SDLL123 - Frequency of a line of trees simplified with gyroscopy

Summary:

This test makes it possible to validate the calculation 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 modelings are carried out:

- Modeling b: `POU_D_E`
- Modeling D: `POU_D_EM`
- Modeling E: `POU_D_TG`
- Modeling F: `POU_D_TGM`

Modelings 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 material

- Beam
  - $E=2.06\,E11\,Pa$ Young modulus
  - $\nu=0.$ Poisson's ratio
  - $\rho=7800.\,kg/m^{-3}$ Density
- Disc
  - $m=0.03829\,Kg$
  - mass tensor of 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 : $DX=DY=DZ=0$

number of revolutions:
$\omega=10000\,tr/mn$

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 matrices of rigidity, mass, gyroscopic and of damping calculated by *Code_Aster*. For the research of the frequencies of the quadratic modal problem, one uses:

- the mathematical bookseller python `numpy` (search for eigenvalues)
- the order `CALC_MODES`

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

2.2 Reference variables

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

2.3 Result of reference

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

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

CALC_MODES		
$N°$	$FREQ(Hz)$	$AMOR\_REDUIT$
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

2.4 Uncertainty on the solution

Digital solution

3 Modeling A

3.1 Characteristics of modeling A

Modelings POU_D_E and DIS_TR
Many nodes: 19
Many meshs:19 are 18 SEG2 and 1 POI1
Group of nodes:
$PALIER\_A$
$PALIER\_B$

3.2 Sizes tested and results

- ***The first modal calculation:* it is of type GEP**. It is solved *via* the operator CALC_MODES + SOLVEUR_MODAL=_F (METHODE=' SORENSEN') (concept MODES).

$N°$	$FREQ(Hz)$ displayed in .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 the order INFO_MODE. The GEP being standard (real symmetrical matrices) 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 to check that they give the same results well.
  One determines ainci the number of eigenvalues (NB_FREQ) contained strictly in a frequential band [FREQ_MIN, FREQ_MAX] (if Sturm) or in the disc of center FREQ_CENTRE and of ray, into frequential, $\frac{\sqrt{\text{RAYON\_CONTOUR}}}{2\pi}$ (if APM) . One specifies the method of enumeration used (Sturm 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
NBMOD02	-1.0	130.0	3 One counts $(\lambda_i)_{i=1,3}$.	Sturm
NBMOD03	-1.0	1200.0	7 One counts	Sturm

			$(\lambda_i)_{i=1,7}$.	
NBMOD11	0.0+0.0j	5,684 10^5 (= $(120 x 2\pi)^2$)	1 Idem NBMOD01	APM
NBMOD12	0.0+0.0j	6,671 105 (= $(130 x 2\pi)^2$)	3 Idem NBMOD02	APM
NBMOD13	0.0+0.0j	5,684 107 (= $(1200 x 2\pi)^2$)	7 Idem NBMOD03	APM

- ***The second modal calculation:*** it is of type QEP**.** It is solved *via* the operator `CALC_MODES + SOLVEUR_MODAL=_F (METHODE=' QZ')` (concept `MODEQ`).

$N°$ [1]	$FREQ(Hz)$ displayed in `.mess` (= $\frac{\Im(\lambda_i)}{2\pi}$)	$AMORTISSEMENT$ displayed in `.mess` (= $\frac{-\Re(\lambda_i)}{\lvert\lambda_i\rvert}$)	Module of the eigenvalue (= $\lvert\lambda_i\rvert$)	Tolerance
Without object	Not retained in *Code_Aster* because real eigenvalue	Without object	0	Without object
Without 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 Only the order in the structure of data *Code_Aster*, since there is no relation of order in the complex plan.

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

Concept	CENTRE_CONTOUR	RAYON_CONTOUR	NB_FREQ	Method of enumeration
NBMOD04	0.0+0.0j	779,114 (= $124x2\pi$)	4 One counts the 2 zero values + the couple $(\lambda_{1,}\bar{\lambda}_1)$.	APM
NBMOD05	0.0+779.114J (= $0.0+124x2\pi j$)	7	2 the 2 values are counted λ_1 and λ_2 without their combined.	APM
NBMOD06	0.0+0.0j	1,884 10^4 (= $3000x2\pi$)	22 One counts the 2 zero values + the couples $(\lambda_i,\bar{\lambda}_i)_{i=1,10}$.	APM
NBMOD07	0.0+0.0j	1,338 10^5 (= $21300x2\pi$)	84 One counts the 2 zero values + the couples $(\lambda_i,\bar{\lambda}_i)_{i=1,41}$.	APM
NBMOD08	779,114 (1.0+J) (= $124x2\pi(1.0+j)$)	701,203 (= $0.9x124x2\pi$)	0	APM

4 Modeling B

4.1 Characteristics of modeling B

Modelings POU_D_E and DIS_TR

Many nodes	19			
Many meshs	18	That is to say:	SEG2	18

Group of nodes:

$PALIER\_A$
$PALIER\_B$

4.2 Sizes tested and results

- **CALC_MODES**

$N°$	$FREQ(Hz)$	Tolerance
1	123.915	10^{-4}

$N°$	$AMOR\_REDUIT$	Tolerance
1	0.0	$10^{-4}\ \%$

5 Modeling C

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

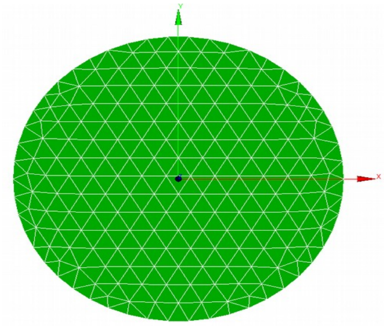
6 Modeling D

6.1 Characteristics of modeling D

Modelings POU_D_EM and DIS_TR

Many nodes	19			
Many meshs	18	That is to say:	SEG2	18

Group of nodes:
$PALIER\_A$
$PALIER\_B$
Grid of the section



6.2 Sizes tested and results

- **CALC_MODES**

$N°$	$FREQ(Hz)$	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}

$N°$	$AMOR\_REDUIT$	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} %

7 Modeling E

7.1 Characteristics of modeling E

Modelings POU_D_TG and DIS_TR

Many nodes	19			
Many meshs	18	That is to say:	SEG2	18

7.2 Sizes tested and results

- **CALC_MODES**

The tests ensure to it not regression of the code and relate to the frequency and reduced damping.

8 Modeling F

8.1 Characteristics of modeling F

Modelings `POU_D_TGM` and `DIS_TR`

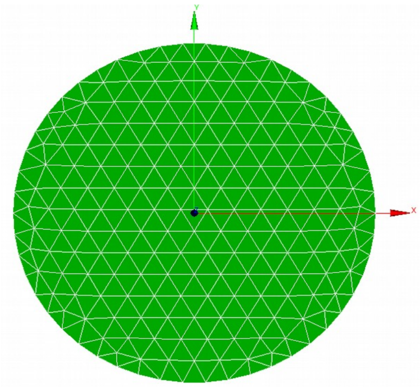
Many nodes	19			
Many meshs	18	That is to say:	`SEG2`	18

Group of nodes:

$PALIER\_A$

$PALIER\_B$

Grid of the section



8.2 Sizes tested and results

- **`CALC_MODES`**

The tests ensure to it not regression of the 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 elements of right beam 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 module python.