SDLL04 - Beam hurled on two bearings, coupled to a Summarized

spring-mass system:

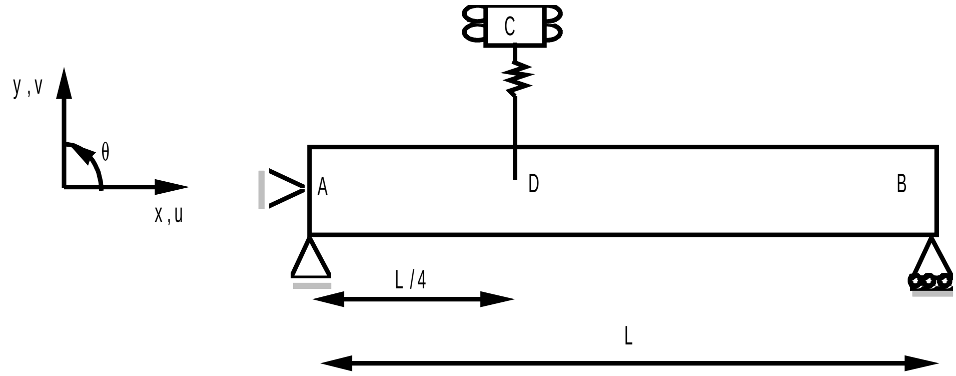
This plane problem consists in seeking the frequencies of vibration of a mechanical structure made up of a beam embed-slide and a mass connected to the beam by a spring. The stiffness of spring and the mass depend on a variable parameter, which will make it possible to highlight the displacement of the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

This problem makes it possible to test the beam element of Timoshenko in bending, the computation of the eigenfrequencies by the method of the inverse iterations and the method of Lanczos, discrete elastic connection between a point mass and a node of a beam.

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

1 Problem of reference

1.1 Geometry



Length: $L=10$ $(a=\bar{AD}\ \ b=\bar{DB})$

$m_e = lmabda\,\rho\,A\,L = 780\,\lambda\,kg$

$k_e = \pi^4 m_e = 780\,\lambda\,\pi^4\,N/m$

Cross-section:

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

3 cases to study:

$\lambda=0.$

$\lambda=0.001$

$\lambda=0.01$

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

Point: A $u=v=0.$

Point: B $v=0.$

Point: 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 file 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:

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

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

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

When the secondary system is granted exactly on the first mode of this beam, the new eigenfrequencies 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 a normalized eigen mode with 1 at the point D .

2.2 Results of reference

the first two eigenfrequencies for $\lambda=0.$

the first three eigenfrequencies 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.

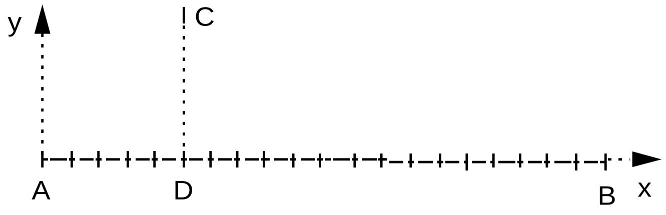
2.4 Bibliographical references

• NOUR-OMID, SACKMAN, KIUREGHIAN. Modal characterization of equipment continous structure system. Newspaper of Sound and Vibration, V.88 n°4, p. 459,472 (1983).

3 Modelization A

3.1 Characteristic of the modelization

One uses straight beams of Timoshenko `POU_D_T` and discrete elements `DIS_T`.



Cutting:
AD : 5 meshes `SEG2`
DB : 15 meshes `SEG2`
CD : 1 mesh `SEG2`

Modelization:
`POU_D_T` for all meshes of 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 beam: AB — `DDL_IMPO: (GROUP_NO: NPOUTRE DZ: 0. , DRX: 0, DRY: 0.)`
with the nodes ends: — `(GROUP_NO: A 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 Characteristic of the mesh

Many nodes: 22
Number of meshes and types: 21 meshes `SEG2` 1 nets `POI1`

3.3 Quantities tested and Frequency

results (Hz)

λ	**Order of the eigen mode**	**Reference**
$0.$	bending 1	1.5707
	bending 2	6.2831
0.001	1 bending	1.5460
	2 bending	1.5958
	3 bending 2	6.2336
0.01	1 bending	1.4937
	2 bending	1.6506
	3 bending 2	6.2874

3.4 Remarks

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

```
MODE_ITER_SIMULTMETHODE: "TRI_DIAG"
                       OPTION: "PLUS_PETITE"
                       NMAX_FREQ: 2
```

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

```
MODE_ITER_INVOPTION     : "NEAR"
                       LIST_FREQ: (1.5, 1.6,6.5)
```

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

```
MODE_ITER_INVOPTION     : LIST_FREQ "ADJUSTS
                       ": (1. , 7.)
```

Contents of the file results:

Case 1: the first 2 eigenfrequencies, modal eigenvectors and parameters.

Case 2: the first 3 modal eigenfrequencies and parameters.

Case 3: the first 3 eigenfrequencies, modal eigenvectors and parameters.

4 Summary of the results

the unfolding of the eigenfrequencies induced by the disturbance of the initial model is represented perfectly.