

# Code\_Aster

Version  
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Titre : SSLP315 - Propagation de fissure debouchante dans [...]  
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grid

## SSLP315 - Propagation of emerging crack in a perforated plate 2D of width finished with XFEM

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### Summary:

The goal of this test is to check that the four methods of propagation available in the operator `PROPA_FISS` (grid, simplex, upwind, geometrical) give the same result for a propagation 2D in mixed mode.

An emerging crack is propagated in a plate rectangular comprising three holes and subjected to an inflection three points. After four propagations, the position of the bottom of the crack obtained by each method is compared with the position of reference given by the method grid.

## 1 Problem of reference

### 1.1 Geometry

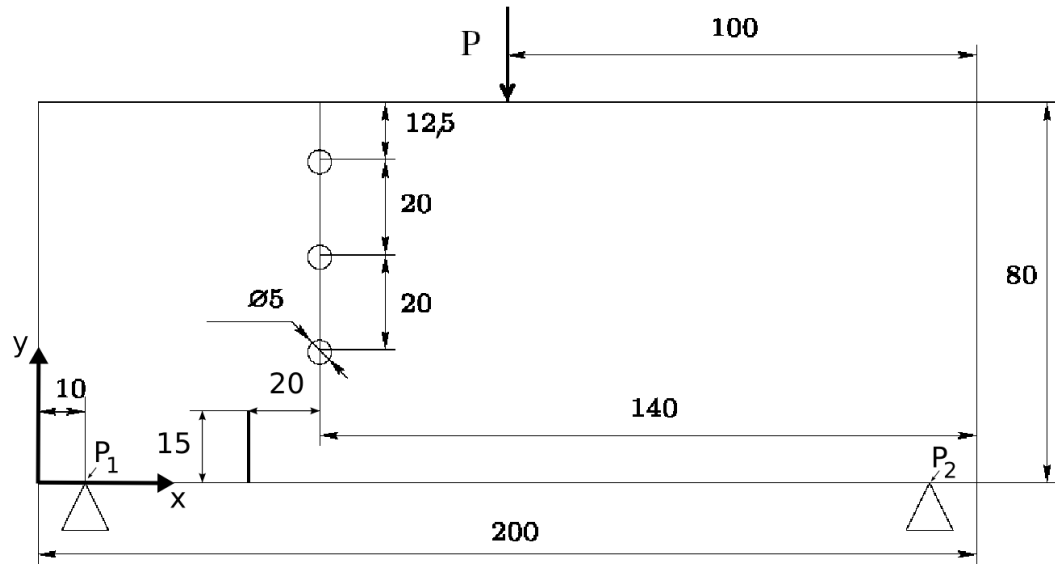


Figure 1.1-a: geometry of the fissured plate

All dimensions are expressed in millimetres.

### 1.2 Properties of material

Young modulus  $E = 200\,000\text{ MPa}$

Poisson's ratio  $\nu = 0.3$

### 1.3 Boundary conditions and loadings

Boundary conditions:

Not  $P_1$  :  $\Delta X = \Delta Y = 0$

Not  $P_2$  :  $\Delta Y = 0$

Loading:

Force:  $P = 1000\text{ N}$

The report of load is fixed equal to zero. The value of the force  $P$  data above is thus the maximum value of the cycle of tiredness.

## 2 Reference solution

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### 2.1 Method of calculating

One uses the method grid of PROPA\_FISS (modeling  $A$ ) to calculate the position of the crack after four propagations.

With each call of PROPA\_FISS the projection of the crack is imposed equalizes with  $2\text{ mm}$ .

### 2.2 Sizes and results of reference

After four propagations, the position of the bottom of the crack calculated by the method grid is the following one:

Propagation	Coordinate $x$	Coordinate $y$
4	42.13970	20.60376

Table 2.1 - Reference solution

This position is used as position of reference.

## 3 Modeling A

### 3.1 Characteristics of modeling

Method `GRID` is used by `PROPA_FISS` to calculate the new position of the bottom of the crack. The factors of intensity of the constraints are calculated by using the operator `CALC_G`.

### 3.2 Characteristics of the grid

The structure is modelled by a grid made up of 4464 elements `TRIA3` (see Figure 3.2-a).

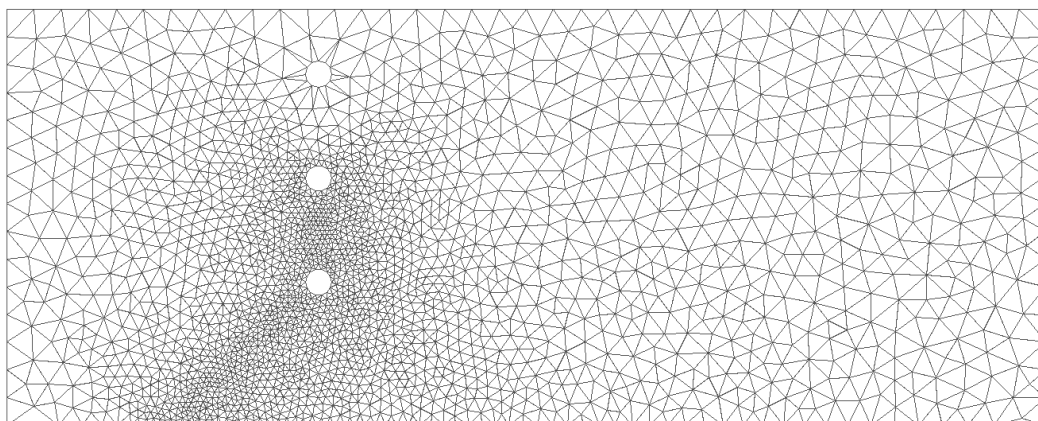


Figure 3.2-a: grid of the structure

The grid is refined more in the zone of propagation. In this zone the dimension of the smallest edge of the elements is equal to  $1.5\text{ mm}$ .

### 3.3 Sizes tested and results

The position of the bottom of the crack, after four propagations calculated by the method `grid`, is taken as value of reference:

Propagation	Coordinate $x$	Coordinate $y$
4	42.13970	20.60376

Table 3.3-1

### 3.4 Remarks

The position of the bottom of the crack cannot be recovered in the command file for the methods `simplex`, `upwind` and `geometrical` (modelings `D`, `C` and `E`). For these methods one will check that the position of the bottom is in the same element as that associated with this modeling (more details are given in the description of each modeling).

## 4 Modeling B

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### 4.1 Characteristics of modeling

Method `GRID` is used by `PROPA_FISS` to calculate the new position of the bottom of the crack. The factors of intensity of the constraints are calculated by using the operator `POST_K1_K2_K3`. The same model that described for modeling A is used.

### 4.2 Characteristics of the grid

One uses the same grid as that of modeling A.

### 4.3 Sizes tested and results

The position of the bottom of the crack after four propagations is the following one:

Propagation	Coordinate $x$	Coordinate $y$
4	42,05	20,62

One tests the not-regression of these values with a relative precision of 0.1%.

For information, one can calculate the error on coordinated bottom of crack compared to the reference solution (modeling *A*):

Coordin ate	Current value [ mm ]	Value of reference [ mm ]	Error [ mm ]
$x$	42,05	42,14	-0,09
$y$	20,62	20,6	0,02

By coherence, one uses a tolerance equal to that which will be used for modelings *C*, *D* and *E*, it be-have-to say *2.0 mm* (see these modelings for more details).

One can consider here that the position of the bottom calculated by this modeling is almost the same one as that of reference.

### 4.4 Remarks

The position of the bottom calculated respects the tolerance used. That means that the position of the bottom of crack calculated by the method `grid` more `POST_K1_K2_K3` is very close to that of reference.

## 5 Modeling C

### 5.1 Characteristics of modeling

Method `UPWIND` is used by `PROPA_FISS` to solve the equations of propagation of the crack. One **auxiliary grid** is used because the type of mesh of the grid of the structure is not usable by the method `UPWIND`.

The same model that described for modeling A is used.

### 5.2 Characteristics of the grid

For the structure one uses the same grid as that of modeling A.

The auxiliary grid used is made up of 952 elements `QUAD4` (see figure 5.2-a).

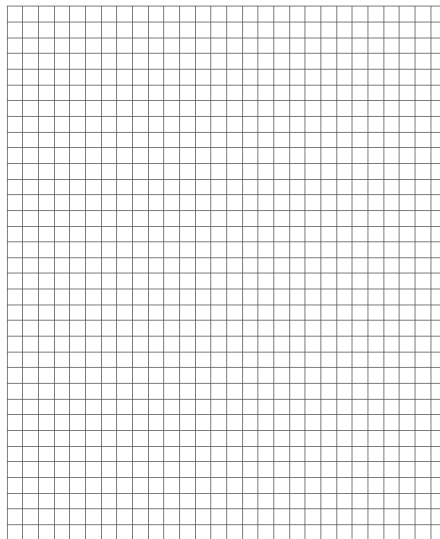


Figure 5.2-a: auxiliary grid

The dimension of the element is  $0.5 \times 0.5 \text{ mm}$ .

The grid is extended to the only zone of the structure interested by the propagation of the crack.

### 5.3 Sizes tested and results

The position of the bottom of the crack cannot be recovered in the command file and thus one cannot check directly if the solution calculated by the method fast marching is coherent with the reference solution. One can however check that the bottom of the crack is in the same element as that which contains the bottom of the crack of the reference solution. In fact, the distance between the bottom of crack and each node of this element is given by the value of the level sets and one can say that the bottom of crack is contained in the element if the value of the level sets on these nodes is lower than the length of the backbone of the element.

The nodes of the element of reference are the following: `N304`, `N1040` and `N1512`. The length of the backbone of the element is  $2.0 \text{ mm}$ . One uses this value as tolerance on the value of the level sets.

The value of the level sets to each node can be recovered in the command file by using the operator `POST_RELEVE_T`:

Node	LSN [ mm ]	LST [ mm ]
N304	-0.772	-1.436
N1040	1.22	-1.72
N1512	0.719	-0.242

## 5.4 Remarks

All the values tested respect the tolerance used. That means that the position of the bottom of crack calculated by the method UPWIND is very close to that of reference.



## 6 Modeling D

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### 6.1 Characteristics of modeling

Method `SIMPLEX` is used by `PROPA_FISS` to solve the equations of propagation of the crack. The same model that described for modeling A is used.

### 6.2 Characteristics of the grid

One uses the same grid as that of modeling A.

### 6.3 Sizes tested and results

The position of the bottom of the crack cannot be recovered in the command file and thus one cannot check directly if the solution calculated by the method `SIMPLEX` is coherent with the reference solution. One can however check that the bottom of the crack is in the same element as that which contains the bottom of the crack of the reference solution. In fact, the distance between the bottom of crack and each node of this element is given by the value of the level-sets and one can say that the bottom of crack is contained in the element if the value of the level-sets on these nodes is lower than the length of the backbone of the element.

The nodes of the element of reference are the following: *N304* , *N1040* and *N1512* . The length of the backbone of the element is *2.0 mm* . One uses this value as tolerance on the value of the level sets.

The value of the level sets to each node can be recovered in the command file by using the operator `POST_RELEVE_T`:

Node	LSN [ mm ]	LST [ mm ]
<i>N304</i>	-7.14928E-01	-1.36882E+00
<i>N1040</i>	1.24559E+00	-1.83307E+00
<i>N1512</i>	8.74599E-01	-3.14722E-01

### 6.4 Remarks

All the values tested respect the tolerance used. That means that the position of the bottom of crack calculated by the method `SIMPLEX` is very close to that of reference.

## 7 Modeling E

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### 7.1 Characteristics of modeling

Method `GEOMETRICAL` is used by `PROPA_FISS` to update the position of the crack. One **auxiliary grid** is used for the representation of the level-sets. That makes it possible to test the use of this method under the same conditions as those of the method `UPWIND` (modeling C) for a direct comparison.

The same model that described for modeling A is used.

### 7.2 Characteristics of the grid

The same grid is used that of modeling A. One uses the same auxiliary grid as that of modeling C.

### 7.3 Sizes tested and results

The position of the bottom of crack cannot be recovered in the command file and thus one cannot check directly if the solution calculated by the method `GEOMETRICAL` is coherent with the reference solution. One can however check that the bottom of crack is in the same element as that which contains the bottom of crack of the reference solution. In fact, the distance between the bottom of crack and each node of this element is given by the value of the level sets and one can say that the bottom of crack is contained in the element if the value of the level sets on these nodes is lower than the length of the backbone of the element.

The nodes of the element of reference are the following: *N304* , *N1040* and *N1512* . The length of the backbone of the element is of *2.0 mm* . One uses this value as tolerance on the value of the level sets.

The value of the level sets to each node can be recovered in the command file by using the operator `POST_RELEVE_T`:

Node	LSN [ mm ]	LST [ mm ]
<i>N304</i>	-0,757	-1,356
<i>N1040</i>	1,213	-1,844
<i>N1512</i>	0,847	-0,321

### 7.4 Remarks

All the values tested respect the tolerance used. That means that the position of the bottom of crack calculated by the method `GEOMETRICAL` with the auxiliary grid is very close to that of the reference.

## 8 Summary of the results

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All methods used ( GRID\_CALC\_G, GRID\_POST\_K1\_K2\_K3, UPWIND, SIMPLEX, GEOMETRICAL) allowed to calculate the position of a crack propagating in mixed mode. The got results are comparable between them.

That makes it possible to validate the implementation of the methods in the operator PROPA\_FISS.