# HPLV100 - Parallelepiped of which the Young modulus is function of the temperature

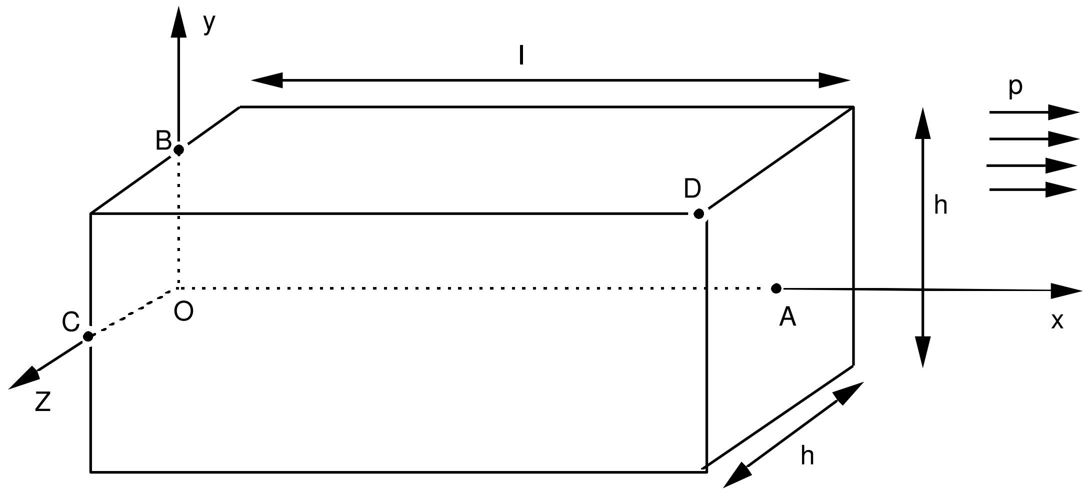
**Summary**

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

Modeling does not have anything physics 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: $E=\dfrac{1000.}{800.-T}$ ( $T$ being the temperature)

Poisson's ratio: $\nu=0.3$

## 1.3 Boundary conditions and loadings

- Thermics

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

$n$ étant la normale sortante.

- Mechanics:

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

- Pressure:

$p=1.$

# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

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

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

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

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

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

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

## 2.2 Result of reference

Temperature at the point $O$ and at the point $D$ .

Displacement of the point $A$ .

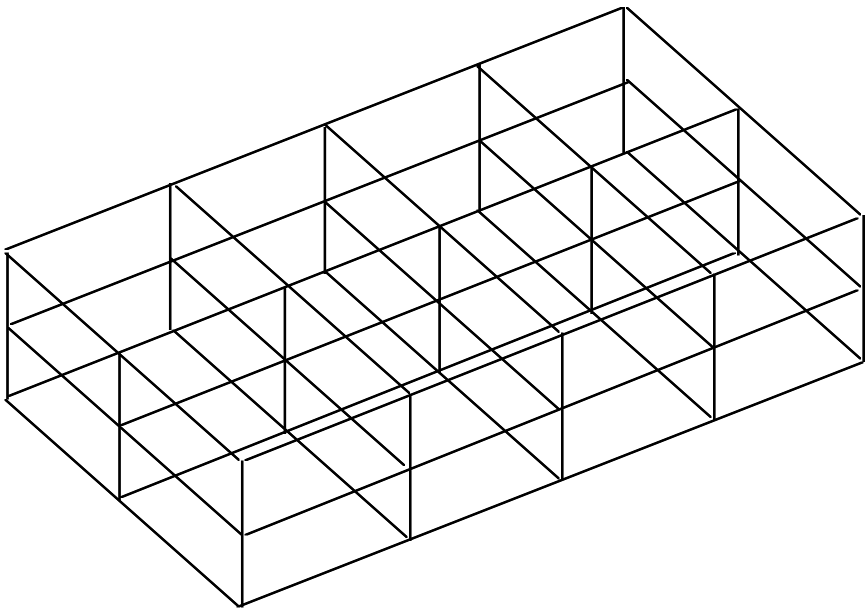
## 2.3 Bibliographical reference

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

# 3 Modeling A

## 3.1 Characteristics of modeling

3D



## 3.2 Characteristics of the grid

Many nodes: 141

Many meshs 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 precision. 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.