SDLL123 - Frequency of line of trees simplified with gyroscopy

Summarized:

This test makes it possible to validate the computation of the modes in rotation of a system of rotating shafts.

In this test, it is about a simple model of rotor with 1 discs simply supported.

Four modelizations are carried out:

- Modelization b: POU_D_E
- Modelization D: POU_D_EM
- Modelization E: POU_D_TG
- Modelization F: POU_D_TGM

the modelizations A and C are without object for the gyroscopy. They are tests of mathematical validation.

1 Problem of reference

1.1 Geometry

•Beam:

$L=0.9\,m$

$r=0.025\,m$

1.2 Properties of the material

•Beam

- $E=2.06\,E11\,Pa$ Modulus Young
- $\nu=0.$ Poisson's ratio
- $\rho=7800.\,kg/m^{-3}$ Density

•tensor

- $m=0.03829\,Kg$
- Disc of mass inertia
- $I_{yy}=1.8\times10^{-6}\,Kg.m^2$
- $I_{yy}=1.8\times10^{-6}\,Kg.m^2$
- $I_{zz}=1.8\times10^{-6}\,Kg.m^2$
- $I_{xy}=I_{yz}=I_{xz}=0.$

1.3 Boundary conditions and loadings

imposed Displacements (m) :

Points A and B : $DX=DY=DZ=0$

rotational speed:

$\omega=10000\,tr/mn$

2 Reference solution

2.1 Method of calculating used for the reference solutions

the reference solution is a solution obtained with python. Indeed, two methods of calculating were used to determine the frequencies. Each method uses the stiffness matrixes, of mass, gyroscopic and of damping calculated by *Code_Aster*. For the search of the frequencies of the quadratic modal problem one uses:

- the mathematical bookseller python `numpy` (search for eigenvalues)
- command `MODE_ITER_SIMULT`

It is thus not strictly speaking a NON-regression. On the other hand for the validation of the beam elements and in the absence of comparative data, it is indeed NON-regression.

2.2 Reference variables

- $FREQ$ frequency
- $AMOR\_REDUIT$: reduced damping

2.3 Result of reference

As indication, the results of reference for the right beam of Eulerian are given below.

numpy	
$N°$	$FREQ(Hz)$
1	123.915
2	124.546
3	497.033
4	499.575

MODE_ITER_SIMULT		
$N°$	$FREQ(Hz)$	$AMOR\_REDUIT$
1	123.915	0.0
20	7971.6	0.0
40	21163.265	0.0
60	37289.789	0.0
80	74712.423	0.0
100	1.8639955×10^5	0.0
107	2.0492518×10^5	0.0

2.4 Uncertainty on the solution

numerical Solution

3 Modelization A

3.1 Characteristic of the modelization A

Modelizations POU_D_E and DIS_TR
Many nodes: 19
Number of meshes: 19 are 18 SEG2 and 1 POI1
Nodes group:
$PALIER\_A$
$PALIER\_B$

3.2 Quantities tested and results

First C alcul modal: **it is of type GEP** . One solves it *via* the operator MODE_ITER_SIMULT + METHODE=' SORENSEN' (concept MODES).

$N°$	$FREQ(Hz)$ displayed in the .mess	Tolerance
2	124.231	10-6
3	124.231	10-6
4	498.302	10-6
5	498.302	10-6
6	1118.15	10-6
7	1118.15	10-6
8	1993.47	10-6
9	1993.47	10-6
10	2021.39	10-6
11	2850.72	10-6

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 determines ainci 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, $\frac{\sqrt{\text{RAYON\_CONTOUR}}}{2\pi}$ (if APM) . One specifies the method of enumeration used (Sturm type or APM).

Concept	FREQ_MIN/ CENTRE_CONTOUR	FREQ_MAX/ RAYON_CONTOUR	NB_FREQ	Method of enumeration
NBMOD01	-1.0	120.0	1 One counts λ_1 .	Sturm type
NBMOD02	-1.0	130.0	3 One counts $(\lambda_i)_{i=1,3}$.	Sturm type

NBMOD03	-1.0	1200.0	7 One counts $(\lambda_i)_{i=1,7}$.	Sturm type
NBMOD11	0.0+0.0j	5.684 105 (= $(120x2\pi)^2$)	1 Idem NBMOD01	APM
NBMOD12	0.0+0.0j	6.671 105 (= $(130x2\pi)^2$)	3 Idem NBMOD02	APM
NBMOD13	0.0+0.0j	5.684 107 (= $(1200x2\pi)^2$)	7 Idem NBMOD03	APM

the Second modal computation: it is of type QEP **.** One solves it *via* the operator `MODE_ITER_SIMULT + METHODE=' QZ'` (concept `MODEQ`)

$N°$[1]	$FREQ(Hz)$ displayed in `the .mess` (= $\frac{\Im(\lambda_i)}{2\pi}$)	$AMORTISSEMENT$ displayed in `the .mess` (=formule $\frac{-\Re(\lambda_i)}{\|\lambda_i\|}$)	Modulates eigenvalue (= $\|\lambda_i\|$)	Toleranc e
Withou t object	not retained in *Code_Aster* because real eigenvalue	Without object	0	Without object
Withou t object	not retained in *Code_Aster* because real eigenvalue	Without object	0	Without object
1	123.915 + the complex combined	10-11	778.5	0.5
2	124.546 + the complex combined	10-09	782.5	0.5
…	…	…	…	…
10	2850.72 + the complex combined	10-15	18849.5	0.5
11	3099.17 + the complex combined	10-11	19472.6	0.5
…	…	…	…	…
41	21273.2 + the complex combined	10-12	133663.4	0.5
42	21380.2 + the complex combined	10-12	134335.7	0.5

1 the order in the data structure *Code_Aster*, since there is no relation of order in the complex plane.

…	…	…	…	…

One tests also command INFO_MODE. Since it is about a QEP with real matrixes, its eigenvalues, either real, or complex are combined. One cannot thus use only method APM here. It strictly determines the number of eigenvalues (NB_FREQ) contained here in the disc of center CENTRE_CONTOUR and RAYON_CONTOUR.

Concept	CENTRE_CONTOUR	RAYON_CONTOUR	NB_FREQ	Method of enumeration
NBMOD04	0.0+0.0j	779.114 (= $124\text{x}2\pi$)	4 One counts the 2 zero values + the couple $(\lambda_{1,}\bar{\lambda}_1)$.	APM
NBMOD05	0.0+779.114j (= $0.0+124\text{x}2\pi j$)	7	2 one counts the 2 values λ_1 and λ_2 combined to them.	APM
NBMOD06	0.0+0.0j	1.884 104 (= $3000\text{x}2\pi$)	22 One counts the 2 zero values + the couples $(\lambda_i,\bar{\lambda}_i)_{\text{i=1,10}}$.	APM
NBMOD07	0.0+0.0j	1.338 105 (= $21300\text{x}2\pi$)	84 One counts the 2 zero values + the couples $(\lambda_i,\bar{\lambda}_i)_{\text{i=1,41}}$.	APM
NBMOD08	779.114 (1.0+j) (= $124\text{x}2\pi(1.0+j)$)	701.203 (=formule $0.9\text{x}\,124\text{x}2\pi$)	0	APM

4 Modelization B

4.1 Characteristic of the modelization B

Modelizations `POU_D_E` and `DIS_TR`

Many nodes 19

Number of meshes 18 Are: `SEG2` 18

Nodes group:

$PALIER\_A$

$PALIER\_B$

4.2 Quantities tested and results

•**MODE_ITER_SIMULT**

$N°$	$FREQ(Hz)$	Tolerance
1	123.915	10^{-4}
20	7971.6	10^{-4}
40	21163.265	10^{-4}
60	37289.789	10^{-4}
80	74712.423	10^{-4}
100	186399.55	10^{-4}
107	204925.18	10^{-4}

$N°$	$AMOR\_REDUIT$	Tolerance
1	0.0	10^{-4} %
20	0.0	10^{-4} %
40	0.0	10^{-4} %
60	0.0	10^{-4} %
80	0.0	10^{-4} %
100	0.0	10^{-4} %
107	0.0	10^{-4} %

5 Modelization C

This test of type purely mathematical validation is without object for the gyroscopy.

6 Modelization D

6.1 Characteristic of the modelization D

Modelizations POU_D_EM and DIS_TR

Many nodes 19

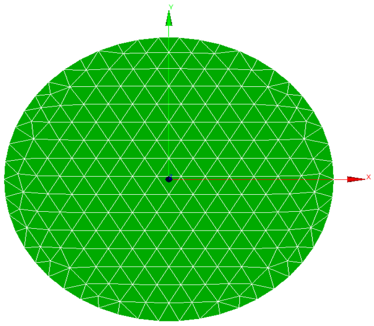
Number of meshes 18 Is: SEG2 18

Nodes group:

$PALIER\_A$

$PALIER\_B$

Mesh of the section



6.2 Quantities tested and results

•**MODE_ITER_SIMULT**

$N°$	$FREQ(Hz)$	Tolerance
1	123.429	10^{-4}
20	7507.3	10^{-4}
40	18555.3	10^{-4}
60	35125.2	10^{-4}
80	54195.4	10^{-4}
100	101504.0	10^{-4}
107	107718.3	10^{-4}

$N°$	$AMOR\_REDUIT$	Tolerance
1	0.0	10^{-4} %
20	0.0	10^{-4} %
40	0.0	10^{-4} %
60	0.0	10^{-4} %
80	0.0	10^{-4} %
100	0.0	10^{-4} %

107	0.0	10^{-4} %

7 Modelization E

7.1 Characteristic of the modelization E

Modelizations POU_D_TG and DIS_TR

Many nodes 19

Number of meshes 18 Is: SEG2 18

7.2 Quantities tested and results

•**MODE_ITER_SIMULT**

the tests ensure non regression code and relate to the frequency and reduced damping.

8 Modelization F

8.1 Characteristic of the modelization F

Modelizations POU_D_TGM and DIS_TR

Many nodes 19

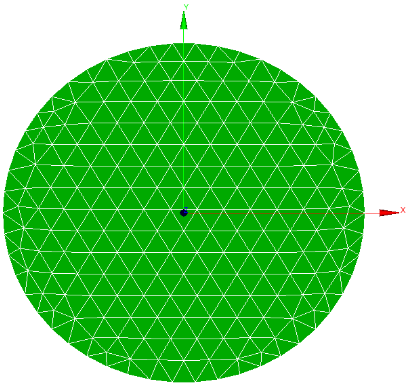
Number of meshes 18 Is: SEG2 18

Nodes group:

$PALIER\_A$

$PALIER\_B$

Mesh of the section



8.2 Quantities tested and results

•**MODE_ITER_SIMULT**

the tests ensure non regression code and relate to the frequency and reduced damping.

9 Summary of the results

One notes a good establishment of the gyroscopic effect for all the beam elements right of *Code_Aster*. In analytical absence of reference for the multifibre validation of the elements beams and/or with warping subjected to the gyroscopic effect, the validation is done by comparison with the results provided by the modulus python.