

HSLA303 - Cylinder under pressure and thermal dilation

Summary:

Calculation is carried out into axisymmetric. The goal of the test is to validate them predeformations (keyword PRE_EPSI).

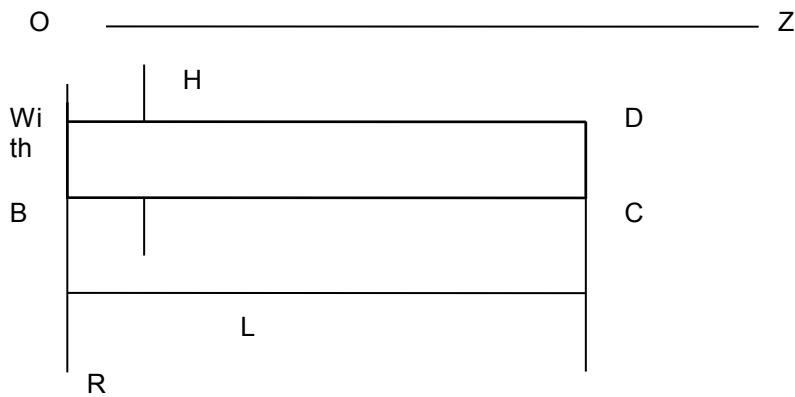
The cylinder is subjected to a homogeneous thermal dilation (ΔT constant).

The followed procedure is the following one:

- that is to say ε_1 the field of deformations resulting from one 1^{er} calculation, the cylinder being subjected to a homogeneous thermal dilation ΔT (U_1 the field of resulting displacements),
- in the second calculation, the cylinder is subjected to an internal pressure, with like predeformations the field of deformations ε_1 (either U_2 the resulting field of displacements),
- one then compares the results with the field U , obtained with cylinder under pressure, but without predeformations. One must have the relation: $U_2 = U + U_1$.

1 Problem of reference

1.1 Geometry



Length: $L = 1 \text{ m}$
Thickness: $h = 0.0025 \text{ m}$
External ray: $Re = 0.05 \text{ m}$

1.2 Material properties

$$E = 2.1 \times 10^{11} \text{ Pa}$$

$$\nu = 0.3$$

$$\alpha = 0.12 \times 10^{-4} / ^\circ \text{C}$$

1.3 Boundary conditions and loadings

- Section AB in support (direction z),
- Thermal dilation in the thickness (calculation 1): $\Delta T = 100 \text{ }^\circ \text{C}$
- Internal pressure (calculation 2): $p = 2 \times 10^8 \text{ N/m}^2$
- Taking into account of the basic effect.

1.4 Initial conditions

Without object for the static analysis.

2 Reference solution

2.1 Method of calculating used for the reference solution

- The deformation due to direct compression is given by:

$$\varepsilon_{zz} = \frac{(1-2\nu)(2R_e - h)}{4Eh} p = 3.714 \times 10^{-3}, \quad R_e = \text{external ray}$$

- Axial displacement due to the pressure is given by:

$$U_z = Z \varepsilon_{zz}$$

- The deformations due to the thermal loading are worth:

$$\varepsilon_{rr} = \varepsilon_{\theta\theta} = \varepsilon_{zz} = \alpha \Delta T = 1.2 \times 10^{-3}$$

- Radial displacement due to the thermal loading is worth:

$$U_r = r \varepsilon_{rr} = 1.2 \times 10^{-3} r$$

2.2 Results of reference

- Deformation and radial and axial displacement at the points A, B, C, D had with the thermal loading.
- Deformation and axial displacement at the points A, B, C, D had with the pressure.

2.3 Uncertainty on the solution

Analytical solution.

3 Modeling A

3.1 Characteristics of modeling

AXIS, mesh $Q8$

Cutting: 10 elements according to the length
1 element in the thickness

Limiting conditions:

in A , B DDL_IMPO = (GROUP_NO = 'WITH', DY = 0.)
DDL_IMPO = (GROUP_NO = 'B', DY = 0.)

Pressure + basic effect: field U

PRES_REP: (GROUP_MA = cont_pr, CLOSE = 2.E8)
FORCE_CONTOUR: (GROUP_MA = effond , FY = 1.95E9)

Thermal dilation: field U_1

char_no:
CREA_CHAMP (AFFE = (ALL = 'YES', NOM_CMP = 'TEMP', VALE = 100.))

char_th:
AFFE_MATERIAU (AFFE_VARC = F (ALL = 'YES', CHAM_GD = CHAR_NO, VALE_REF =
0. , NOM_VARC = 'TEMP',)

Predeformations: field U_2

PRE_EPSI: (ALL = 'YES', EPXX = 1.2E-3, EPYY = 1.2E-3,
EPZZ = 1.2E-3, EPXY = 0.)

Names of the nodes:

$A=N1$ $B=N2$ $C=N3$ $D=N4$

3.2 Characteristics of the grid

Many nodes: 53

Many meshes and types: 10 QUAD8, 22 SEG3

3.3 Sizes tested and results

Results concerning the fields U_1 , U_2 , U

Field	Localization	Variables	Reference
Thermal field U_1	A	$Ur(DX)$	5.7×10^{-5}
	B	$Ur(DX)$	6×10^{-5}
	C	$Ur(DX)$	6×10^{-5}
		DY	1.2×10^{-3}
	D	$Ur(DX)$	5.7×10^{-5}
		$U(DY)$	1.2×10^{-3}
	A , mesh $M1$	ϵ_{rr}	1.2×10^{-3}
		$\epsilon_{\theta\theta}$	1.2×10^{-3}
		ϵ_{zz}	1.2×10^{-3}
	B , mesh $M1$	ϵ_{rr}	1.2×10^{-3}
		$\epsilon_{\theta\theta}$	1.2×10^{-3}
		ϵ_{zz}	1.2×10^{-3}
	C , mesh $M10$	ϵ_{rr}	1.2×10^{-3}
		$\epsilon_{\theta\theta}$	1.2×10^{-3}
		ϵ_{zz}	1.2×10^{-3}
	D , mesh $M10$	ϵ_{rr}	1.2×10^{-3}
$\epsilon_{\theta\theta}$		1.2×10^{-3}	
ϵ_{zz}		1.2×10^{-3}	
Field of pressure U	C	$U_{\theta}(DY)$	$3,714 \times 10^{-3}$
	D	$U_{\theta}(DY)$	$3,714 \times 10^{-3}$
	C , mesh $M10$	$\epsilon_{\theta\theta}$	$3,714 \times 10^{-3}$
	D , mesh $M10$	$\epsilon_{\theta\theta}$	$3,714 \times 10^{-3}$
Field U_2	C	$U_{\theta\theta}$	$4,914 \times 10^{-3}$
	D	$U_{\theta\theta}$	$4,914 \times 10^{-3}$
	C , mesh	$\epsilon_{\theta\theta}$	$4,914 \times 10^{-3}$
	D , mesh	$\epsilon_{\theta\theta}$	$4,914 \times 10^{-3}$

3.4 Remarks

- The goal of the test is not to obtain a high degree of accuracy on the level of the results, but simply to check the relation: $U_2 = U + U_1$; so calculation was carried out only with one coarse grid.
- It is noted that the required relation is well checked at the loose lead of the cylinder.
- It is checked in addition that the field of deformation resulting from thermal dilation is uniformly equal to 1.2×10^{-3} .

4 Summary of the results

The option `PRE_EPSI` (predeformations into constant) provides completely satisfactory results.