SSLL402 - Dynamometric ring

Abstract:
This test makes it possible to check in linear elasticity the computation of the internal forces and the stresses on a curved beam.

A modelization makes it possible to test the curved elements of Timoshenko (`POU_C_T`).

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

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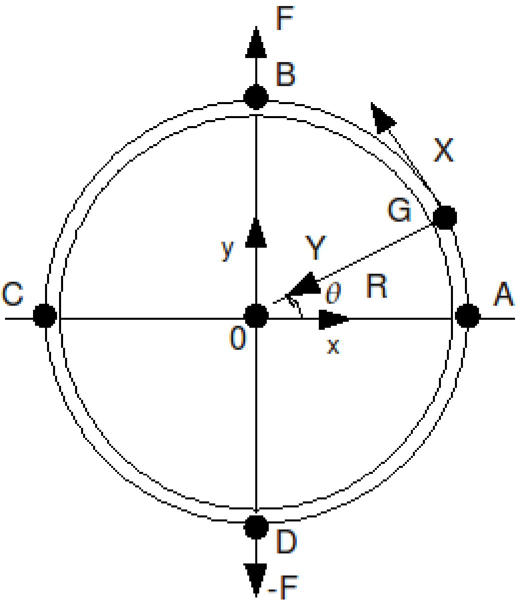
1 Problem of reference

1.1 circular

Geometry Ring



Appears 1-a : Circular ring.

$R=2\,m$

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

1.2 Properties of the materials

Modulus Young: $E=2.10^{11}\,Pa$

Poisson's ratio: $\nu=0.3$

1.3 Boundary conditions and loading

Boundary condition:

$DX=DY=DZ=DRX=0$ on the point A

$DY=DZ=0$ on the point C

Loading:

on B $F=1\,N$,

on D $F=-1\,N$.

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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 constitutive law connecting M to the rotation of the norm and given that the latter is null 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

Internal forces for $\theta=0°$ and $90°$.

2.3 Uncertainty on the analytical

solution Solution.

2.4 Bibliographical references

1. Ratio n° 2314/A of the Institute Aerotechnics “Proposal and realization for new cases tests missing to the validation of the beams *Aster* ”

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3 Modelization A

3.1 Characteristic of the modelization

The model is composed of 4 elements curved beam of Timoshenko.

3.2 Characteristics of the mesh

It consists of 4 elements `POU_C_T`.

3.3 Grandeus tested and Internal force

3.3.1 results with $\theta=0°$

	Type of Reference	Reference	Tolerance
N	ANALYTIQUE	5.000E-01	1,00E-003 %
Vy	ANALYTIQUE	0.0000	1,00E-005 *
MFz	ANALYTIQUE	3.6338E-01	1,00E-003 %

* absolute Deviation

3.3.2 Internal force to $\theta=90°$

	Type of Reference	Reference	Tolerance
N	ANALYTIQUE	0.0000	1,00E-005 *
Vy	ANALYTIQUE	– 5.0000E-01	1,00E-003 %
MFz	ANALYTIQUE	– 6.3662E-01	1,00E-003 %

*Ecart absolute

3.3.3 Stress to $\theta=0°$

	Type of Reference	Reference	Tolerance
$SIXX$	ANALYTIQUE	4.6426E+05	1,00E-003 %
$SIXY$	ANALYTIQUE	0.0000	1,00E-003 %

* absolute Deviation

3.3.4 Stress to $\theta=90°$

	Type of Reference	Reference	Tolerance
$SIXX$	ANALYTIQUE	– 8.1056E+05	1,00E-003 %
$SIXY$	ANALYTIQUE	– 1.8568E+03	1,00E-003 %

3.4 Remarks

symmetry compared to the axis (A,C) implies the nullity of the shears T in A and in C. The following equilibrium Oy of the half-ring (A,B,C) imposes in A and C a normal force equal to $\frac{F}{2}$. Symmetry compared to the axis (B,D) implies that the moments in A and C are equal in absolute value and of contrary meaning.

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4 Summary of the results

the results agree with the analytical solution and make it possible to validate the computation of the internal forces (EFGE_ELNO) and stresses (SIPM_ELNO) by the curved beam elements (POU_C_T).

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