SDNV108 – Hollow voluminal cylinder in rotation around its axis, taken into account of the gyroscopy

Summary:

This test makes it possible to validate the calculation of the modes in rotation of a voluminal model with and without gyroscopic stiffness.

It is about a simple model of hollow roll, free-free in rotation around its axis. This example is drawn from the reference [1].

The results of calculations are compared with those obtained with ANSYS. The results coincide perfectly with the reference solution.

Contents

1 Problem of reference

The objective of this case test is to validate gyroscopic modeling in 3D of a full cylinder (options MECA_GYRO and RIGI_ROTA) in Code_Aster.

One compares the results got by the modeling of Code_Aster with those obtained in ANSYS.

1.1 Geometry

One considers a hollow roll length $L=0{,}254\,m$, of ray $R=0{,}09525\,m$ and thickness $Ep=0{,}03810\,m$.

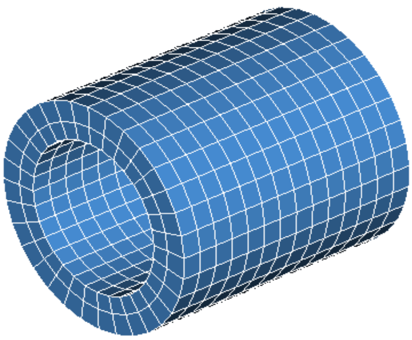

Image 1.1-1: Geometry of the hollow roll

1.2 Material properties

The cylinder has a density of $\rho=7\,860\,kg/m^3$.
The Young modulus is $E=207.10^9\,N\,m^{-2}$ and the Poisson's ratio is $\nu=0{,}28$.

1.3 Boundary conditions and loadings

The cylinder is in free-free configuration. It is with the stop or in rotation with 1000.2000 and 3000 tr/min.

2 Reference solution

The reference solution is a calculation 3D carried out with ANSYS V14.

1. ANSYS V14.

3 Modeling A

3.1 Characteristics of modeling

The rotor is modelled by linear voluminal elements (modeling '3D', MECA_HEXA8).

CALC_MODES calculate the modes suitable for stop (IE. without gyroscopic damping) and in rotation, IE. with gyroscopic damping (option MECA_GYRO), but by taking account or not effect of softening by the stiffness centrifuges (option RIGI_ROTA).

3.2 Characteristics of the grid

Many meshs HEXA8	896

Table 3.2-1

3.3 Results: comparison enters calculations of Code_Aster and ANSYS

The table 3.3-1 give the digital values tested in this CAS-test. They is the Eigen frequencies of the cylinder in free-free configuration to the stop and 3000 tr/min.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	2627,2	6,00%
Mode 2	'EXTERNAL'	2627,6	6,00%
Mode 3	'EXTERNAL'	3017,1	4,00%
Mode 4	'EXTERNAL'	3017,3	4,00%
Mode 5	'EXTERNAL'	6276,1	1,00%
Mode 6	'EXTERNAL'	6276,1	1,00%
Mode 7	'EXTERNAL'	6327	1,00%
Mode 8	'EXTERNAL'	6487,5	2,00%
Mode 9	'EXTERNAL'	6487,6	2,00%
Mode 10	'EXTERNAL'	6937,8	4,00%
Mode 11	'EXTERNAL'	6938,8	4,00%
Mode 12	'EXTERNAL'	7090,9	3,00%
Mode 13	'EXTERNAL'	7091	3,00%
Mode 14	'EXTERNAL'	7410,5	4,00%

Table 3.3-1: Summary of the results tested with the stop

The variation with the stop between the two models seems important (up to 6%). The explanation lies in the fact that under-just code ANSYS the linear voluminal elements. Code_Aster not allowing the under-integration of the elements HEXA8, we used an exact integration. One cannot thus check if the variation decreases with these elements. On the other hand, Code_Aster allows under-integration for the elements HEXA20 (cf modelings B and C).

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	53,42	1,00%
Mode 2	'EXTERNAL'	100	1,00%
Mode 3	'EXTERNAL'	2588,8	6,00%
Mode 4	'EXTERNAL'	2666,6	6,00%
Mode 5	'EXTERNAL'	2982,4	4,00%
Mode 6	'EXTERNAL'	3052,4	4,00%
Mode 7	'EXTERNAL'	6256,1	1,00%
Mode 8	'EXTERNAL'	6296,5	1,00%
Mode 9	'EXTERNAL'	6326,2	1,00%
Mode 10	'EXTERNAL'	6455,1	2,00%
Mode 11	'EXTERNAL'	6520,1	2,00%

Table 3.3-2: Summary of the results tested in rotation without centrifugal softening

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	26,63	1,00%
Mode 2	'EXTERNAL'	26,63	1,00%
Mode 3	'EXTERNAL'	50	1,00%
Mode 4	'EXTERNAL'	50	1,00%
Mode 5	'EXTERNAL'	2588,4	6,00%
Mode 6	'EXTERNAL'	2666,1	6,00%
Mode 7	'EXTERNAL'	2982,1	4,00%
Mode 8	'EXTERNAL'	3052	4,00%
Mode 9	'EXTERNAL'	6255,8	1,00%
Mode 10	'EXTERNAL'	6296,2	1,00%
Mode 11	'EXTERNAL'	6326	1,00%
Mode 12	'EXTERNAL'	6455	2,00%
Mode 13	'EXTERNAL'	6519,9	2,00%

Table 3.3-3: Summary of the results tested in rotation with centrifugal softening

4 Modeling B

4.1 Characteristics of modeling

The rotor is modelled by quadratic voluminal elements (modeling `'3D'`, `MECA_HEXA20`).

`CALC_MODES` calculate the modes suitable for stop (IE. without gyroscopic damping) and in rotation, IE. with gyroscopic damping (option `MECA_GYRO`), but by taking account or not effect of softening by the stiffness centrifuges (option `RIGI_ROTA`).

4.2 Characteristics of the grid

Many meshs `HEXA20`	112

Table 4.2-1

4.3 Results: comparison enters calculations of Code_Aster and ANSYS

The table 4.3-1 give the digital values tested in this CAS-test. They is the Eigen frequencies of the cylinder in free-free configuration to the stop and 3000 tr/min.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	2562,08	3,00%
Mode 2	'EXTERNAL'	2562,08	3,00%
Mode 3	'EXTERNAL'	2962,72	2,00%
Mode 4	'EXTERNAL'	2962,72	2,00%
Mode 5	'EXTERNAL'	6231,34	1,00%
Mode 6	'EXTERNAL'	6231,34	1,00%
Mode 7	'EXTERNAL'	6313,73	1,00%
Mode 8	'EXTERNAL'	6420,42	1,00%
Mode 9	'EXTERNAL'	6420,42	1,00%
Mode 10	'EXTERNAL'	6658,75	3,00%
Mode 11	'EXTERNAL'	6658,75	3,00%
Mode 12	'EXTERNAL'	7040,85	1,00%
Mode 13	'EXTERNAL'	7040,85	1,00%
Mode 14	'EXTERNAL'	7159,02	3,00%

Table 4.3-1: Summary of the results tested with the stop (elements `HEXA20`)

The variation with the stop between the two models seems important (maximum variation of 3%). The explanation lies in the fact that under-just code ANSYS the quadratic voluminal elements (cf modeling C) whereas this modeling uses elements with an exact integration.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	53,26	2,00%
Mode 2	'EXTERNAL'	100	1,00%
Mode 3	'EXTERNAL'	2524,2	3,00%
Mode 4	'EXTERNAL'	2601,5	3,00%
Mode 5	'EXTERNAL'	2928,5	2,00%
Mode 6	'EXTERNAL'	2998,1	2,00%
Mode 7	'EXTERNAL'	6211,4	1,00%
Mode 8	'EXTERNAL'	6251,8	1,00%
Mode 9	'EXTERNAL'	6313	1,00%
Mode 10	'EXTERNAL'	6388,2	1,00%

Table 4.3-2: Summary of the results tested in rotation without centrifugal softening

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	26,63	2,00%
Mode 2	'EXTERNAL'	26,63	2,00%
Mode 3	'EXTERNAL'	50	1,00%
Mode 4	'EXTERNAL'	50	1,00%
Mode 5	'EXTERNAL'	2523,74	3,00%
Mode 6	'EXTERNAL'	2600,99	3,00%
Mode 7	'EXTERNAL'	2928,09	2,00%
Mode 8	'EXTERNAL'	2997,72	2,00%
Mode 9	'EXTERNAL'	6211,33	1,00%
Mode 10	'EXTERNAL'	6251,73	1,00%
Mode 11	'EXTERNAL'	6312,84	1,00%
Mode 12	'EXTERNAL'	6388,03	1,00%

Table 4.3-3: Summary of the results tested in rotation with centrifugal softening

5 Modeling C

5.1 Characteristics of modeling

The rotor is modelled by quadratic voluminal elements (modeling `'3D_SI'`, `MECA_HEXS20`).

`CALC_MODES` calculate the modes suitable for stop (IE. without gyroscopic damping) and in rotation, IE. with gyroscopic damping (option `MECA_GYRO`), but by taking account or not effect of softening by the stiffness centrifuges (option `RIGI_ROTA`).

5.2 Characteristics of the grid

Many meshs `HEXS20`	112

Table 5.2-1

5.3 Results: comparison enters calculations of Code_Aster and ANSYS

The table 5.3-3 give the digital values tested in this CAS-test. They is the Eigen frequencies of the cylinder in free-free configuration to the stop and 3000 tr/min.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	2562,08	2,00%
Mode 2	'EXTERNAL'	2562,08	2,00%
Mode 3	'EXTERNAL'	2962,72	1,00%
Mode 4	'EXTERNAL'	2962,72	1,00%
Mode 5	'EXTERNAL'	6231,34	1,00%
Mode 6	'EXTERNAL'	6231,34	1,00%
Mode 7	'EXTERNAL'	6313,73	1,00%
Mode 8	'EXTERNAL'	6420,42	1,00%
Mode 9	'EXTERNAL'	6420,42	1,00%
Mode 10	'EXTERNAL'	6658,75	2,00%
Mode 11	'EXTERNAL'	6658,75	2,00%
Mode 12	'EXTERNAL'	7040,85	1,00%
Mode 13	'EXTERNAL'	7040,85	1,00%
Mode 14	'EXTERNAL'	7159,02	2,00%

Table 5.3-1: Summary of the results tested with the stop (elements `HEXS20`)

With under-integration, it is noted indeed that the difference between Code_Aster and ANSYS decreases by 3% to 1.5% at the most.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	53,26	2,00%
Mode 2	'EXTERNAL'	100	1,00%
Mode 3	'EXTERNAL'	2524,2	2,00%
Mode 4	'EXTERNAL'	2601,5	2,00%
Mode 5	'EXTERNAL'	2928,5	2,00%
Mode 6	'EXTERNAL'	2998,1	2,00%
Mode 7	'EXTERNAL'	6211,4	1,00%
Mode 8	'EXTERNAL'	6251,8	1,00%
Mode 9	'EXTERNAL'	6313	1,00%
Mode 10	'EXTERNAL'	6388,2	1,00%

Table 5.3-2: Summary of the results tested in rotation without centrifugal softening

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	26,63	2,00%
Mode 2	'EXTERNAL'	26,63	2,00%
Mode 3	'EXTERNAL'	50	1,00%
Mode 4	'EXTERNAL'	50	1,00%
Mode 5	'EXTERNAL'	2523,74	2,00%
Mode 6	'EXTERNAL'	2600,99	2,00%
Mode 7	'EXTERNAL'	2928,09	2,00%
Mode 8	'EXTERNAL'	2997,72	2,00%
Mode 9	'EXTERNAL'	6211,33	1,00%
Mode 10	'EXTERNAL'	6251,73	1,00%
Mode 11	'EXTERNAL'	6312,84	1,00%
Mode 12	'EXTERNAL'	6388,03	1,00%

Table 5.3-3 : Summary of the results tested in rotation with centrifugal softening

6 Summary of the results

The cas-test implements the rotation of a hollow roll around its axis. Modeling 3D of the gyroscopy programmed in Code_Aster compared to the results got with the model are equivalent 3D is thus validated in ANSYS.