SSLV105 - Stiffening centrifuges of a beam in rotation

Summarized:

Test of Structural mechanics in linear static analysis.

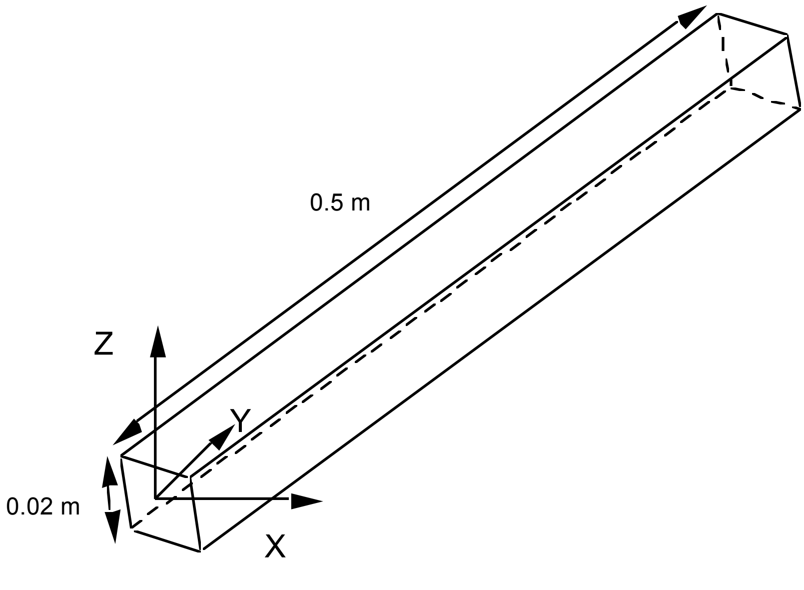
The geometry is that of a slender beam subjected to a rotation around one of its ends. 2 modelizations: multifibre elements 3D (HEXA20) and beams. One tests here the inertia forces of rotation (like test SSLV104) with taking into account of the centrifugal stiffening.

The reference solution (analytical) takes into account the term of additional stiffness due to rotation. The results are identical to the reference solution.

1 Problem of reference

1.1 Geometry

the structure is made up of a directed slender beam carried in space by the axis of directing vector $(1,1,1)$.



Square section of area: $4.0\,10^{-4} m^2$

Length of beam: $0.5\,m$

1.2 Material properties

$E=2.10^{11} Pa$

$\nu=0$

$\rho=7800\,kg/m^3$

1.3 Boundary conditions and loadings

free clamped Beam in rotation around an axis perpendicular to its greater dimension and passing by the center of the clamped face.

Coordinates of the vector rotation: $(1,0,-1)$.

Rotational speed: $\omega=3000\,rd/s$.

The important value rotational speed does not have anything physics.

2 Reference solution

2.1 Method of calculating used for the reference solution

In local coordinate system of beam: the equation relating to displacement U_x (without neglecting lengthening) is:

$$\frac{\partial^2 U_x}{\partial x^2}+\frac{\rho}{E}\omega^2(x+U_x)=0$$

With the boundary conditions: $$U_x(0)=0$$ $$\frac{\partial U_x}{\partial x}(L)=\sigma_{xx}(L)=0$$

One poses $\alpha=\sqrt{\frac{\rho\omega^2}{E}}$

By integrating the preceding differential equation one obtains, in the reference of beam:

$$U_x(x)=\frac{\sin(\alpha x)}{\alpha\cos(\alpha L)}-x \quad U_y=U_z=0$$

The displacement of any points of the beam is thus written in the total reference:

$$U_x(X,Y,Z)=\frac{1}{\sqrt{3}}\left(\frac{\sin(\alpha r)}{\alpha\cos(\alpha L)}-r\right)$$
$$U_y(X,Y,Z)=\frac{1}{\sqrt{3}}\left(\frac{\sin(\alpha r)}{\alpha\cos(\alpha L)}-r\right)$$
$$U_z(X,Y,Z)=\frac{1}{\sqrt{3}}\left(\frac{\sin(\alpha r)}{\alpha\cos(\alpha L)}-r\right)$$
with $r=\sqrt{X^2+Y^2+Z^2}$

2.2 Results of reference

Values of three displacements to the center of the section furthest away from the rotational axis.

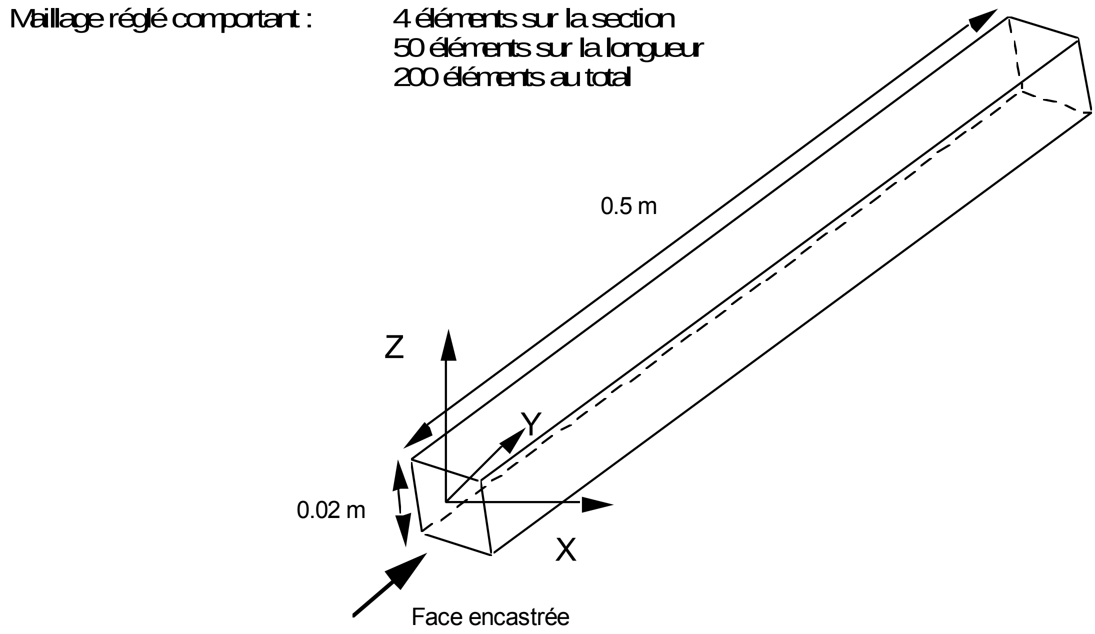
2.3 Uncertainty on the solution

Without object (analytical solution).

3 Modelization A

3.1 Characteristic of the modelization

Elements 3D (HEXA20)



3.2 Characteristic of the mesh

Many nodes: 1521

Number of meshes and types: 200 HEXA20

3.3 Standard

Identification	Results of reference	*Value of reference*	Tolerance (%)
DX in L	"ANALYTIQUE"	8.75 10-3	0.1
DY in L	"ANALYTIQUE"	8.75 10-3	0.1
DZ in L	"ANALYTIQUE"	8.75 10-3	0.1

4 Modelization B

4.1 Characteristic of the modelization

Elements multifibre Beams

4 fibers in the section
8 elements over the length

4.2 Characteristics of the mesh

Many nodes: 9

Number of meshes and types: 8 SEG2

4.3 Standard

Identification	Results of reference	*Value of reference*	Tolerance (%)
DX in L	"ANALYTIQUE"	8.75 10-3	3.E-5
DY in L	"ANALYTIQUE"	8.75 10-3	3.E-5
DZ in L	"ANALYTIQUE"	8.75 10-3	3.E-5

5 Summary of correct

the Operation results of option RIGI_ROTA.

The beams with 8 elements give the solution to 2.10-5%. With only one element the error is only of 0.6%.

In comparison, the elements 3D with 200 elements give the solution to 0.01%.
This is due to the fact that the solution is integrated almost exactly with the beams.
To note the increase in axial displacement compared to the case without stiffening (SSLV104 [V3.04.104]).