SDLV132 - Taking into account, by under-structuring, of a solid mass generalized in a modal calculation of line of trees

Summary:

This test makes it possible to validate the taking into account, by under-structuring, of a solid mass generalized for a calculation of line of trees.

In this test, there is a model of rotor with constant circular section resting on a solid mass via stages considered as infinitely rigid. This example is drawn from the handbook of qualification of CADYRO, software finite elements intended to model the dynamic behavior of rotors.

1 Problem of reference

1.1 Geometry

The structure is composed of a rotor of L2 length and circular section, of two stages infinitely rigid and of a solid mass of circular beams sections.

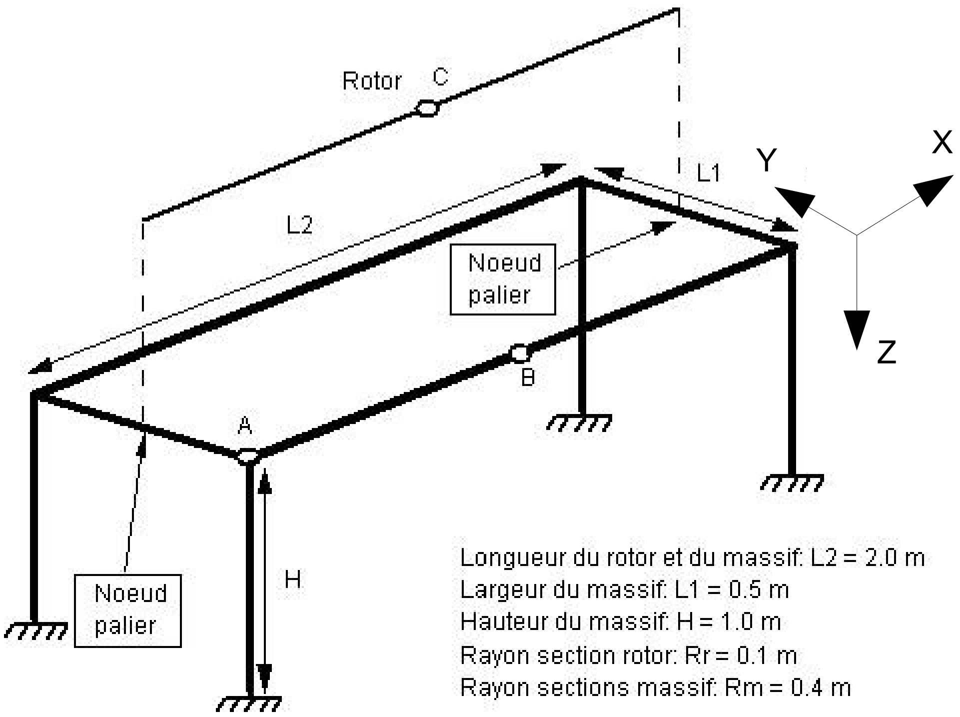

Figure 1.1-a- has: Model of rotor with 2 stages and a solid mass

Coordinates of the nodes in the reference mark (X, Y, Z) :

Support: $A(0.0/-0.25/0.0)$
$B(0.0/-0.25/1.0)$
Rotor: $C(0.0/0.0/1.0)$

1.2 Properties of material

The geometrical characteristics and material are listed in the following table.

Material	$E=210^{11} N/m^2$	$\rho=7800 kg/m^3$	$\nu=0.0$
Length of the rotor		$L=2 m$	
Ray of the rotor		$Rr=0.1 m$	
Length of the solid mass		$L=2 m$	
Width of the solid mass		$l=0.5 m$	
Height of the solid mass		$H=1 m$	
Ray of the beams of the solid mass		$Rm=0.1 m$	

Table 1.2-1

The two nodes stages are located exactly in the middle of each with dimensions solid mass.

The coefficients of stiffness in translation of the stages are: $Kzz=Kyy=1.0\mathrm{E}+12\ kg.s^{-2}$

$Kzy=Kyz=0.0\ kg.s-2$

$Czz=Cyy=Czy=Cyz=0.0\ kg.s^{-1}$

1.3 Boundary conditions

The stages of the rotor rest on the solid mass via connections considered as infinitely rigid. The four feet of the solid mass are embedded. The rotor and the solid mass thus are coupled perfectly with the nodes stages, according to the method of CRAIG-BAMPTON.

2 Reference solution

2.1 Method of calculating

The infinitely rigid stages and the absence of rotation of the tree make it possible to carry out a direct calculation with *Code_Aster* first clean modes of the structure solid mass-stage-rotor which will be used as reference to calculation substructure in *Code_Aster*.
Validation of the taking into account, by under-structuring, of a solid mass generalized in a calculation of lines of trees in *Code_Aster* will consist in comparing the Eigen frequencies obtained by a direct calculation and a calculation substructure (under-structuring of the Craig-Bampton type).
One will also endeavour to validate each one of the substructures rotor-stages and solid mass separately.

In addition to the comparison between total calculation and calculation substructure in *Code_Aster*, one validates also the results compared to those of CADYRO [1].

2.2 Sizes and results of reference

Results of *Code_Aster* give at the same time the frequencies of the modes and the deformations modal. Only the frequencies are actually tested.

2.3 References

[1] CADYRO, software finite elements intended to envisage the dynamic behavior of rotors in inflection file of validation – note HP-61/94/049/B.

3 Modeling A

3.1 Characteristics of modeling

3.2 Characteristics of the grid

The rotor is with a grid in 40 finite elements of tree of the type POU_D_T regularly distributed and comprises 2 discrete elements of type DIS_TR for the modeling of the stages.
Many nodes: 41
Number and type of elements: 40 SEG2
2 POI1

3.3 Sizes tested and results

The criteria of tolerance into relative are of 1% on the results of the type 'SOURCE_EXTERNE' and of 5th-3% on the results of the type 'NON_REGRESSION'.
The values of the first 6 Eigen frequencies of the rotor are the following ones.

N° Fréq	Rotor ASTER	Calculation CADYRO
	F (Hz)	F (Hz)
1	1.00860E+02	1.0090E+02
2	1.00860E+02	1.0090E+02
3	3.92529E+02	3.9305E+02
4	3.92529E+02	3.9305E+02
5	8.50239E+02	8.5242E+02
6	8.50239E+02	8.5242E+02

Table 3.3-1 : Eigen frequencies of the rotor

The values of the first 10 Eigen frequencies of the solid mass are the following ones.

N° Fréq	Rotor ASTER	Calculation CADYRO
	F (Hz)	F (Hz)
1	2.19224E+02	2.21045E+02
2	2.56714E+02	2.59147E+02
3	3.44965E+02	3.47706E+02
4	4.17655E+02	4.20215E+02
5	4.88441E+02	4.92291E+02
6	5.17576E+02	5.21767E+02
7	6.19092E+02	6.24727E+02
8	6.41466E+02	6.45547E+02
9	7.32139E+02	7.36375E+02
10	7.76297E+02	7.78041E+02

Table 3.3-2 : Eigen frequencies of the solid mass

The values of the first 7 frequencies to the stop, for the two methods of calculating (direct and substructure), are presented in the table below.

N° Fréq	Rotor ASTER direct calculation	Calculation ASTER calculation substructure	Calculation CADYRO
	F (Hz)	F (Hz)	F (Hz)
1	1.00675E+02	1.00675E+02	1.00717E+02
2	1.00827E+02	1.00827E+02	1.00866E+02
3	2.19250E+02	2.19933E+02	2.21064E+02
4	2.56711E+02	2.56822E+02	2.59143E+02
5	3.40422E+02	3.48884E+02	3.42981E+02
6	3.91994E+02	3.92003E+02	3.92524E+02
7	3.96857E+02	3.98334E+02	3.97556E+02

Table 3.3-3 : Eigen frequencies obtained by calculations direct and substructure

4 Modeling B

4.1 Characteristics of modeling

Identical to modeling A, but use of the operators CREA_ELEM_SSD and ASSE_ELEM_SSD. The modal calculation of the direct model (not substructure) was not taken again.

4.2 Sizes tested and results

The values of the first 7 frequencies to the stop are presented in the table below.

N° Fréq	Calculation ASTER calculation substructure	Calculation CADYRO
	F (Hz)	F (Hz)
1	1.00712E+02	1.00717E+02
2	1.00861E+02	1.00866E+02
3	2.21761E+02	2.21064E+02
4	2.59264E+02	2.59143E+02
5	3.51439E+02	3.42981E+02
6	3.92474E+02	3.92524E+02
7	3.99088E+02	3.97556E+02

Table 4.2-1 : Eigen frequencies obtained by dynamic under-structuring

5 Summary of the results

This CAS-test makes it possible to numerically validate the taking into account of a generalized solid mass of line of trees by a calculation substructure. The got results are in concord with the values of reference, resulting from the handbook of qualification of the code of lines of trees CADYRO.