HPLP300 - Plate with Young modulus function of temperature

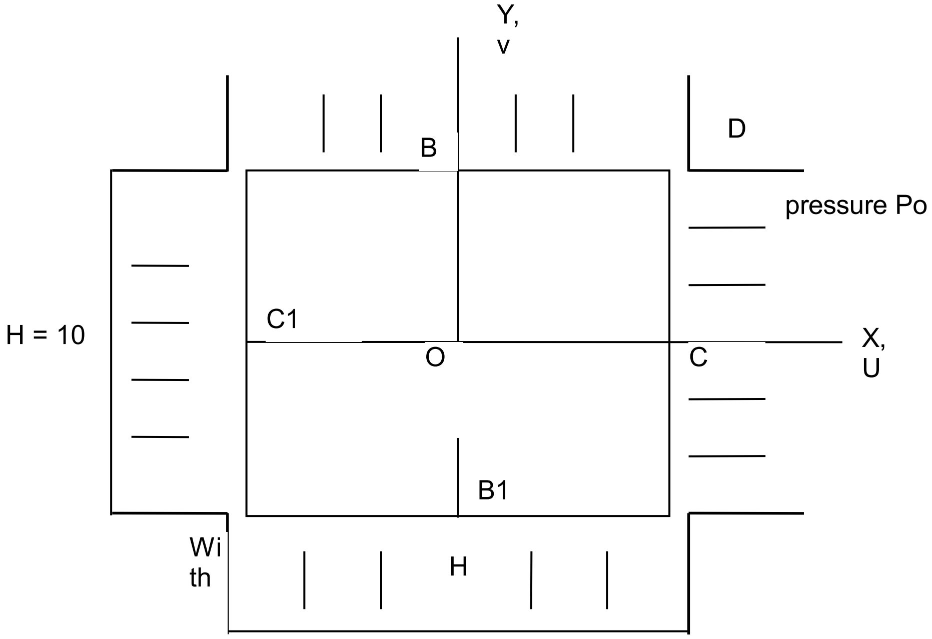
Summary:

This thermoelastic test makes it possible to compare the solution obtained by *Code_Aster* with an analytical solution, when the Young modulus varies in a nonlinear way compared to the temperature.

This test is deduced from the test $3D$ HPLV100 describes in [V7.03.100] (parallelepiped whose Young modulus is function of the temperature).

1 Problem of reference

1.1 Geometry



1.2 Material properties

Thermal conductivity: $\lambda=1$

Young modulus: $E=\frac{10000}{8000-T}$, $T=température$

Poisson's ratio: $\nu=0.3$

1.3 Boundary conditions and loadings

1.3.1 Thermics

$T(0)=40$

$\lambda\frac{\partial T}{\partial n}=-4$ on edge $x=h/2$

$\lambda\frac{\partial T}{\partial n}=+4$ on edge $x=-h/2$

$\lambda \frac{\partial T}{\partial n} = -3$ on edge $y = h/2$

$\lambda \frac{\partial T}{\partial n} = +3$ on edge $y = -h/2$

1.3.2 Mechanics

Not O blocked ($u = v = 0$)
Following displacement x blocked in B
Uniform pressure po being exerted normally on contour: $po = 1$.

2 Reference solution

2.1 Method of calculating used for the reference solution

The field of temperature is given by:

$$T = -4X - 3Y + 40$$

The field of displacements is given by:

$$u = -Vp\left[Bxy + \frac{C}{2}\left(x^2 - y^2\right) + Dx + \frac{Ch}{4}y\right]$$

$$v = -Vp\left[\frac{B}{2}\left(y^2 - x^2\right) + Cxy + Dy - \frac{Ch}{4}y\right]$$

where $B = 0.003 \quad C = 0.004 \quad D = 0.76 \quad p = \frac{1 - v}{v} po$

The field of deformations is given by:

$$\varepsilon = \varepsilon_{xx} = \varepsilon_{yy} = -vp\left(By + Cx + D\right) \quad \varepsilon_{xy} = 0$$

The stress field is given by:

$$\sigma = \sigma_{xx} = \sigma_{yy} = \frac{E}{1 - v}\varepsilon = -\frac{1000}{800 - T}\frac{vp}{1 - v}\left(0.004x + 0.003y + 0.76\right) = -\frac{v}{1 - v}p = -po$$

2.2 Results of reference

Temperature at the points $O, A, B, C, D, B1, C1$
Displacements at the points $A, B, C, D, B1, C1$

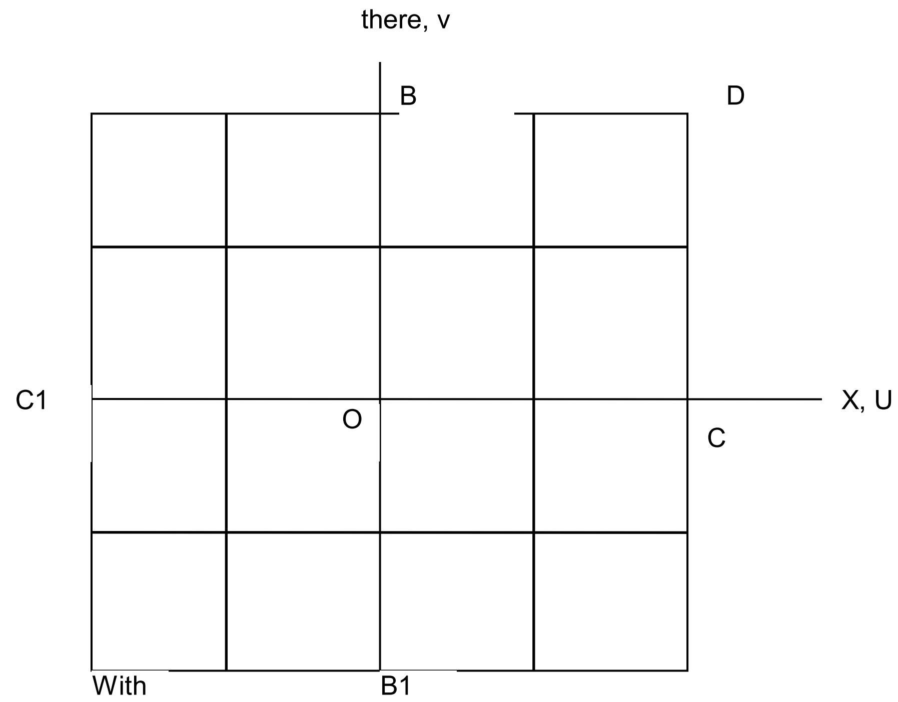
2.3 Uncertainty on the solution

Analytical solution.

3 Modeling A

3.1 Characteristics of modeling

It is about a modeling in plane constraints.



Cutting: 4×4 elements

Limiting conditions:

1) in O, $u=v=0$
2) in B, $u=0$

3.2 Characteristics of the grid

Many nodes: 65

Number of meshs and type: 16 `QUAD8`

Name of the nodes

$O=N38$ $A=N1$ $B=N23$ $C=N16$ $D=N3$ $B1=N9$ $C1=N30$

3.3 Sizes tested and results

Localization	Type of value	Reference
Not A	T	75.
Not B	T	25.
Not C	T	20.
Not D	T	5.
Not $B1$	T	55.
Not $C1$	T	60.
Not O	T	40.
Not A	u	2.68975
	v	2.55
Not B	u	0.
	v	-2.65125
Not C	u	-2,695
Not D	u	-2.7002
	v	-2,695
Not $B1$	u	0.0700
	v	2.59875
Not $C1$	u	2,625

3.4 Remarks

It is necessary to discretize the function finely $E(t)$ to get satisfactory results. One took for this test 160 points of discretization, for the interval of temperatures [5. , 75.].

4 Summary of the results

Results got with *Code_Aster* are in concord with the analytical solution.