

SSL402 - Dynamometric ring

Summary:

This test made it possible at the origin to check in linear elasticity the calculation of the interior efforts and of the constraints on a beam curves (POU_C_T), these elements were removed. One uses right beams now to deal with the problem.

A modeling makes it possible to test the elements of right beams of Timoshenko (POU_D_T).

The reference solution is analytical and the got results are of very good quality.

1 Problem of reference

1.1 Geometry

Circular ring

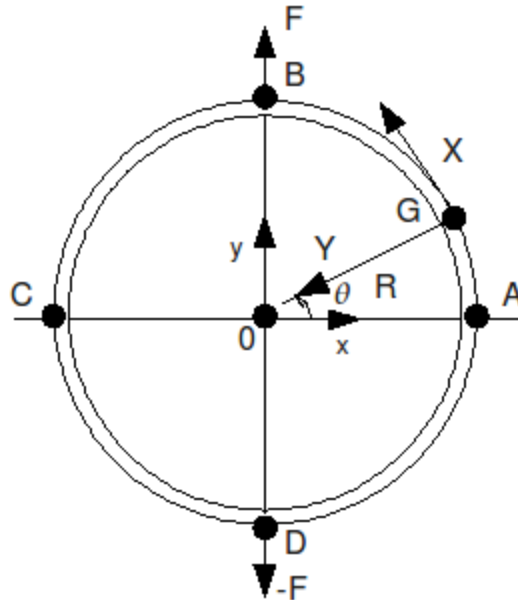


Figure 1-a : Circular ring.

$$R = 2m$$

The section (full) is a circle of radius $0,01m$.

1.2 Properties of materials

Young modulus: $E = 2 \cdot 10^{11} Pa$

Poisson's ratio: $\nu = 0.3$

1.3 Boundary conditions and loading

Boundary condition:

$$DX = DY = DZ = DRX = 0 \text{ on the point } A$$

$$DY = DZ = 0 \text{ on the point } C$$

Loading:

on B, $F = 1N$,

on D, $F = -1N$.

2 Reference solutions

2.1 Method of calculating used for the reference solutions: analytical

On the section (A, B) $\left(0 < \theta < \frac{\pi}{2}\right)$, we have:

$$N = \frac{F}{2} \cos \theta, \quad Vy = -\frac{F}{2} \sin \theta, \quad M_z = -\frac{FR}{2} (1 - \cos \theta) + \Gamma.$$

On the section (B, C) $\left(\frac{\pi}{2} < \theta < \pi\right)$, we have:

$$N = -\frac{F}{2} \cos \theta, \quad Vy = \frac{F}{2} \sin \theta, \quad M_z = -\frac{FR}{2} (1 + \cos \theta) + \Gamma.$$

By the use of the law of behavior connecting M with the rotation of the normal and given that the latter is worthless in A and in B , we have:

$$\int_0^{\frac{\pi}{2}} M d\theta = 0,$$

from where: $\Gamma = M_A = M_C = \frac{\pi - 2}{2\pi} F R$

2.2 Results of reference

Interior efforts for $\theta = 0^\circ$ and 90° .

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

1. Report n° 2314/A of the Institute Aerotechnics "Proposal and realization for new cases tests missing with the validation of the beams Aster"

3 Modeling A

3.1 Characteristics of modeling

The model is composed of 800 elements POU_D_T.

3.2 Characteristics of the grid

It consists of 800 SEG2.

3.3 Grandeus tested and results

3.3.1 Interior effort with $\theta=0^\circ$

	Type of Reference	Reference	Tolerance
N	ANALYTICAL	5.000E-01	1,00E-003 %
V_y	ANALYTICAL	0.0000	2,00E-003 *
MF_z	ANALYTICAL	3.6338E-01	1,00E-003 %

* absolute Deviation

3.3.2 Interior effort with $\theta=90^\circ$

	Type of Reference	Reference	Tolerance
N	ANALYTICAL	0.0000	2,00E-003 *
V_y	ANALYTICAL	- 5.0000E-01	1,00E-003 %
MF_z	ANALYTICAL	- 6.3662E-01	1,00E-003 %

*Ecart absolute

3.3.3 Constraint with $\theta=0^\circ$

	Type of Reference	Reference	Tolerance
$SIXXMAX$	ANALYTICAL	4.6426E+05	1,00E-003 %

3.3.4 Constraint with $\theta=90^\circ$

	Type of Reference	Reference	Tolerance
$SIXXMIN$	ANALYTICAL	- 8.1056E+05	1,00E-003 %

3.4 Remarks

Symmetry compared to the axis (A, C) imply the nullity of the shearing action T in A and in C .

Following balance O_y half-ring (A, B, C) impose in A and in C a normal effort equal to $\frac{F}{2}$.

Symmetry compared to the axis (B, D) imply that the moments in A and in C are equal in absolute value and contrary direction.

4 Summary of the results

The results are very close to the analytical solution (error lower than 1.0E-05) except for two values (NR with $\theta=90^\circ$ and Vy with $\theta=0^\circ$) for which the error is of 2.0E-03. It is noticed that this error decreases slowly when the grid is refined, but the precision of 1.0E-05 is still not reached with 1000 elements per quadrant.