HPLV100 - Parallelepiped whose Young modulus is function of the temperature

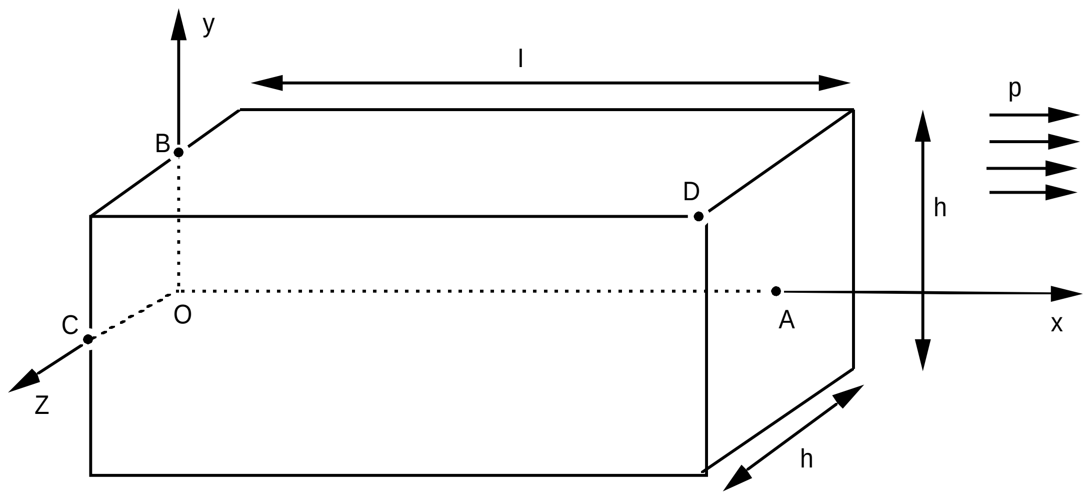
Summarized

This thermoelastic computation compares the solution provided by *Code_Aster* with an analytical solution when the Young modulus varies in a nonlinear way compared to the temperature.

The modelization nothing physics has and is described in [V7.90.01].

1 Problem of reference

1.1 Geometry



l = 20. h = 10. O = (0. 0. 0.) A = (20. 0. 0.) D = (20. 5. 5.)

1.2 Material properties

thermal Conductivity: $\lambda=1.$

Young modulus: $E=\frac{1000.}{800.-T}$ (T being the temperature)

Poisson's ratio: $\nu=0.3$

1.3 Boundary conditions and loadings

- Mechanical

$$T(A)=0.,\quad \lambda\frac{\partial T}{\partial n} \begin{aligned}&= -2. \text{ pour } x = l\\ &= +2. \text{ pour } x = 0\\ &= -3. \text{ pour } y = h/2.\\ &= +3. \text{ pour } y = -h/2.\\ &= -4 \text{ pour } z = h/2.\\ &= +4. \text{ pour } z = -h/2.\end{aligned}$$

n étant la normale sortante.

- Thermal:

$$u_x(O) = u_y(O) = u_z(O) = 0.$$
$$u_x(B) = u_x(C) = u_z(B) = 0.$$

- Pressure:

$$p=1.$$

2 Reference solution

2.1 Method of calculating used for the reference solution

$T=-2x-3y-4z+40$

On a donc : $E=\frac{1000}{2x+3y+4z+760}\,E_{\min}=1.38 \quad E_{\max}=120$

$$u_x(x,y,z)=p\left\{\frac{A}{2}\left[x^2+\nu\left(y^2+z^2\right)\right]+B\;xy+C\,xz+Dx-\nu\frac{Ah}{4}(y+z)\right\}$$

$$u_y(x,y,z)=-\nu\,p\left\{A\;xy+\frac{B}{2}\left[y^2-z^2+\frac{x^2}{\nu}\right]+C\,yz+Dy-\frac{Ah}{4}x-\frac{Ch}{4}z\right\}$$

$$u_z(x,y,z)=-\nu\,p\left\{A\;xz+B\;yz+\frac{C}{2}\left[z^2-y^2+\frac{x^2}{\nu}\right]+Dz+\frac{Ch}{4}y-\frac{Ah}{4}x\right\}$$

Avec : $A=0.002,\quad B=0.003,\quad C=0.004,\quad D=0.76$

2.2 Result of reference

Temperature to the point O and the point D.

Displacement of the point A.

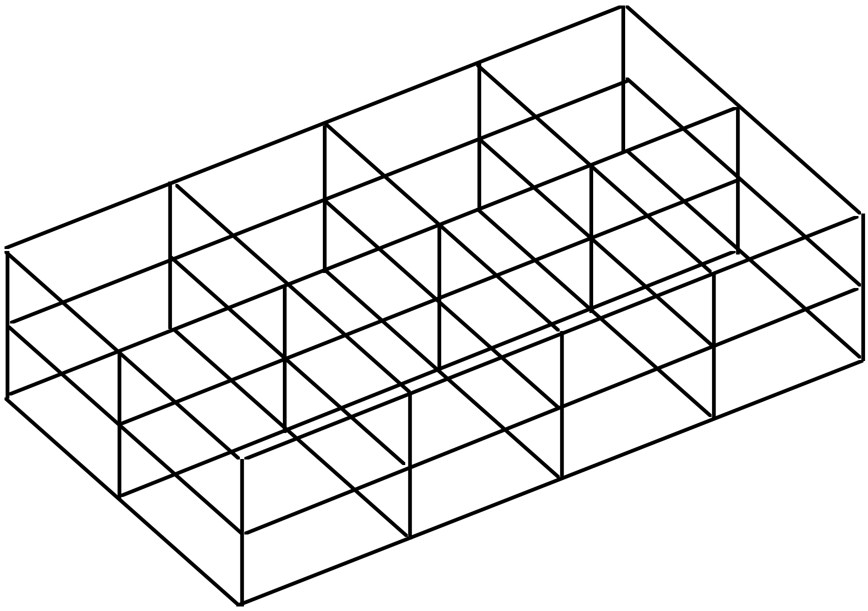
2.3 Bibliographical reference

1) S. ANDRIEUX “an analytical solution to a problem of linear elasticity 3D isotropic with Young modulus function of the variables of space [V4.90.01].

3 Modelization A

3.1 Characteristic of the modelization

3D



3.2 Characteristic of the mesh

Many nodes: 141
Number of meshes and types: 16 HEXA20

3.3 Remarks

It is necessary to envisage a large number of points of discretization of the curve $E(T)$ to obtain the desired accuracy. Here 250 points were taken (E_i, T_i).

3.4 Values tested

Identification		Reference
0	T	+40.
D	T	– 35.
A	u_x	+15.6
	u_y	– 0.57
	u_z	– 0.77
D	u_x	+16.3
	u_y	– 1.785
	u_z	– 2.0075

4 Summary of the results

This problem requires a very fine discretization of the function $E(T)$ to obtain the reference solution.