SDLD313 - System masses spring with 2 degrees of hysteretic freedom with damping

Summary:

This one-way problem consists in carrying out a harmonic analysis of a mechanical structure made up of a set of mass-springs with damping hysteretic and subjected to a sinewave excitation. This test of mechanics of the structures corresponds to a dynamic analysis of a discrete model having a linear behavior. It understands three modelings.

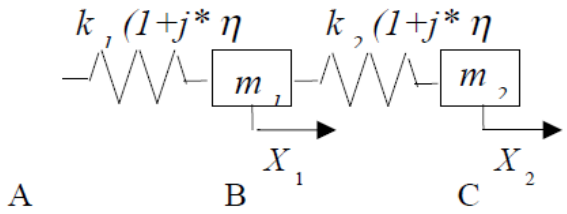
Via modeling A, one tests the discrete elements in translation (mass, arises), the options AMOR_HYST of AFFE_CARA_ELEM.
Via modeling B, one tests the elements of beam (POU_D_T), options AMOR_HYST of DEFI_MATERIAU,
Via modeling C, one tests modal calculation (CALC_MODES) complex.

The results got for the first two modelings (field of displacement for various frequencies of excitation) are in concord with the results of guide VPCS. The results got for the third modeling are in concord with the semi-analytical results.

1 Problem of reference

1.1 Geometry

We consider the system represented by the diagram below:



Specific masses: m_1 and m_2

Stiffnesses of connection: k_1 and k_2

Damping hysteretic: η_1 and η_2

1.2 Properties of material

Spring of elastic translation linear

$K_1 = 28000\ N/m$
$K_2 = 28000\ N/m$

Specific mass

$M_1 = 10\ kg$
$M_2 = 5\ kg$

Damping hysteretic

$\eta_1 = 0.1$
$\eta_2 = 0.0$

1.3 Boundary conditions and loadings

Boundary conditions:

Points A, B, C embedded in DY and DZ

Points A : embedded $(DX = 0)$.

Loading: Sinusoidal concentrated force of variable frequency at the point C

$$F_{x_4} = F_0 \sin \Omega t$$
$$\Omega = 2\pi f \quad 0\ Hz \le f \le 21.0543\ Hz$$
$$F_0 = constante = 100\mathrm{N}$$

1.4 Initial conditions

Without object for the study of the permanent harmonic mode.

2 Reference solution

2.1 Method of calculating

The system of differential equations of the second order coupled is form:

$$M\ddot{u}+Ku=F$$

with $M=\begin{bmatrix}0&0&0\\0&10&0\\0&0&5\end{bmatrix}$ and $K=28000\begin{bmatrix}1+0.1j&-1-0.1j&0\\-1-0.1j&2+0.1j&-1\\0&-1&1\end{bmatrix}$

The solution ω with a harmonic excitation $\mathbf{F}=\mathbf{F_0}e^{j\omega t}(j^2=-1)$ is form $u=u_0e^{j\omega t}$, which leads to: $(\mathbf{K}-\mathbf{M}\omega^2)u_0=\mathbf{F_0}$

This system is solved for all ω.

2.2 Sizes and results of reference

Displacement according to x point C for certain frequencies.
Eigen frequencies and damping reduced.

2.3 Uncertainties on the solution

Semi-analytical solution.

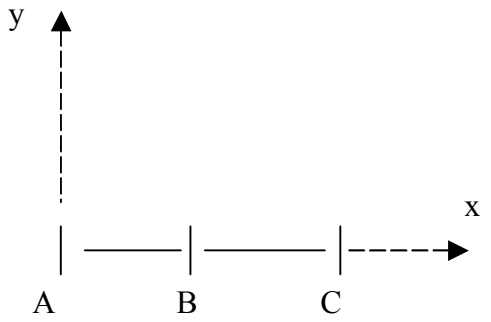
2.4 Bibliographical references

[1] J. PIRANDA: Note of modal use of analysis software MODAN - Version 0.2 (1990). Laboratory of Mechanics Applied - University of Frank County - Besancon (France).

3 Modeling A

3.1 Characteristics of modeling

Discrete element of rigidity in translation



Characteristics of the elements

DISCRETE :	with nodal masses	M_T_D_N
	and matrices of rigidity	K_T_D_L

Boundary conditions:

in all the nodes	DDL_IMPO:	(ALL: 'YES' DY: 0. , DZ: 0.)
with the node end A		(GROUP_NO: With DX: 0.)

Names of the nodes:

Not $A = N1$

Not $B = N2$

Not $C = N3$

3.2 Characteristics of the grid

Many nodes: 3

Many meshs and types: 2 SEG2

3.3 Sizes tested and results

Parts real and imaginary of the component DX displacement of the point C.

Frequency	Reference	*Aster*	% Difference
0.00	7.1075E-03 – 3.5360E-04	7.1074964639321E-03 – 3.5360678925035E-04	1.08E-04
3.36870E+00	9.388216E-03 – 7.31196E-04	9.3882649899583E-03 – 7.3120610001073E-04	5.31E-04
6.48480E+00	– 5.0269E-03 – 7.07103E-02	– 5.0349198344062E-03 – 7.0708581052416E-02	0,012
8.00060E+00	– 9.54931E-03 – 2.2154E-03	– 9.5490053525137E-03 – 2.2153458282190E-03	0,003
1.18746E+01	– 4.23259E-05 – 3.57193E-04	– 4.2266734408325E-05 – 3.5719325443817E-04	0,016
1.34747E+01	2.35524E-03 – 5.01765E-04	2.3552527130123E-03 – 5.0176685846530E-04	5.34E-04
1.55802E+01	– 1.6395374E-02 – 6.871471E-02	– 1.6420641488151E-02 – 6.8704047854161E-02	0,039
2.10543E+01	– 1.88977E-03 – 5.53314E-06	– 1.8897660707219E-03 – 5.5328629109043E-06	2.08E-04

3.4 Remarks

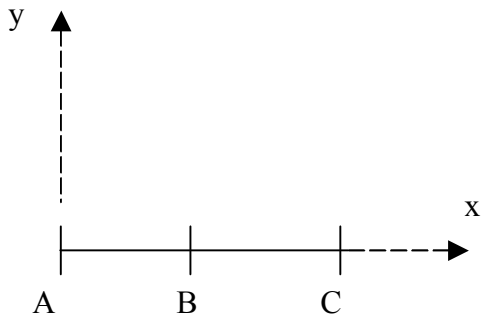
Contents of the file results:

Values of the displacement of the component DX point C for all the frequencies of 0 with $2.10543\mathrm{E}+01\mathrm{Hz}$ by step of 3.3687 .

4 Modeling B

4.1 Characteristics of modeling

Continuous element of standard beam in traction



Characteristics of the elements

DISCRETE :	nodal masses	M_T_D_N
BEAM:	matrices of rigidity	POU_D_T

Boundary conditions:

in all the nodes DDL_IMPO: (ALL: 'YES' DY: 0. , DZ: 0.)
with the node end A (GROUP_NO: With DX: 0.)

Names of the nodes:

Not $A = N1$
Not $B = N2$
Not $C = N3$

4.2 Characteristics of the grid

Many nodes: 3
Many meshs and types: 2 SEG2

4.3 Sizes tested and results

Parts real and imaginary of the component DX displacement of the point C.

Frequency	Reference	*Aster*	% Difference
0.00	7.1075E-03 – 3.5360E-04	7.1074964639321E-03 – 3.5360678925035E-04	1.08E-04
3.36870E+00	9.388216E-03 – 7.31196E-04	9.3882649899583E-03 – 7.3120610001073E-04	5.31E-04
6.48480E+00	– 5.0269E-03 – 7.07103E-02	– 5.0349198344064E-03 – 7.0708581052416E-02	0,012
8.00060E+00	– 9.54931E-03 – 2.2154E-03	– 9.5490053525137E-03 – 2.2153458282190E-03	0,003
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1.55802E+01	– 1.6395374E-02 – 6.871471E-02	– 1.6420641488152E-02 – 6.8704047854161E-02	0,039
2.10543E+01	– 1.88977E-03 – 5.53314E-06	– 1.8897660707219E-03 – 5.5328629109043E-06	2.08E-04

4.4 Remarks

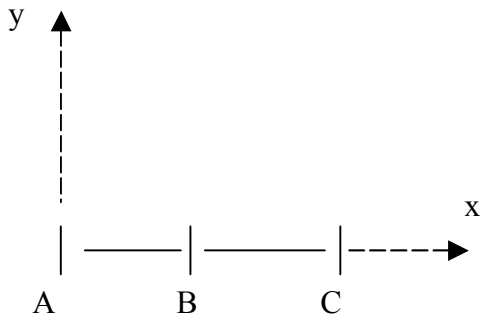
Contents of the file results:

Values of the displacement of the component DX point C for all the frequencies of 0 with $2.10543\mathrm{E}+01\mathrm{Hz}$ by step of 3.3687 .

5 Modeling C

5.1 Characteristics of modeling

Discrete element of rigidity in translation



Characteristics of the elements

DISCRETE :	with nodal masses	M_T_D_N
	and matrices of rigidity	K_T_D_L

Boundary conditions:

in all the nodes	DDL_IMPO:	(ALL: 'YES' DY: 0. , DZ: 0.)
with the node end A		(GROUP_NO: With DX: 0.)

Names of the nodes:

$Point\ A = N1$	$A = N1$
$Point\ B = N2$	$B = N2$
$Point\ C = N3$	$C = N3$

5.2 Characteristics of the grid

Many nodes: 3
Many meshs and types: 2 SEG2

5.3 Sizes tested and results

Eigen frequencies and reduced depreciation.

Eigen frequencies:

Sequence number	Reference	*Aster*	% Difference
1	6.4537	6.44568	–0,124
2	15.5806	1.55612	–0,124

Reduced depreciation:

Sequence number	Reference	*Aster*	% Difference
1	0.05	0.05	–1.39E-14
2	0.05	0.05	2.78E-14

6 Summary of the results

The got results are excellent.