TPLP02 - Orthotropic square

Abstract:

This test is resulting from the validation independent of version 3 in linear steady thermal.

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

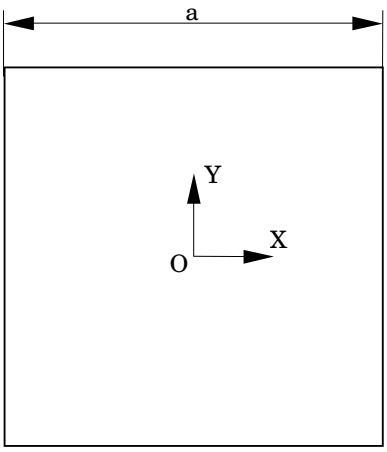
The features tested are the use of plane thermal elements, of an orthotropic material, three types of limiting conditions:

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

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 the thermal

$\lambda_x = 1.0\, W/m.°C$ material conductivity along the thermal x
$\lambda_y = 0.75\, W/m.°C$ axis conductivity along the axis y

1.3 Boundary conditions and loadings

- density flux:

  $\varphi_y = 60\, W/m^2$ face $y = -0.1$ (entering flux)
  $\varphi_y = -60\, W/m^2$ face $y = 0.1$ (outgoing flux)

- convection on the sides $x = -0.1$ and $x = 0.1$: $h = 15\, W/m^2°C$,

- 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

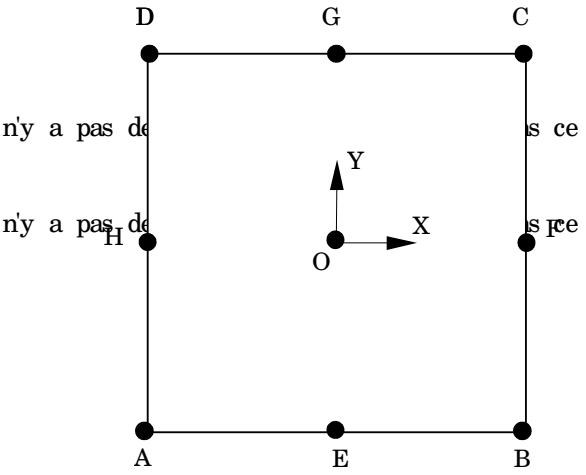
2.1 Method of calculating used for the reference solution

the reference solution is that given in file TPLP02/89 of analytical guide

VPCS 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



$\varphi_x = 45\ W/m^2$ = constante
$\varphi_y = 60\ W/m^2$ = constante

2.2 Results of reference

Temperature to the points located on the figure above.

2.3 Uncertainty on the solution

analytical Solution.

2.4 Bibliographical references

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

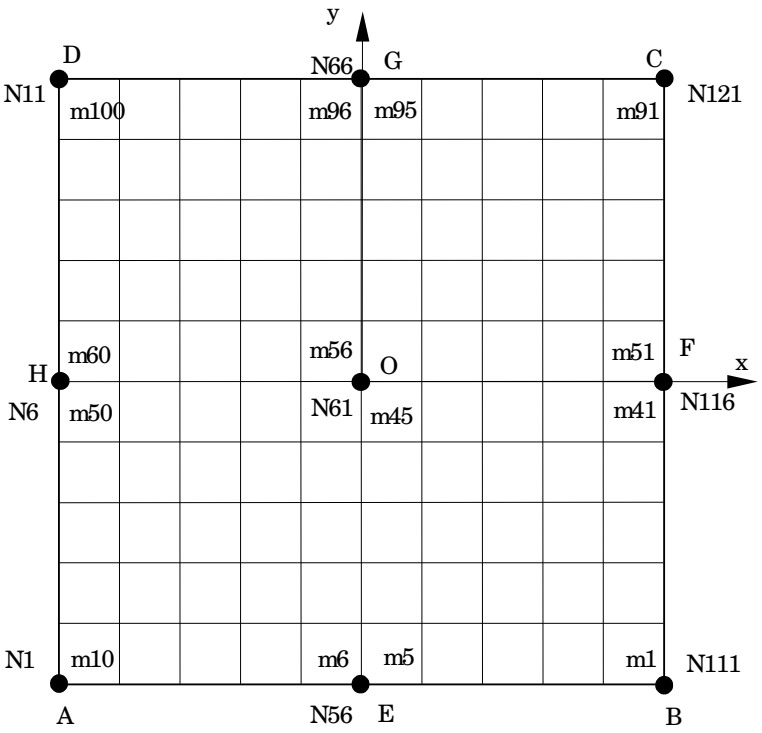
3 Modelization A

3.1 Characteristic of the modelization

PLANE (QUAD4)

Conditions limites:

- coté AB φ_y = 60 W/m²
- coté CD φ_y = -60 W/m²
- coté BC h = 15 W/m² °C
  T_{ext} = 15-80y
- coté AD h = 15 W/m² °C
  T_{ext} = 30-80y



3.2 Characteristic of the mesh

Many nodes:	121
Number of meshes and types:	100 QUAD4

3.3 Values tested

Identification	Reference
Temperature	$°C$
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
Flux	W/m^2
$\phi_x(A)$	45.0
$\phi_x(H)$	45.0
$\phi_x(D)$	45.0

$\phi_x(B)$	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 one “normally is result expected” 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 commands:

- DEFI_FONCTION associated with operand NOM_PARA, allowing to define a variation in the external temperature according to the X-coordinate or the Y-coordinate,
- DEFI_MATERIAU associated with key word THER_ORTH, allowing to define the characteristics of an orthotropic material,
- AFFE_CARA_ELEM associated with key word MASSIF, allowing to define the axes of orthotropy.