TPLL100 - Anisotropic plane wall in steady thermal

Summarized:

The purpose of this test which relates to the steady and transitory linear thermal is validating the Cartesian anisotropy.

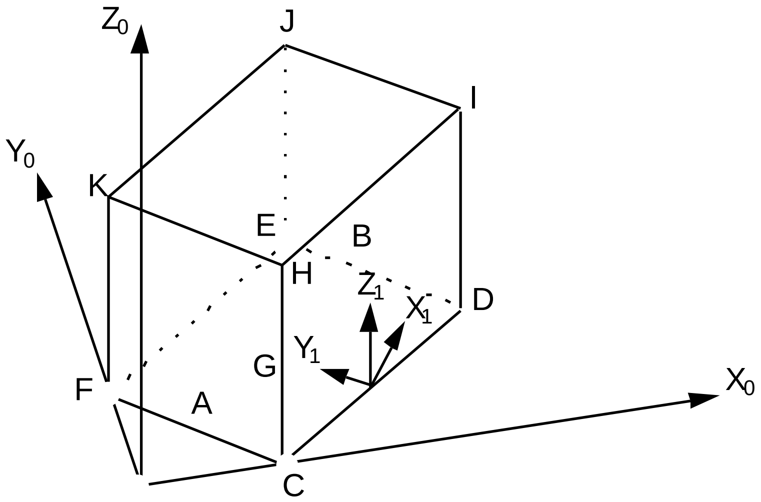
Two modelizations are carried out:

- a first into voluminal,
- a second out of plane.

The got results are in perfect agreement with the analytical values.

1 Problem of reference

1.1 Geometry



In the reference $(X_{0,} Y_{0,} Z_0)$, the points have as coordinates:

$C(0.03 ; 0 \; ; 0)$ $D(0.07 ; 0.03 ; 0)$ $E(0.04 ; 0.07 ; 0)$
$F(0 \; ; 0.04 ; 0)$ $A(0.015 ; 0.02 ; 0)$ $B(0.055 ; 0.05 ; 0)$
$G(0.035 ; 0.035 ; 0)$

$$FK = CH = DI = EJ = 0.05 . Z_0$$

$$(CD , X_1) = \frac{\pi}{4} rad \; Z_0 // Z_1$$

1.2 Material properties

anisotropic Material, direction privileged along the axes of the reference $(X_{1,} Y_{1,} Z_1)$:

$$\lambda_X = 1 \; W/m°C \quad \lambda_Y = 0.5 \; W/m°C \quad \lambda_L = 2 \; W/m°C$$
$$\rho C_P = 2 \; J/m^3 °C$$

1.3 Boundary conditions and loadings

face $FEJK$: Outgoing flux of $400 \; W/m^2$.

face $CDIH$: Flux entering of $400 \; W/m^2$.

face $EDIJ$: Outgoing flux of $1200 \; W/m2$.

face $FCHK$: Imposed temperature $100 °C$.

Other sides: condition of Neumann.

1.4 Initial conditions

to do this steady calculation, one does a transient computation for which the boundary conditions are constant in time. This makes it possible to test elementary computations of mass and stiffness intervening in the first member as well as the second member.

2 Reference solution

2.1 Method of calculating used for the analytical reference solution

Solution.
Temperature varying linearly according to CD

Isotherms parallel with the sides $CHKF$ and $DIJE$.

In the reference: $\left(\frac{CD}{\|CD\|},\frac{CH}{\|CH\|},\frac{CF}{\|CF\|},\right)$, one a:

$$\begin{bmatrix}\varphi_x\\ \varphi_y\\ \varphi_z\end{bmatrix}=\begin{bmatrix}-(\lambda_X\cos^2\alpha+\lambda_Y\sin^2\alpha)\frac{\partial T}{\partial x}\\ -(\lambda_X-\lambda_Y)\cos\alpha\sin\alpha\frac{\partial T}{\partial x}\\ 0\end{bmatrix}$$

with:

$$\varphi_x=1200 \quad \varphi_y=400 \quad \alpha=(X_{1,}CD) \quad T(x)=\frac{-\varphi_x}{\lambda_{X_1}\cos^2\alpha+\lambda_Y\sin^2\alpha}x+T(A)$$

that is to say: $T(x)=-1600.\mathrm{x}+20.$

If $\beta=(CD,X_0)$: $\begin{array}{ll}\varphi.X_0=\cos\beta.\varphi_X-\sin\beta\,\varphi_y & \text{soit } 720\\ \varphi.Y_0=\sin\beta.\varphi_X+\cos\beta\,\varphi_L & \text{soit } 720\end{array}$

2.2 Results of reference

Temperature to the points A, B, G.

Flux following the directions X_0 and Y_0.

$T(A)=100 \quad T(B)=20 \quad T(G)=60 \quad \Phi.X_0=720 \quad \Phi.Y_0=1040$

2.3 Bibliographical references

1) N. RICHARD: Note technical HM-18/94/0011, “Development of the thermal anisotropy in the software *Aster*”.

3 Modelization A

3.1 Characteristic of the modelization

θ of the time scheme, forced on 1 to test the computation of the second member.
4 elements 3D, HEXA8.

3.2 Characteristics of the mesh

4 Hexa 8.

3.3 Values tested

Identification	Reference
$T(A)$ $N7$ *	100°
$T(B)$ $N2$	20°C
$T(G)$ $N13$	60°C
$\varphi.X_0$	720
$\varphi.Y_0$	1040

*: imposed temperature

3.4 Remarks

the analytical solution being of order 1 and the field represented by the discretization, the code finds, with the errors rounding close, this solution.

4 Modelization B

4.1 Characteristic of the modelization

Similar to the modelization A, but solved in 2D in the plane $CDEF$.

4.2 Characteristics of the mesh

4 QUAD4.

4.3 Values tested

Identification	Reference
$T(A)$ $N5$ *	100°
$T(B)$ $N2$	20°C
$T(G)$ $N8$	60°C
$\varphi.X_0$	720
$\varphi.Y_0$	1040

*: imposed temperature

4.4 Remarks

the analytical solution being of order 1 and the field represented by the discretization, the code finds, with the errors rounding close, this solution.

5 Summary of the results

key word ANGL_REP introduces into the command AFFE_CARA_ELEM is thus tested in 3D and 2D plane on an anisotropic problem of thermal.