SDLD02 - Spring-mass system with 8 degrees of freedom

Summarized:

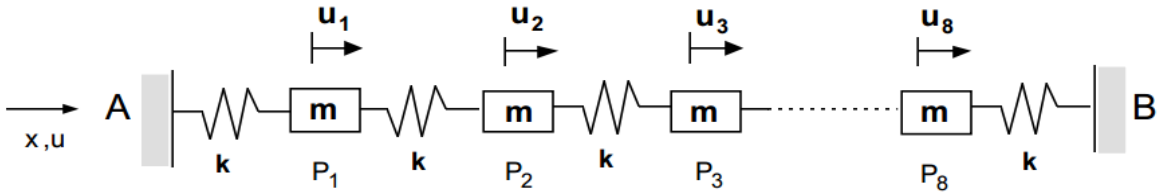
This two-dimensional problem consists in searching the frequencies and the modes of vibration of a mechanical structure made up of masses and springs. This benchmark of Structural mechanics corresponds to a dynamic analysis of a discrete model having a linear behavior.

This test allows a complete validation of the options of modelization of discrete stiffness and mass (without finite elements) offered by the command AFFE_CARA_ELEM. Four different modelizations are proposed: two modelizations for the discrete elements in translation and two others for the discrete elements in translation/rotation. In addition, various features of commands MODE_ITER_INV (computation of values and eigenvectors per inverse iteration), MODE_ITER_SIMULT (computation of the values and eigenvectors by the method of Lanczos) and NORME_MODE (definition of the norm of an eigenvector) are tested.

This test refers to a test VPCS, but it was modified. Indeed, the test *Code_Aster* directs the mechanical system towards an axis $3y=4x$, which makes it possible to validate the entry of the data in local coordinate system.

1 Problem of reference

1.1 Geometry



Point masses: $m_{P_1}=m_{P_2}=m_{P_3}=\ldots\ \ldots=m_{P_8}=m$

Stiffness of connection: $k_{AP1}=k_{P1P2}=k_{P2P3}=\ldots\ \ldots=k_{P8B}=k$

1.2 Material properties

Comes out from elastic translation linear	$k=10^5\,N/m$
Point mass	$m=10\,kg$

1.3 Boundary conditions and loadings

Points A and B : embedded ($u=0$).

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 SDLD02/89 of the guide VPCS which presents the method of calculating in the following way:

The problem led to search the eigenvalues and eigenvectors of:

$$(\boldsymbol{K}-\boldsymbol{M}\,\omega_i)\,\Phi_i=0$$

$$K=\begin{bmatrix} k & -k & & & & \\ -k & 2k & -k & & & \\ & & .. & & & \\ & & & -k & 2k & -k \\ & & & & -k & k \end{bmatrix} \quad M=\begin{bmatrix} 0 & & & & & \\ & m & & & & \\ & & .. & & & \\ & & & & m & \\ & & & & & 0 \end{bmatrix}$$

from where:

$$f_i=\frac{1}{\pi}\sqrt{\frac{k}{m}}\cos\left(\frac{n+1-i}{(n+1)}\frac{\pi}{2}\right)$$

$i=1,2,\ldots,n$

n = many masses

Φ_i^t calculated by resolution of the linear system.

2.2 Results of reference

the first 8 eigenfrequencies and the first and eighth eigenvectors normalized such as:

Test VPCS provides modes normalized to $\Phi^t M\,\Phi=10$. Normalized modes are presented:

with the unit generalized mass: $\Phi^t M\,\Phi=1$; the components of reference are divided by $\sqrt{10}$,

with the stiffness generalized what amounts dividing the preceding components by ω_i,

with the largest component of displacement.

2.3 Uncertainty on the analytical

solution Solution.

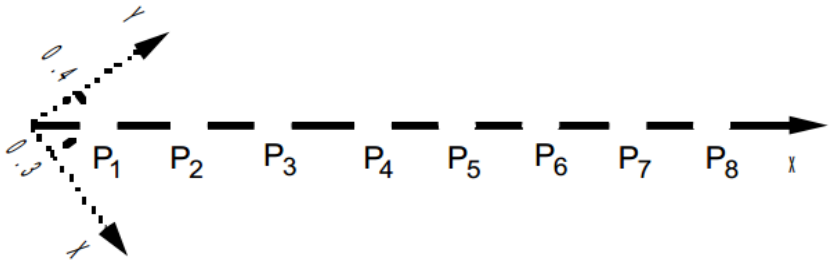
2.4 Bibliographical references

[1] Mr. LALANNE, P. BERTHIER, J. DERHAGOPIAN. Mechanics of linear vibrations. Paris: MASSON, 2° edition, chapter 3, p. 100-101 (1986)

3 Modelization A

3.1 Characteristic of the modelization

Discrete element of stiffness in translation DIS_T



Characteristics of the elements:

ORIENTATION: in all the nodes with a DISCRETE $\alpha = 53.130102°$

angle:

with nodal masses all nodes	M_T_D_N	out of absolute coordinate system	$(m = 10.)$
stiffness matrixes all meshes	K_T_D_L	in local coordinate system	$(Kx = 1.10^5)$
with the nodes limiting	ends	K_T_D_N	$(K_x = 1.10^5)$

in local coordinate system Conditions:

DDL_IMPO: (TOUT: "YES" DZ: 0.)
LIAISON_DDL : (such as $3Dy = 4Dx$ in all the nodes)

Names of the nodes: $P_1, P_2, \ldots, P_8$
$Point\ A = N1$ $N2$

3.2 Characteristics of the mesh

Many nodes: 8
Number of meshes and types: 7 SEG2

3.3 Quantities tested and results

Identification Number of the eigen mode	Reference
1	5.5274
2	10.8868
3	15.9155
4	20.4606
5	24.3840
6	27.5664
7	29.9113

8	31.3474

Mode normalized with 1 to the largest Natural

component of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 0.3473
	P2	– 0.6527
	P3	– 0.8793
	P4	– 1.
	P5	– 1.
	P6	– 0.8793
	P7	– 0.6527
	P8	– 0.3473
Translation 8 (Dy) Φ_8	P1	0.3473
	P2	– 0.6527
	P3	0.8793
	P4	– 1.
	P5	1.
	P6	– 0.8793
	P7	0.6527
	P8	– 0.3473

Error maximum lower than: 0.03%.

Mode normalized with the Natural unit

generalized mass of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 4.0781E-2
	P2	– 7.6654E-2
	P3	– 1.0327E-1
	P4	– 1.1743E-1
	P5	– 1.1743E-1
	P6	– 1.0327E-1
	P7	– 7.6654E-2
	P8	– 4.0781E-2
Translation 8 (Dy) Φ_8	P1	4.0781E-2
	P2	– 7.6654E-2
	P3	1.0327E-1
	P4	– 1.1743E-1
	P5	1.1743E-1
	P6	– 1.0327E-1
	P7	7.6654E-2
	P8	– 4.0781E-2

maximum Error lower than: 0.03%.

Mode normalized with the generalized stiffness unit

Nature of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 1.1742E-3
	P2	– 2.2072E-3
	P3	– 2.9735E-3
	P4	– 3.3813E-3
	P5	– 3.3813E-3
	P6	– 2.9735E-3
	P7	– 2.2072E-3
	P8	– 1.1742E-3
Translation 8 (Dy) Φ_8	P1	2.0705E-4
	P2	– 3.8918E-4
	P3	5.2432E-4
	P4	– 5.9621E-4
	P5	5.9621E-4
	P6	– 5.2432E-4
	P7	3.8918E-4
	P8	– 2.0705E-4

maximum Error lower than: 0.03%.

One tests also command INFO_MODE. The GEP being standard (real symmetric matrixes) its eigenvalues belongs only to the real axis. On this case, one can thus compare the two methods of enumeration (COMPTAGE/METHODE=' STURM' and "APM") and check that they give the same results well.
One thus determines the number of eigenvalues (NB_FREQ) contained strictly in a frequential tape [FREQ_MIN, FREQ_MAX] (if Sturm type) or in the disc of center FREQ_CENTRE and radius, into frequential, $\frac{\sqrt{\text{FREQ\_RAYON\_CONTOUR}}}{2\pi}$ (if APM) . One specifies the method of enumeration used (Sturm type or APM).

Concept	FREQ_MIN/ FREQ_CENTRE	FREQ_MAX/ FREQ_RAYON_ CONTOUR	NB_FREQ	Method of enumeration
NBMOD01	0.0	5	0	Sturm type
NBMOD02	0.0	21	4 One counts $(\lambda_i)_{i=1,4}$	Sturm type
NBMOD03	0.0	32	8 One counts $(\lambda_i)_{i=1,8}$	Sturm type
NBMOD11	0.0+0.0j	986.96 (= $(5\times 2\pi)^2$)	0 Idem NBMOD01	APM
NBMOD12	0.0+0.0j	1740.99 (= $(21\times 2\pi)^2$)	4 Idem NBMOD02	APM
NBMOD13	0.0+0.0j	4042.58 (= $(32\times 2\pi)^2$)	8 Idem NBMOD03	APM
NBMOD4	$10000.0+0.0j$	5000.0	1	APM

	(= $(15.91x2\pi)^2$)		One counts λ_1	
NBMOD5	$1000.0(10.0+j)$	900.0	0	APM

3.4 Remarks

Computations carried out by:

```
MODE_ITER_INVOPTION    : LIST_FREQ "ADJUSTS
                     ": (5. , 10. , 15. , 20. , 24. , 27. , 30. , 32.)
                     CALC_MODE: (OPTION: "DIRECT")
```

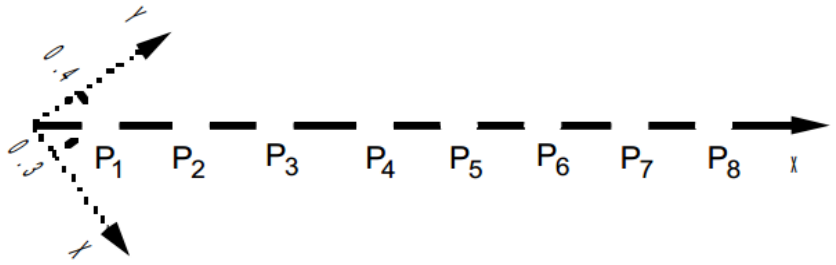
Contents of the file results:

the first 8 eigenfrequencies, modal eigenvectors and parameters

4 Modelization B

4.1 Characteristic of the modelization

Discrete element of stiffness in translation DIS_T



Characteristics of the elements:

ORIENTATION: in all the nodes with a DISCRETE $\alpha = 53.130102°$

angle:

nodal masses all nodes	M_T_N	out of absolute coordinate system	($m = 10.$)
stiffness matrixes all meshes	K_T_L	in local coordinate system	($K_x = 1.10^5$)
with the nodes ends	K_T_N	in local coordinate system	($K_x = 1.10^5$)

limiting Conditions:

DDL_IMPO: (TOUT: "YES" DZ: 0.)

LIAISON_DDL: (such as $3Dy = 4Dx$ in all the nodes)

Names of the nodes: $P_1, P_2, ..., P_8$

4.2 Characteristics of the mesh

Many nodes: 8
Number of meshes and types: 7 SEG2

4.3 Quantities tested and results

Identification Number of the eigen mode	Reference
1	5.5274
2	10.8868
3	15.9155
4	20.4606
5	24.3840
6	27.5664
7	29.9113
8	31.3474

Mode normalized with 1 to the largest Natural

component of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 0.3473
	P2	– 0.6527
	P3	– 0.8793
	P4	– 1.
	P5	– 1.
	P6	– 0.8793
	P7	– 0.6527
	P8	– 0.3473
Translation 8 (Dy) Φ_8	P1	0.3473
	P2	– 0.6527
	P3	0.8793
	P4	– 1.
	P5	1.
	P6	– 0.8793
	P7	0.6527
	P8	– 0.3473

Error maximum lower than: 0.03%.

Mode normalized with the Natural unit

generalized mass of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 4.0781E-2
	P2	– 7.6654E-2
	P3	– 1.0327E-1
	P4	– 1.1743E-1
	P5	– 1.1743E-1
	P6	– 1.0327E-1
	P7	– 7.6654E-2
	P8	– 4.0781E-2
Translation 8 (Dy) Φ_8	P1	4.0781E-2
	P2	– 7.6654E-2
	P3	1.0327E-1
	P4	– 1.1743E-1
	P5	1.1743E-1
	P6	– 1.0327E-1
	P7	7.6654E-2
	P8	– 4.0781E-2

maximum Error lower than: 0.03%.

Mode normalized with the generalized stiffness unit

Nature of the eigen mode	Not	Reference

Translation 1 (Dy) Φ_1	P1	– 1.1742E-3
	P2	– 2.2072E-3
	P3	– 2.9735E-3
	P4	– 3.3813E-3
	P5	– 3.3813E-3
	P6	– 2.9735E-3
	P7	– 2.2072E-3
	P8	– 1.1742E-3
Translation 8 (Dy) Φ_8	P1	2.0705E-4
	P2	– 3.8918E-4
	P3	5.2432E-4
	P4	– 5.9621E-4
	P5	5.9621E-4
	P6	– 5.2432E-4
	P7	3.8918E-4
	P8	– 2.0705E-4

maximum Error lower than: 0.03%.

4.4 Remarks

Computations carried out by:

```
MODE_ITER_SIMULTMETHODE    : "TRI_DIAG"
                        CALC_FREQ:   OPTION = "PLUS_PETITE"
                                     NMAX_FREQ = 8
```

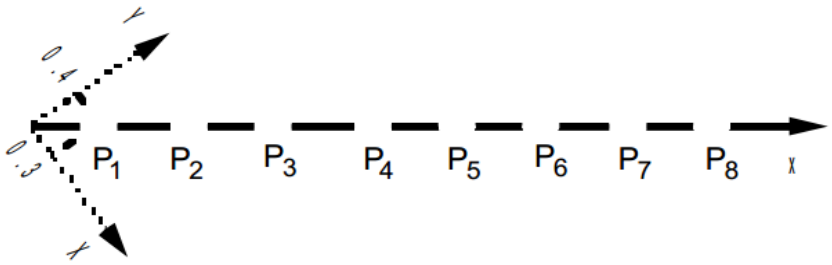
Contents of the file results:

the first 8 eigenfrequencies, modal eigenvectors and parameters

5 Modelization C

5.1 Characteristic of the modelization

Transposition of the test of reference to the case of the degrees of freedom of rotation (torsion spring + inertia) by means of the discrete element of stiffness in translation/rotation DIS_TR.



Characteristics of the elements:

ORIENTATION: in all the nodes with a DISCRETE $\alpha = 53.130102°$

angle:

with nodal masses all nodes	M_TR_D_N	out of absolute coordinate system	$(I_{xx} = 10.)$
stiffness matrixes all meshes	K_TR_D_L	in local coordinate system	$(KR_x = 1.10^5)$
with the nodes limiting	ends	K_TR_D_N	$(KR_x = 1.10^5)$

in local coordinate system Conditions:

DDL_IMPO: (TOUT: "YES" DX: 0. , DZ: 0. , DRZ: 0.)

LIAISON_DDL : (such as $3DRY = 4DRY$ in all the nodes)

Names of the nodes: $P_1, P_2, ..., P_8$

5.2 Characteristics of the mesh

Many nodes: 8

Number of meshes and types: 7 SEG2

5.3 Quantities tested and results

Identification Number of the eigen mode	Reference
1	5.5274
2	10.8868
3	15.9155
4	20.4606
5	24.3840
6	27.5664
7	29.9113

8	31.3474

Mode normalized with 1 to the largest Natural

component of the eigen mode	Not	Reference
Rotation 1 (DRY) Φ_1	P1	– 0.3473
	P2	– 0.6527
	P3	– 0.8793
	P4	– 1.
	P5	– 1.
	P6	– 0.8793
	P7	– 0.6527
	P8	– 0.3473
Rotation 8 (DRY) Φ_8	P1	0.3473
	P2	– 0.6527
	P3	0.8793
	P4	– 1.
	P5	1.
	P6	– 0.8793
	P7	0.6527
	P8	– 0.3473

Error maximum lower than: 0.03%.

Mode normalized with the Natural unit

generalized mass of the eigen mode	Not	Reference
Rotation 1 (DRY) Φ_1	P1	– 4.0781E-2
	P2	– 7.6654E-2
	P3	– 1.0327E-1
	P4	– 1.1743E-1
	P5	– 1.1743E-1
	P6	– 1.0327E-1
	P7	– 7.6654E-2
	P8	– 4.0781E-2
Rotation 8 (DRY) Φ_8	P1	4.0781E-2
	P2	– 7.6654E-2
	P3	1.0327E-1
	P4	– 1.1743E-1
	P5	1.1743E-1
	P6	– 1.0327E-1
	P7	7.6654E-2
	P8	– 4.0781E-2

maximum Error lower than: 0.03%.

Mode normalized with the generalized stiffness unit

Nature of the eigen mode	Not	Reference

Rotation 1 (DRY) Φ_1	P1	– 1.1742E-3
	P2	– 2.2072E-3
	P3	– 2.9735E-3
	P4	– 3.3813E-3
	P5	– 3.3813E-3
	P6	– 2.9735E-3
	P7	– 2.2072E-3
	P8	– 1.1742E-3
Rotation 8 (DRY) Φ_8	P1	2.0705E-4
	P2	– 3.8918E-4
	P3	5.2432E-4
	P4	– 5.9621E-4
	P5	5.9621E-4
	P6	– 5.2432E-4
	P7	3.8918E-4
	P8	– 2.0705E-4

maximum Error lower than: 0.03%.

5.4 Remarks

Computations carried out by:

```
MODE_ITER_INVOPTION    : LIST_FREQ "ADJUSTS
                     ": (5. , 10. , 15. , 20. , 24. , 27. , 30. , 32.)
                     CALC_MODE: (OPTION: "DIRECT")
```

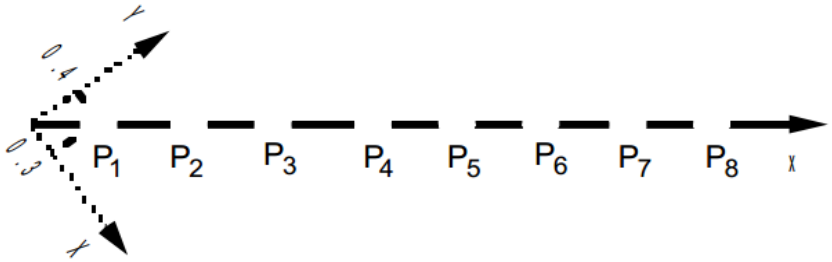
Contents of the file results:

the first 8 eigenfrequencies, modal eigenvectors and parameters

6 Modelization D

6.1 Characteristic of the modelization

Transposition of the test of reference to the case of the degrees of freedom of rotation (torsion spring + inertia) by means of the discrete element of stiffness in translation/rotation: DIS_TR.



Characteristics of the elements:

ORIENTATION: in all the nodes with a DISCRETE $\alpha = 53.130102°$

angle:

with nodal masses all nodes	M_TR_N	out of absolute coordinate system	$(I_{xx} = 10.)$
stiffness matrixes all meshes	K_TR_L	in local coordinate system	$(KR_x = 1.10^5)$
with the nodes limiting	ends	K_TR_N	$(KR_x = 1.10^5)$

in local coordinate system Conditions:

```
DDL_IMPO: (TOUT: "YES" DX: 0. ,  DY: 0. ,  DZ: 0. ,  DRZ: 0. )
```

LIAISON_DDL : (such as $3\mathrm{DRY} = 4\mathrm{DRY}$ in all the nodes)

Names of the nodes: $P_1, P_2, \ldots, P_8$

6.2 Characteristics of the mesh

Many nodes: 8

Number of meshes and types: 7 SEG2

6.3 Quantities tested and results

Identification	Reference
Number of the eigen mode	
1	5.5274
2	10.8868
3	15.9155
4	20.4606
5	24.3840
6	27.5664
7	29.9113

8	31.3474

Mode normalized with 1 to the largest Natural

component of the eigen mode	Not	Reference
Rotation 1 (DRY) Φ_1	P1	– 0.3473
	P2	– 0.6527
	P3	– 0.8793
	P4	– 1.
	P5	– 1.
	P6	– 0.8793
	P7	– 0.6527
	P8	– 0.3473
Rotation 8 (DRY) Φ_8	P1	0.3473
	P2	– 0.6527
	P3	0.8793
	P4	– 1.
	P5	1.
	P6	– 0.8793
	P7	0.6527
	P8	– 0.3473

Error maximum lower than: 0.03%.

Mode normalized with the Natural unit

generalized mass of the eigen mode	Not	Reference
Rotation 1 (DRY) Φ_1	P1	– 4.0781E-2
	P2	– 7.6654E-2
	P3	– 1.0327E-1
	P4	– 1.1743E-1
	P5	– 1.1743E-1
	P6	– 1.0327E-1
	P7	– 7.6654E-2
	P8	– 4.0781E-2
Rotation 8 (DRY) Φ_8	P1	4.0781E-2
	P2	– 7.6654E-2
	P3	1.0327E-1
	P4	– 1.1743E-1
	P5	1.1743E-1
	P6	– 1.0327E-1
	P7	7.6654E-2
	P8	– 4.0781E-2

maximum Error lower than: 0.03%.

Mode normalized with the generalized stiffness unit

Nature of the eigen mode	Not	Reference

Rotation 1 (DRY) Φ_1	P1	– 1.1742E-3
	P2	– 2.2072E-3
	P3	– 2.9735E-3
	P4	– 3.3813E-3
	P5	– 3.3813E-3
	P6	– 2 9735E-3
	P7	– 2.2072E-3
	P8	– 1.1742E-3
Rotation 8 (DRY) Φ_8	P1	2.0705E-4
	P2	– 3.8918E-4
	P3	5.2432E-4
	P4	– 5.9621E-4
	P5	5.9621E-4
	P6	– 5.2432E-4
	P7	3.8918E-4
	P8	– 2.0705E-4

maximum Error lower than: 0.03%.

6.4 Remarks

Computations carried out by:

```
MODE_ITER_INVOPTION    : LIST_FREQ "ADJUSTS
                     ": (5. , 10. , 15. , 20. , 24. , 27. , 30. , 32.)
                     CALC_MODE: (OPTION: "DIRECT")
```

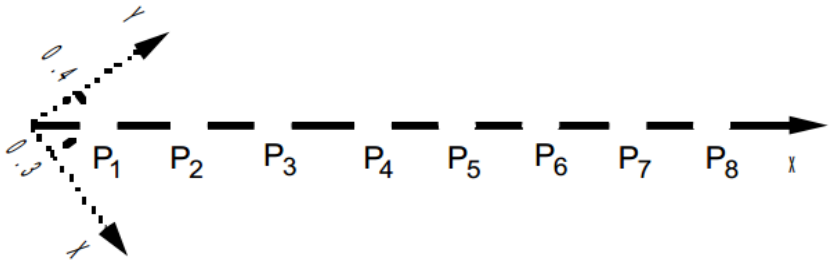
Contents of the file results:

the first 8 eigenfrequencies, modal eigenvectors and parameters

7 Modelization E

7.1 Characteristic of the modelization

Discrete element of stiffness in translation 2D_DIS_T



Characteristic of the elements:

ORIENTATION: in all the nodes with a DISCRETE $\alpha = 53.130102°$

angle:

with nodal masses all nodes	M_T_D_N	out of absolute coordinate system	$(m = 10.)$
stiffness matrixes all meshes	K_T_D_L	in local coordinate system	$(K_x = 1.10^5)$
with the nodes limiting	ends	K_T_D_N	$(K_x = 1.10^5)$

in local coordinate system Conditions:

LIAISON_DDL : (such as $3\mathrm{Dy} = 4\mathrm{Dx}$ in all the nodes)

Names of the nodes: $P_1, P_2, \ldots, P_8$
$Point\ A = N1$ $N2$

7.2 Characteristics of the mesh

Many nodes: 8
Number of meshes and types: 7 SEG2

7.3 Quantities tested and results

Identification Number of the eigen mode	Reference
1	5.5274
2	10.8868
3	15.9155
4	20.4606
5	24.3840
6	27.5664
7	29.9113
8	31.3474

Mode normalized with 1 to the largest Natural

component of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 0.3473
	P2	– 0.6527
	P3	– 0.8793
	P4	– 1.
	P5	– 1.
	P6	– 0.8793
	P7	– 0.6527
	P8	– 0.3473
Translation 8 (Dy) Φ_8	P1	0.3473
	P2	– 0.6527
	P3	0.8793
	P4	– 1.
	P5	1.
	P6	– 0.8793
	P7	0.6527
	P8	– 0.3473

Error maximum lower than: 0.03%.

Mode normalized with the Natural unit

generalized mass of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 4.0781E-2
	P2	– 7.6654E-2
	P3	– 1.0327E-1
	P4	– 1.1743E-1
	P5	– 1.1743E-1
	P6	– 1.0327E-1
	P7	– 7.6654E-2
	P8	– 4.0781E-2
Translation 8 (Dy) Φ_8	P1	4.0781E-2
	P2	– 7.6654E-2
	P3	1.0327E-1
	P4	– 1.1743E-1
	P5	1.1743E-1
	P6	– 1.0327E-1
	P7	7.6654E-2
	P8	– 4.0781E-2

maximum Error lower than: 0.03%.

Mode normalized with the generalized stiffness unit

Nature of the eigen mode	Not	Reference

Translation 1 (Dy) Φ_1	P1	– 1.1742E-3
	P2	– 2.2072E-3
	P3	– 2.9735E-3
	P4	– 3.3813E-3
	P5	– 3.3813E-3
	P6	– 2.9735E-3
	P7	– 2.2072E-3
	P8	– 1.1742E-3
Translation 8 (Dy) Φ_8	P1	2.0705E-4
	P2	– 3.8918E-4
	P3	5.2432E-4
	P4	– 5.9621E-4
	P5	5.9621E-4
	P6	– 5.2432E-4
	P7	3.8918E-4
	P8	– 2.0705E-4

maximum Error lower than: 0.03%.

7.4 Remarks

Computations carried out by:

```
MODE_ITER_INVOPTION    : LIST_FREQ "ADJUSTS
                     ": (5. , 10. , 15. , 20. , 24. , 27. , 30. , 32.)
                     CALC_MODE: (OPTION: "DIRECT")
```

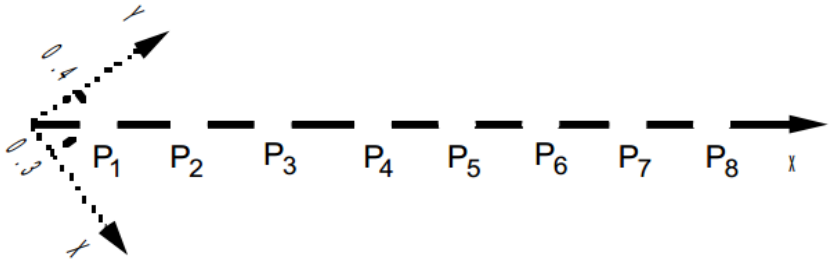
Contents of the file results:

the first 8 eigenfrequencies, modal eigenvectors and parameters

8 Modelization F

8.1 Characteristic of the modelization

Discrete element of stiffness in translation/rotation: 2D_DIS_TR



Characteristics of the elements:

ORIENTATION: in all the nodes with a DISCRETE $\alpha = 53.130102°$

angle:

with nodal masses all nodes	M_T_D_N	out of absolute coordinate system	$(m = 10.)$
stiffness matrixes all meshes	K_T_D_L	in local coordinate system	$(K_x = 1.10^5)$
with the nodes limiting	ends	K_T_D_N	$(K_x = 1.10^5)$

in local coordinate system Conditions:

DDL_IMPO: (TOUT: "YES" DRZ: 0.)
LIAISON_DDL : (such as $3\mathrm{Dy} = 4\mathrm{Dx}$ in all the nodes)

Names of the nodes: $P_1, P_2, \ldots, P_8$

Not $A = N1$ $N2$

8.2 Characteristic of the mesh

Many nodes: 8
Number of meshes and types: 7 SEG2

8.3 Quantities tested and results

Identification Number of the eigen mode	Reference
1	5.5274
2	10.8868
3	15.9155
4	20.4606
5	24.3840
6	27.5664

7	29.9113
8	31.3474

Mode normalized with 1 to the largest Natural

component of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 0.3473
	P2	– 0.6527
	P3	– 0.8793
	P4	– 1.
	P5	– 1.
	P6	– 0.8793
	P7	– 0.6527
	P8	– 0.3473
Translation 8 (Dy) Φ_8	P1	0.3473
	P2	– 0.6527
	P3	0.8793
	P4	– 1.
	P5	1.
	P6	– 0.8793
	P7	0.6527
	P8	– 0.3473

Error maximum lower than: 0.03%.

Mode normalized with the Natural unit

generalized mass of the eigen mode	Not	Reference
Translation 1 (Dy) Φ_1	P1	– 4.0781E-2
	P2	– 7.6654E-2
	P3	– 1.0327E-1
	P4	– 1.1743E-1
	P5	– 1.1743E-1
	P6	– 1.0327E-1
	P7	– 7.6654E-2
	P8	– 4.0781E-2
Translation 8 (Dy) Φ_8	P1	4.0781E-2
	P2	– 7.6654E-2
	P3	1.0327E-1
	P4	– 1.1743E-1
	P5	1.1743E-1
	P6	– 1.0327E-1
	P7	7.6654E-2
	P8	– 4.0781E-2

maximum Error lower than: 0.03%.

Mode normalized with the generalized stiffness unit

Nature of the eigen mode	Not	Reference

Translation 1 (Dy) Φ_1	P1	– 1.1742E-3
	P2	– 2.2072E-3
	P3	– 2.9735E-3
	P4	– 3.3813E-3
	P5	– 3.3813E-3
	P6	– 2.9735E-3
	P7	– 2.2072E-3
	P8	– 1.1742E-3
Translation 8 (Dy) Φ_8	P1	2.0705E-4
	P2	– 3.8918E-4
	P3	5.2432E-4
	P4	– 5.9621E-4
	P5	5.9621E-4
	P6	– 5.2432E-4
	P7	3.8918E-4
	P8	– 2.0705E-4

maximum Error lower than: 0.03%.

8.4 Remarks

Computations carried out by:

```
MODE_ITER_INVOPTION    : LIST_FREQ "ADJUSTS
                     ": (5. , 10. , 15. , 20. , 24. , 27. , 30. , 32.)
                     CALC_MODE: (OPTION: "DIRECT")
```

Contents of the file results:

the first 8 eigenfrequencies, modal eigenvectors and parameters

9 Summary of the results

For all the options of modelization of the discrete elements of stiffness and mass offered by AFFE_CARA_ELEM the solutions obtained are those of the reference solution (frequencies and eigen modes with various standardizations).