TTLP101 - Fissured plate at temperatures imposed with condition of exchange through the lips of the crack

Summary

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 the crack (keyword factor ECHANGE_PAROI operators AFFE_CHAR_THER and AFFE_CHAR_THER_F [U4.44.02]).

Three modelings are considered:

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

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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 the line of left the line in $x=0$, the line of right-hand side the line in $x=LX$ and the line the lower line in $y=0$.

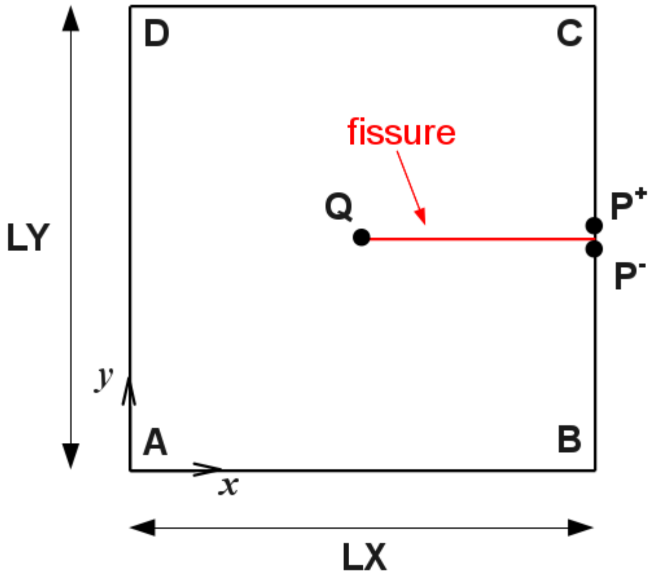

Figure 1.1-a: Geometry of the fissured square plate

One notes P^{+} the point of coordinates $(LX\,, LY^{+}/2)$ (located on the upper lip), P^{-} the point of coordinates $(LX\,, LY^{-}/2)$ (located on the lower lip), and Q the point of coordinates $(LX/2, LY/2)$ (located at a peak of crack).

1.2 Properties of material

Thermal conductivity: $\lambda=1\,W.m^{-1}.K^{-1}$
Voluminal heat-storage capacity: $\rho\,C_p=2\,J.m{-}3.\mathrm{K}^{-1}$
Coefficient of exchange enters the lips of the crack $h=2\,W.m^{-2}.K^{-1}$

1.3 Boundary conditions and loadings

One solves the problem on the time interval $[0.s\,,1.s]$ discretized in 5 pas de equal times (of duration $\Delta t=0.2\,s$). One takes the value by default in THER_LINEAIRE 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:

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

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

1.4 Initial conditions

The initial state is given by solving the stationary problem with $t=0.s$ (with the boundary conditions given to the paragraph 1.3)

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2 Reference solution

2.1 Method of calculating

The reference solution is obtained by refining the network of modeling A (elements classical with crack with a grid): regular grid composed of 500×500 QUAD4 (instead of 100×100 QUAD4 for the grid A)

2.2 Sizes and results of reference

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

Identification	Type 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

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3 Modeling A

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

3.1 Characteristics of modeling

Modeling is used PLAN phenomenon THERMICS.

3.2 Characteristics of the grid

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

3.3 Sizes tested and results

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

Identification	Type of reference	Value of reference	Tolerance
Not P^+ - $TEMP$	'AUTRE_ASTER'	29.156091860463	0.1%
Not P^- - $TEMP$	'AUTRE_ASTER'	23.393394671258	0.1%
Not Q - $TEMP$	'AUTRE_ASTER'	26.25259365185	0.5%

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4 Modeling b: fissures not-with a grid in dimension 2

In this modeling, one considers the 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 the crack is applied using the keyword CRACK keyword factor ECHANGE_PAROI of the operator AFFE_CHAR_THER [U4.44.02].

4.1 Characteristics of modeling

Modeling is used PLAN phenomenon THERMICS.

4.2 Characteristics of the grid

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

4.3 Sizes tested and results

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

Identification	Type of reference	Value of reference	Tolerance
Not P^+ - $TEMP$	'AUTRE_ASTER'	29.156091860463	0.1%
Not P^- - $TEMP$	'AUTRE_ASTER'	23.393394671258	0.1%
Not Q - $TEMP$	'AUTRE_ASTER'	26.25259365185	0.5%

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5 Modeling C: crack not-with a grid in 3D

In this modeling, one considers the structure in $3D$. Wide finite element method ($X\text{-}FEM$) is used. The crack not being with a grid, the condition of exchange between the lips of the crack is applied using the keyword CRACK keyword factor ECHANGE_PAROI of the operator AFFE_CHAR_THER_F [U4.44.02].

5.1 Characteristics of modeling

Modeling is used 3D phenomenon THERMICS.

5.2 Characteristics of the grid

The structure is modelled by a regular grid composed of $11\times11\times1$ HEXA8, respectively along the axes x , y and z . The crack is not with a grid.

5.3 Sizes tested and results

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

Identification	Type of reference	Value of reference	Tolerance
Not P^+ - $TEMP$	'AUTRE_ASTER'	29.156091860463	0.1%
Not P^- - $TEMP$	'AUTRE_ASTER'	23.393394671258	0.1%
Not Q - $TEMP$	'AUTRE_ASTER'	26.25259365185	0.5%

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6 Summaries of the results

The goal of this test is achieved: to validate on a simple case the condition of heat exchange enters the lips of a crack taken into account with the method $\mathrm{X\text{-}FEM}$.

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