TTLP101 - Plate fissured with temperatures imposed with condition of exchange through the lips of crack

Summarized

This test brings into play a square plate with an emerging right crack, subjected to a variation in temperature. A heat exchange takes place between the lips of crack (factor key word ECHANGE_PAROI of operators AFFE_CHAR_THER and AFFE_CHAR_THER_F [U4.44.02]).

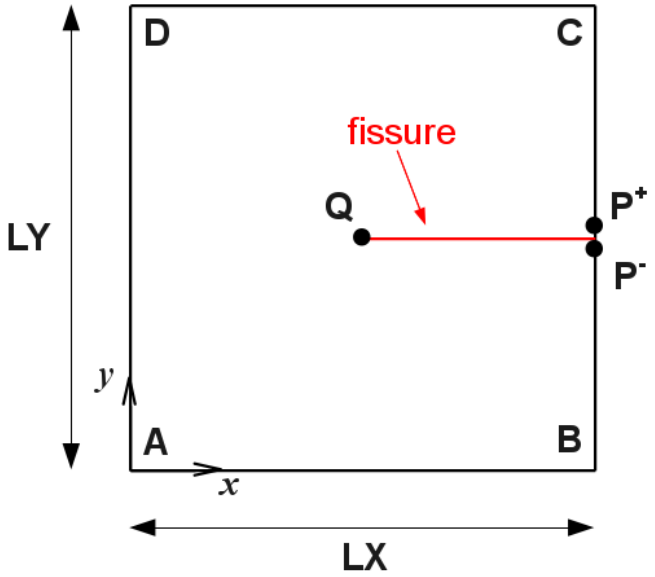
Three modelizations are considered:

- modelization A : $\mathrm{FEM\,2D}$ (crack with a grid)
- modelization B : $\mathrm{X\text{-}FEM\,2D}$, crack in the middle of the elements
- modelization C : $\mathrm{X\text{-}FEM\,3D}$, crack in the middle of the elements

1 Problem of reference

1.1 Geometry

the structure $2d$ is a unit square ($LX=1\,m$, $LY=1\,m$), comprising an on the right emerging right crack, located at middle height. (Figure 1.1-a). One calls line left line in $x=0$, line the line line in $x=LX$ and line lower line in $y=0$.



Appear 1.1-a: Geometry of the fissured square plate

One notes P^+ it not coordinates $\left(LX\,,LY^+/2\right)$ (located on the upper lip), P^- to it not coordinates $\left(LX\,,LY^-/2\right)$ (located on the lower lip), and Q the point of coordinates $\left(LX/2,LY/2\right)$ (located at a peak of crack).

1.2 Properties of the thermal

material Conductivity: $\lambda=1\,W.m^{-1}.K^{-1}$
Voluminal heat capacity: $\rho C_p=2\,J.m-3.\mathrm{K}^{-1}$
Coefficient of heat exchange between the lips of the fissureformule $h=2\,W.m^{-2}.K^{-1}$

1.3 Boundary conditions and loadings

One solves the problem on the time interval $\left[0.s\,,1.s\right]$ discretized in 5 time step equal (of period $\Delta t=0.2\,s$). One takes the value by default in THER_LINEAIRE of the parameter of the theta-diagram: $\theta=0.57$.

On the nodes of the segment AB (see Figure 1.1-a), one imposes the slope of following temperature:

with $t=0.s$, $\bar{T}^{AB}=10°C$; with $t=1.s$, $\bar{T}^{AB}=20°C$

On the nodes of the segment CD (see Figure 1.1-a), one imposes the slope of following temperature:

with $t=0.s$, $T^{CD}=20°C$; with $t=1.s$, $T^{CD}=40°C$

Lastly, on the lips of crack, one imposes a condition of Neumann of type condition of exchange.

1.4 Initial conditions

the initial state is given by solving the steady problem with $t=0.s$ (with the boundary conditions given to paragraph 2)

2 Reference solution

2.1 Méthode de calcul

the reference solution is obtained by refining the mesh of the modelization A (elements classic with crack with a grid): regular mesh composed of 500×500 QUAD4 (instead of 100×100 QUAD4 for the mesh A)

2.2 Quantities and results of reference

One time step tests the temperature at the end of the last ($t=1.s$) at the points P^+, P^- and Q (see Figure 1.1-a).

Standard	identification of reference	Value of reference
Not P^+ - $TEMP$	"AUTRE_ASTER"	29,156091860463 °C
Not P^- - $TEMP$	"AUTRE_ASTER"	23,393394671258 °C
Not Q - $TEMP$	"AUTRE_ASTER"	26,25259365185 °C

3 Modelization A

In this modelization, one considers structure in $2D$. The classical finite element method is used. The crack being with a grid, the condition of exchange between the lips of crack is applied using key word GROUP_MA1/GROUP_MA2 of factor key word the ECHANGE_PAROI of operators AFFE_CHAR_THER and AFFE_CHAR_THER [U4.44.02]. This modelization is used as reference for the continuation.

3.1 Characteristics of the modelization

One uses the modelization PLANE of the THERMAL phenomenon.

3.2 Characteristics of the mesh

the structure is modelled by a regular mesh composed of 100×100 QUAD8, respectively along the axes x and y. The crack is with a grid.

3.3 Quantities tested and results

One time step tests the temperature at the end of the last ($t=1.s$) at the points P^+ , P^- and Q (see Figure 1.1-a).

Standard	identification of reference	Value of reference	Tolerance
Not P^+ - $TEMP$	"AUTRE_ASTER"	29,156091860463	0.1%
Point P^- - $TEMP$	"AUTRE_ASTER"	23,393394671258	0.1%
Point Q - $TEMP$	"AUTRE_ASTER"	26,25259365185	0.5%

4 Modelization b: fissures NON-with a grid in dimension 2

In this modelization, one considers structure in $2D$. The wide finite element method (X-FEM) is used. The crack not being with a grid, the condition of exchange between the lips of crack is applied using the key word FISSURES factor key word ECHANGE_PAROI of operator AFFE_CHAR_THER [U4.44.02].

4.1 Characteristics of the modelization

One uses the modelization PLANE of the THERMAL phenomenon.

4.2 Characteristics of the mesh

the structure is modelled by a regular mesh composed of 101×101 QUAD4, respectively along the axes x y . The crack is not with a grid.

4.3 Quantities tested and results

One time step tests the temperature at the end of the last ($t=1.s$) at the points P^+ , P^- and Q (see Figure 1.1-a). For that one tests the field of temperature after call to operators POST_MAIL_XFEM and POST_CHAM_XFEM.

Standard	identification of reference	Value of reference	Tolerance
Not P^+ - $TEMP$	"AUTRE_ASTER"	29,156091860463	0.1%
Point P^- - $TEMP$	"AUTRE_ASTER"	23,393394671258	0.1%
Point Q - $TEMP$	"AUTRE_ASTER"	26,25259365185	0.5%

5 Modelization C: crack NON-with a grid in 3D

In this modelization, one considers structure in $3D$. The wide finite element method (X-FEM) is used. The crack not being with a grid, the condition of exchange between the lips of crack is applied using the key word FISSURES factor key word ECHANGE_PAROI of operator AFFE_CHAR_THER_F [U4.44.02].

5.1 Characteristics of the modelization

One uses the modelization 3D THERMAL phenomenon.

5.2 Characteristics of the mesh

the structure is modelled by a regular mesh composed of $11 \times 11 \times 1$ HEXA8, respectively along the axes x, y and z. The crack is not with a grid.

5.3 Quantities tested and results

One time step tests the temperature at the end of the last ($t = 1.s$) at the points P^+, P^- and Q (see Figure 1.1-a). For that one tests the field of temperature after call to operators POST_MAIL_XFEM and POST_CHAM_XFEM.

Standard	identification of reference	Value of reference	Tolerance
Not P^+ - $TEMP$	"AUTRE_ASTER"	29,156091860463	0.1%
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6 Summaries of the results

the purpose of this test is reached: to validate on a simple case the condition of heat exchange enters the lips of a crack taken into account with the method X-FEM .