshs SEG2 1 mesh POI1

3.3 Sizes tested and results

Frequency (Hz)

λ	Order of the clean mode	Reference
0.	inflection 1	1.5707
	inflection 2	6.2831
0.001	1 inflection	1.5460
	2 inflection	1.5958
	3 inflection 2	6.2336
0.01	1 inflection	1.4937
	2 inflection	1.6506
	3 inflection 2	6.2874

3.4 Remarks

For $\lambda=0$, one carried out:

```
CALC_MODES
            OPTION = 'PLUS_PETITE'
            CALC_FREQ=_F (NMAX_FREQ = 2)
            SOLVEUR_MODAL=_F (METHOD = 'TRI_DIAG')
```

For $\lambda=0.001$, one carried out:

```
CALC_MODES
            OPTION = 'NEAR'
            CALC_FREQ=_F (FREQ= (1.5, 1.6,6.5))
```

For $\lambda=0.01$, one carried out:

```
CALC_MODES
            OPTION = 'ADJUSTS'
            CALC_FREQ=_F (FREQ= (1. , 7.))
```

Contents of the file results:

Case 1: the first 2 Eigen frequencies, clean vectors and modal parameters.

Case 2: the first 3 Eigen frequencies and modal parameters.

Case 3: the first 3 Eigen frequencies, clean vectors and modal parameters.

4 Summary of the results

The unfolding of the Eigen frequencies induced by the disturbance of the initial model is represented perfectly.