2D

SSLP318 - Propagation of a crack X-FEM not emerging requested in mode I

Summary:

The goal of this test is to check that the operator PROPA_FISS draft correctly cases of multi-cracking.
It is about a plate $2D$ containing only one fissures made up of two funds of crack. Several propagations are calculated by the operator PROPA_FISS. It is checked that the factors of intensity of the constraints of the propagated crack are correct for a propagation in mode I .

1 Problem of reference

1.1 Geometry

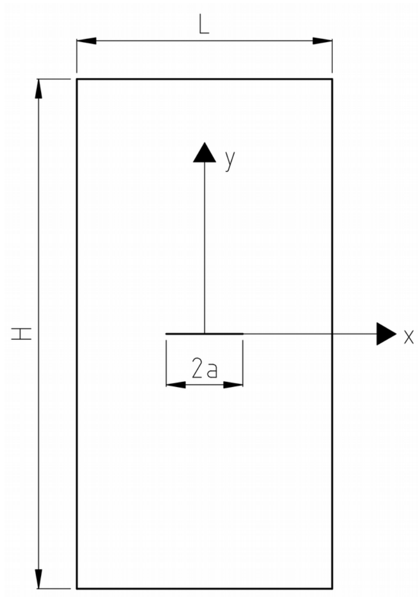

Figure 1.1-a: geometry of the fissured plate

Geometrical dimensions of the fissured plate:

width $L=1000\,mm$
height $H=2000\,mm$

Initial length of the crack: $2a_0=300\,mm$.
The crack is positioned in the middle of the height of the plate ($H/2$).

1.2 Properties of material

Young modulus $E=206000\,MPa$
Poisson's ratio $\nu=0.33$

1.3 Boundary conditions and loadings

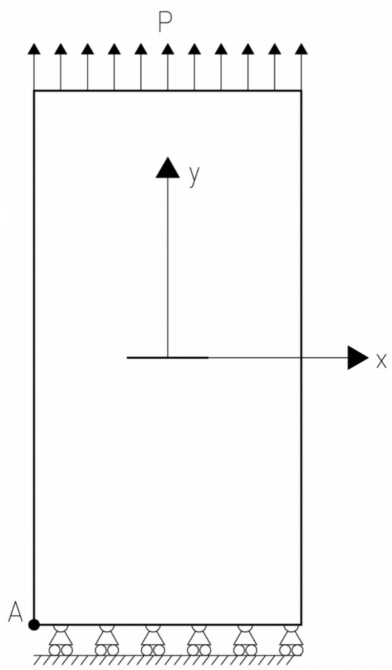

Figure 1.3-a: boundary conditions and loadings

Boundary conditions:

Not A : $\Delta X=\Delta Y=0$

Points of the lower end of the plate: $\Delta Y=0$

Loading:

Pressure applied at the higher end of the plate: $P=1\,MPa$

Three propagations are calculated by imposing an advance of the crack equalizes with $30\,mm$ on the level of each fund of crack. As a consequence of the symmetry of the geometry, boundary conditions and loading, the advances of the two funds of the crack are always equal in advance imposed.

2 Reference solution

2.1 Method of calculating

Three propagations of the crack are calculated. The two funds of the crack always advance same distance and their factors of intensity of the constraints are always equal between them.
One can calculate the factors of intensity of the constraints by using the following equations [bib1]:

$$K_I = -P \cdot \sqrt{\pi \cdot a \cdot \left(\cos\left(\frac{\pi a}{L}\right)\right)^{-1}}$$

$$K_{II} = 0$$

2.2 Sizes and results of reference

For the three propagations calculated in the tests, the half-length of the crack is the following one:

Propagation	has [mm]
1	180.0
2	210.0
3	240.0

Table 2.1

The value of K_I waited is thus the following one for each propagated bottom:

Propagation	K_I [$Pa\sqrt{mm}$]
1	2.2997E+07
2	2.5878E+07
3	2.8894E+07

Table 2.2

The value of K_{II} waited is always equal to zero.

2.3 Bibliography

[1] D.Broek, “Elementary engineering fractures mechanics”, Martinus Nijhoff Publishers, The La Hague, The Netherlands, 1982

3 Modeling A

3.1 Characteristics of modeling

Method UPWIND is used by PROPA_FISS to solve the equations of propagation of the crack.
No auxiliary grid is not used. That is possible because the grid of the structure is very regular.

3.2 Characteristics of the grid

The structure is modelled by a grid made up of 1440 elements QUAD4 (see Figure 3.2-a).

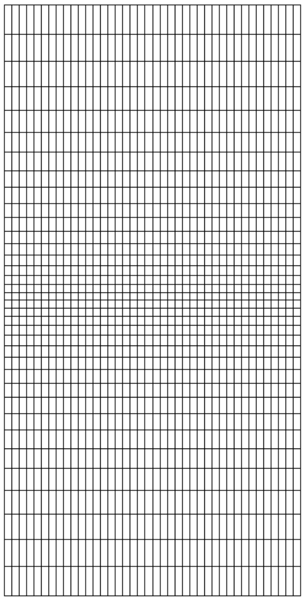

Figure 3.2-a: grid of the structure

The grid is very coarse to reduce the computing time. It is refined more in the zone of propagation of the crack. In this zone the dimension of the elements is of $25 \times 25\,mm$. The largest element used has a dimension equalizes with $25 \times 100\,mm$.

3.3 Sizes tested and results

One tests the values of K_I and K_{II} for the two funds of the crack after each propagation. To check if these values are correct, one uses a relative tolerance equal to 5% for the values of K_I. On the other hand, to check if the value of K_{II} is worthless, one uses an absolute tolerance (threshold value) related to the value of K_I : it is considered that K_{II} is worthless if its value is lower than 1% of the value of K_I. Indeed, in this case one can neglect the value of K_{II}.
One tests the maximum value of K_I and K_{II} between the two funds of the crack.

Propagation	K_I reference [$Pa\sqrt{mm}$]	Tolerance [%]
1	2.2997E+07	5.0
2	2.5878E+07	5.0
3	2.8894E+07	5.0

Propagation	Max K_{II} [$Pa\sqrt{mm}$]	K_I reference [$Pa\sqrt{mm}$]	K_{II} threshold [$Pa\sqrt{mm}$]
1	7.4881E+03	2.2997E+07	2.2997E+05
2	4.0283E+03	2.5878E+07	2.5878E+05
3	2.0639E+04	2.8894E+07	2.8894E+05

3.4 Remarks

All the values tested are in the tolerances used. That means that the method UPWIND calculate correctly at the same time the position of the two funds of the crack and the level sets.
The error obtained on the values of K_I is almost worthless and the values of K_{II} are always about 0.1% of the values of K_I . The got results are thus very satisfactory.

4 Modeling B

4.1 Characteristics of modeling

Method SIMPLEX is used by PROPA_FISS to solve the equations of propagation of the crack. **No auxiliary grid** is not used.

4.2 Characteristics of the grid

One uses the same grid as that of modeling A.

4.3 Sizes tested and results

One tests the values of K_I and K_{II} for the two funds of the crack after each propagation. To check if these values are correct, one uses a relative tolerance equal to 5% for the values of K_I . On the other hand, to check if the value of K_{II} is worthless, one uses an absolute tolerance (threshold value) related to the value of K_I : it is considered that K_{II} is worthless if its value is lower than 1% of the value of K_I . Indeed, in this case one can neglect the value of K_{II} .
One tests the maximum value of K_I and K_{II} between the two funds of the crack.

Propagation	Max K_I [$Pa\sqrt{mm}$]	K_I reference [$Pa\sqrt{mm}$]	Tolerance [%]
1	2.2914E+07	2.2997E+07	5.0
2	2.5803E+07	2.5878E+07	5.0
3	2.8809E+07	2.8894E+07	5.0

Propagation	Max K_{II} [$Pa\sqrt{mm}$]	K_I reference [$Pa\sqrt{mm}$]	K_{II} threshold [$Pa\sqrt{mm}$]
1	7.4881E+03	2.2997E+07	2.2997E+05
2	4.028E+03	2.5878E+07	2.5878E+05
3	2.0639E+04	2.8894E+07	2.8894E+05

4.4 Remarks

All the values tested are in the tolerances used. That means that the method SIMPLEX calculate correctly at the same time the position of the two funds of crack and the level sets.
The error obtained on the values of K_I is almost worthless and the values of K_{II} are always about 0.1% of the values of K_I . The got results are thus very satisfactory.

5 Modeling C

5.1 Characteristics of modeling

Method GEOMETRICAL is used by PROPA_FISS to solve the equations of propagation of the crack. **No auxiliary grid** is not used.

5.2 Characteristics of the grid

One uses the same grid as that of modeling A.

5.3 Sizes tested and results

One tests the values of K_I and K_{II} for the two funds of the crack after each propagation. To check if these values are correct, one uses a relative tolerance equal to 5% for the values of K_I . On the other hand, to check if the value of K_{II} is worthless, one uses an absolute tolerance (threshold value) related to the value of K_I : it is considered that K_{II} is worthless if its value is lower than 1% of the value of K_I . Indeed, in this case one can neglect the value of K_{II} .
One tests the maximum value of K_I and K_{II} between the two funds of the crack.

Propagation	**Max** K_I **[** $Pa\sqrt{mm}$ **]**	K_I **reference [** $Pa\sqrt{mm}$ **]**	**Tolerance [%]**
1	2.2914E+07	2.2997E+07	5.0
2	2.5803E+07	2.5878E+07	5.0
3	2.8809E+07	2.8894E+07	5.0

Propagation	**Max** K_{II} **[** $Pa\sqrt{mm}$ **]**	K_I **reference [** $Pa\sqrt{mm}$ **]**	K_{II} **threshold [** $Pa\sqrt{mm}$ **]**
1	7.4881E+03	2.2997E+07	2.2997E+05
2	4.1930E+03	2.5878E+07	2.5878E+05
3	5.1550E+03	2.8894E+07	2.8894E+05

5.4 Remarks

All the values tested are in the tolerances used. That means that the method GEOMETRICAL calculate correctly at the same time the position of the two funds of crack and the level sets.
The error obtained on the values of K_I is almost worthless and the values of K_{II} are always about 0.1% of the values of K_I . The got results are thus very satisfactory.

6 Summary of the results

All methods used (UPWIND, SIMPLEX, GEOMETRICAL) allowed to calculate well the position of a crack formed by two funds and propagating in mode I. The factors of intensity of constrained were calculated correctly and the methods used calculate correctly the level sets with each propagation.

The got results make it possible to validate the implementation of multi-cracking (case of only one fissures with several funds) in the operator PROPA_FISS.