

TPLP02 - Orthotropic square

Summary:

This test is resulting from the validation independent of version 3 in linear stationary thermics.

It is about a problem 2D plan represented by only one modeling (plane).

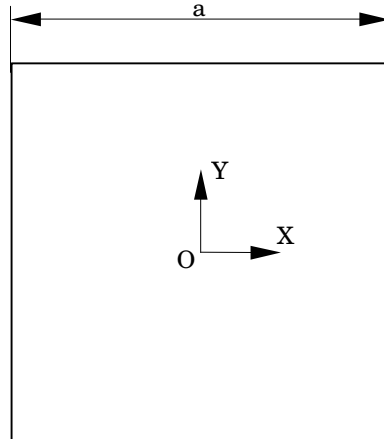
The features tested are the use of thermal elements plans, of an orthotropic material, three types of limiting conditions:

- convection
- linear variation of the outside temperatures,
- imposed flow.

The results are compared with an analytical solution (VPCS).

1 Problem of reference

1.1 Geometry



Cube d'arête $a = 0.2$ m
Centre du cube = $(0.,0.)$

1.2 Properties of material

$\lambda_x = 1.0 \text{ W/m.}^\circ\text{C}$ thermal conductivity along the axis x
 $\lambda_y = 0.75 \text{ W/m.}^\circ\text{C}$ thermal conductivity along the axis y

1.3 Boundary conditions and loadings

- density flux:
 - $\varphi_y = 60 \text{ W/m}^2$ face $y = -0.1$ (entering flow)
 - $\varphi_y = -60 \text{ W/m}^2$ face $y = 0.1$ (outgoing flow)
- convection on the faces $x = -0.1$ and $x = 0.1$: $h = 15 \text{ W/m}^2\text{ }^\circ\text{C}$,
- linear variation of the outside temperatures:
 - $T_{ext} = 30 - 80y$ face $x = -0.1$,
 - $T_{ext} = 15 - 80y$ face $x = 0.1$.

1.4 Initial conditions

Without object.

2 Reference solution

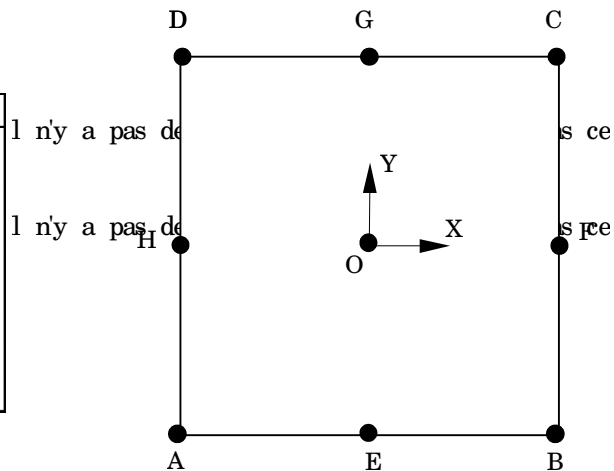
2.1 Method of calculating used for the reference solution

The reference solution is that given in card TPLP02/89 of guide VPCS

Analytical solution.

$$T(x, y, z) = ax + by + d = -45x - 80y + 22.5$$

Point	T(°C)
O	22.5
A	35.0
B	26.0
C	10.0
D	19.0
E	30.5
F	18.0
G	14.5
H	27.0



$$\begin{aligned}\phi_x &= 45 \text{ W/m}^2 = \text{constante} \\ \phi_y &= 60 \text{ W/m}^2 = \text{constante}\end{aligned}$$

2.2 Results of reference

Temperature at the points located on the figure above.

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

- Guide of validation of the software packages of structural analysis. French company of the Mechanics, AFNOR 1990 ISBN 2-12-486611-7

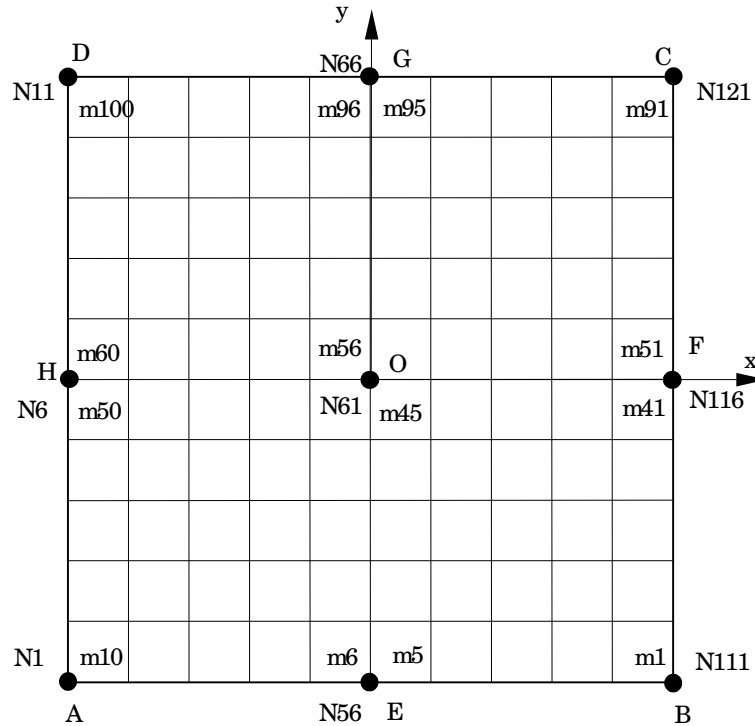
3 Modeling A

3.1 Characteristics of modeling

PLAN (QUAD4)

Conditions limites:

- coté AB $\phi_y = 60 \text{ W/m}^2$
- coté CD $\phi_y = -60 \text{ W/m}^2$
- coté BC $h = 15 \text{ W/m}^2 \text{ }^\circ\text{C}$
 $T_{\text{ext}} = 15-80y$
- coté AD $h = 15 \text{ W/m}^2 \text{ }^\circ\text{C}$
 $T_{\text{ext}} = 30-80y$



3.2 Characteristics of the grid

Many nodes: 121
Many meshes and types: 100 QUAD4

3.3 Values tested

Identification	Reference
Temperature	$^\circ\text{C}$
T (O)	22.5
T (A)	35.0
T (B)	26.0
T (C)	10.0
T (D)	19.0
T (E)	30.5
T (F)	18.0
T (G)	14.5
T (H)	27.0
Flow	W/m^2
$\phi_x(A)$	45.0
$\phi_x(H)$	45.0
$\phi_x(D)$	45.0

Code_Aster

Version
default

Titre : TPLP02 - Carré orthotrope
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$\phi_x(B)$	45.0
$\phi_x(F)$	45.0
$\phi_x(C)$	45.0
$\phi_y(A)$	60.0
$\phi_y(E)$	60.0
$\phi_y(B)$	60.0
$\phi_y(D)$	60.0
$\phi_y(G)$	60.0
$\phi_y(C)$	60.0

4 Summary of the results

The got results are excellent. The computed values by Aster are identical to the values of reference. That is “a normally expected” result since the field solution which is linear belongs to the space of interpolation of the element tested.

This test made it possible to test the following orders:

- `DEFI_FONCTION` associated with the operand `NOM_PARA`, allowing to define a variation in the external temperature according to the X-coordinate or the ordinate,
- `DEFI_MATERIAU` associated with the keyword `THER_ORTH`, allowing to define the characteristics of an orthotropic material,
- `AFFE_CARA_ELEM` associated with the keyword `SOLID MASS`, allowing to define the axes of orthotropism.