

# Code\_Aster

Version  
default

Titre : SSLV315 - Propagation non plane d'une fis[...]  
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simplex

## SSLV315 – Nonplane propagation of a crack emerging with X-FEM

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### Summary:

The goal of this test is to compare the methods of propagation `SIMPLEX`, `GRID`, `UPWIND` and `GEOMETRICAL` of the operator `PROPA_FISS` for a crack `3D` solicited in mixed mode.

## 1 Problem of reference

### 1.1 Geometry

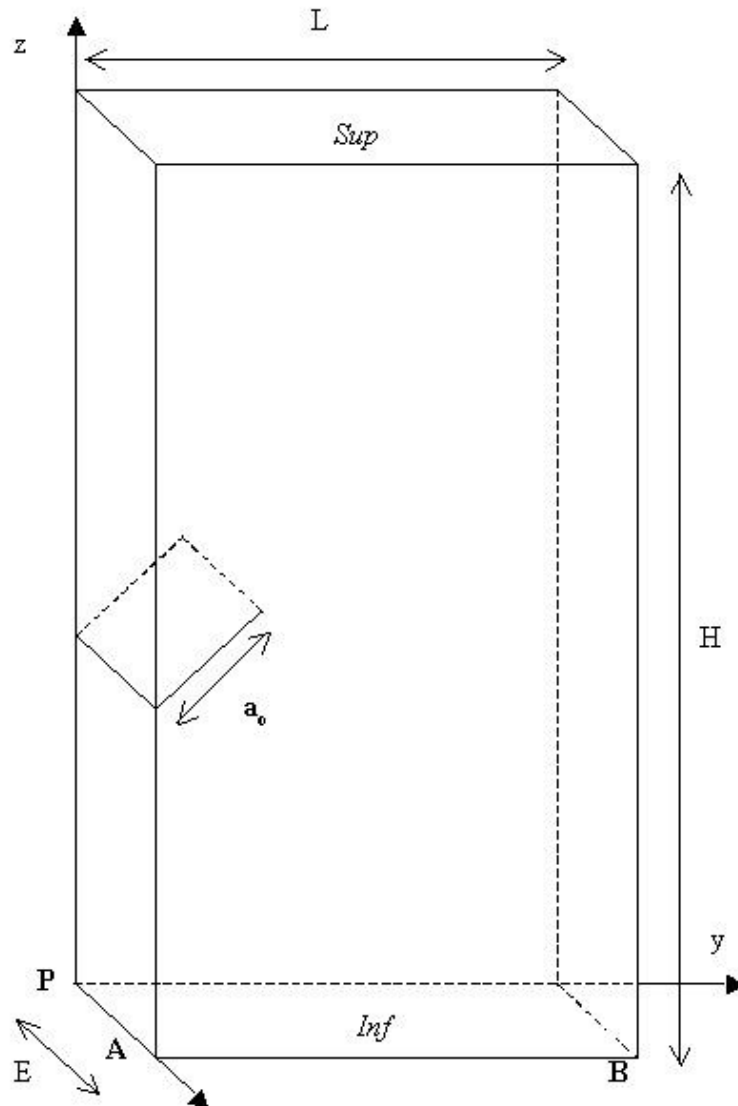


Figure 1.1-a: geometry of the fissured plate

Geometrical dimensions of the fissured plate:

width	$L = 8\text{ m}$
thickness	$E = 1\text{ m}$
height	$H = 18\text{ m}$

The crack is initially directed with  $45^\circ$ , the face being initially positioned in  $(x, 2, 9)$ .

## 1.2 Properties of material

Young modulus  $E = 205000 \text{ MPa}$   
Poisson's ratio  $\nu = 0.3$

For the case of modelings with cohesive elements, the parameters material are:

Critical stress  $\sigma_c = 2 \text{ MPa}$   
Energy tenacity  $G_c = 17.75 \text{ N.m}^{-1}$

## 1.3 Boundary conditions and loadings

Boundary conditions:

Not  $P$  :  $\Delta X = \Delta Y = \Delta Z = 0$   
Points on the segment  $AB$  :  $\Delta X = \Delta Z = 0$   
Points on surface INF :  $\Delta Z = 0$

Loading:

Pressure on surface SUP :  $P = -1 \text{ MPa}$

## 2 Reference solution

The results of modeling B (method Grid) are taken as reference.

For modelings B, C, G and H, one checks to it not regression of the code compared to the position of the bottom of crack.

For modelings A, D, E, F, I and J, one checks that the nodes closest to the trace of the bottom of crack on the plan  $(1, y, z)$  at the last moment of propagation have their level-set very close to zero.

Moment of propagation	Node	Coordinate $y_i$	Coordinate $z_i$
	N219	3.14	9.00
	N1576	2.57	8.70
3	N1577	2.86	8.70
	N2636	2.57	9.30
	N2637	2.86	9.30

These nodes are those included in a ray of capture being worth the backbone of an element, centered on the trail of bottom of crack on the plan  $(1, x, y)$ .

One identifies these nodes in the file message ( `.mess` ) modeling B and one estimates the value of their level-sets in modelings A, D, E, F, I and J.

## 3 Modeling A

### 3.1 Characteristics of modeling

Method `SIMPLEX` is used by `PROPA_FISS`.

### 3.2 Characteristics of the grid

The structure is modelled by a grid made up of 6720 elements `HEXA8` (see Figure 3.2-a).

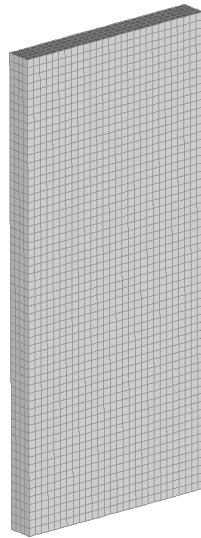


Figure 3.2-a: grid of the structure

The grid is not very refined to reduce the computing time. The size of the elements is uniform and equal to  $0.29 \times 0.33 \times 0.25 \text{ m}$ .

### 3.3 Sizes tested and results

One extracts the level set normal ( $LSN$ ) and tangent ( $LST$ ) by using the operator `POST_RELEVE_T` and it is checked that the values maximum and minimal remain understood in the circle of capture of the nodes tested around the face of crack, that is to say 2/3 :

$Propag. i$	$Max LSN_i$	$Min LSN_i$	$Max LST_i$	$Min LST_i$
3	0,233	0.40	0.33	0.28

The got results show well that the level-sets remain lower than the ray in which the face of crack was localised. That means that the bottom of crack was correctly located by the method `SIMPLEX`.

## 4 Modeling B

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### 4.1 Characteristics of modeling

Method `GRID` is used by `PROPA_FISS`.  
The option `CALC_K_G` is used by `CALC_G`.

### 4.2 Characteristics of the grid

One uses the same grid as for modeling A.

### 4.3 Sizes tested and results

One tests, in nonregression, the position of the bottom of crack to the last iteration of propagation.

Moment of propagation	Coordinate $y_i$	Coordinate $z_i$
3	2.8	9

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## 5 Modeling C

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### 5.1 Characteristics of modeling

Method GRID is used by PROPA\_FISS.  
The option POST\_K1\_K2\_K3 is used by CALC\_G.

### 5.2 Characteristics of the grid

One uses the same grid as for modeling A.

### 5.3 Sizes tested and results

One tests, in nonregression, the position of the bottom of crack to the last iteration of propagation.

Moment of propagation	Coordinates $y_i$	Coordinates $z_i$
3	2.8	9

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## 6 Modeling D

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### 6.1 Characteristics of modeling

Method UPWIND without auxiliary grid is used by PROPA\_FISS.

### 6.2 Characteristics of the grid

One uses the same grid as that of modeling A.

### 6.3 Sizes tested and results

One extracts the level set normal (  $LSN$  ) and tangent (  $LST$  ) by using the operator POST\_RELEVE\_T and it is checked that the values maximum and minimal remain understood in the circle of capture of the nodes tested around the face of crack, that is to say 2/3 :

<i>Propag.i</i>	<i>Max LSN<sub>i</sub></i>	<i>Min LSN<sub>i</sub></i>	<i>Max LST<sub>i</sub></i>	<i>Min LST<sub>i</sub></i>
3	0,216	-0,479	0,317	-0,307

The got results show well that the level-sets remain lower than the ray in which the face of crack was localised. That means that the bottom of crack was correctly located by the method UPWIND.



## 7 Modeling E

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### 7.1 Characteristics of modeling

Method `GEOMETRICAL` is used by `PROPA_FISS`.

### 7.2 Characteristics of the grid

One uses the same grid as that of modeling A.

### 7.3 Sizes tested and results

One extracts the level set normal (  $LSN$  ) and tangent (  $LST$  ) by using the operator `POST_RELEVE_T` and it is checked that the values maximum and minimal remain understood in the circle of capture of the nodes tested around the face of crack, that is to say 2 / 3 :

<i>Propag. i</i>	<i>Max LSN<sub>i</sub></i>	<i>Min LSN<sub>i</sub></i>	<i>Max LST<sub>i</sub></i>	<i>Min LST<sub>i</sub></i>
3	0,235	0,397	0,333	0,272

The got results show well that the level-sets remain lower than the ray in which the face of crack was localised. That means that the bottom of crack was correctly located by the method `GEOMETRICAL`.

## 8 Modeling G

### 8.1 Characteristics of modeling

The goal of this modeling is to validate in a total way the unit of the procedure of propagation *with cohesive elements*. Method `GEOMETRICAL` is thus used by `PROPA_FISS`, alternatively with the operations `DETEC_COHESIF` and `PROPA_COHESIF`, respectively to bring up to date the level-set tangent (and thus the face of propagation) and the level-set normal (and thus “the possible” surface of cracking). The angle of junction is determined by `CALC_G`, and the cohesive elements are introduced into the model by the order `DEFI_CONTACT`.

### 8.2 Characteristics of the grid

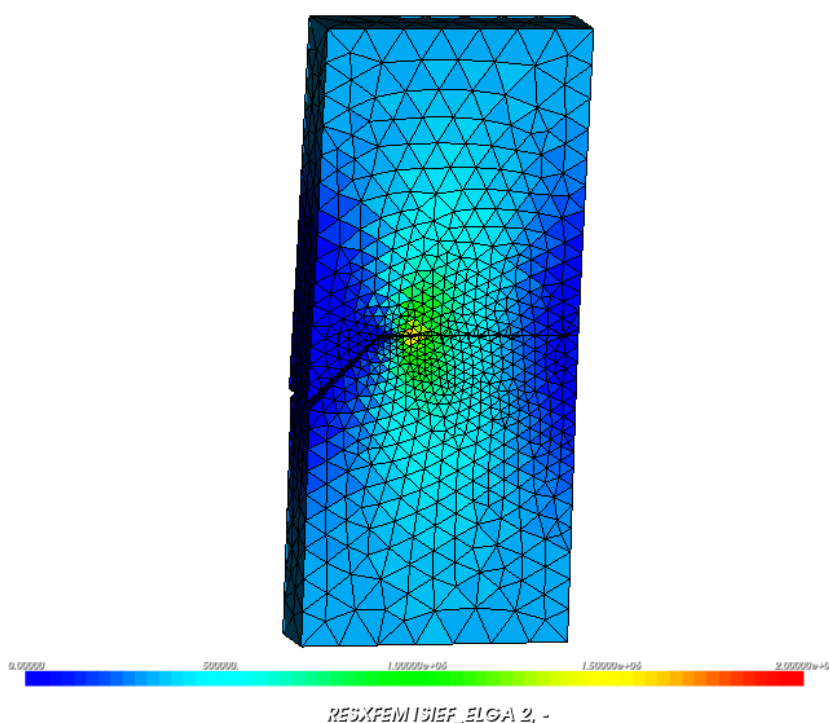
One uses a grid not structured, the initial crack being with a grid. It comprises 16632 elements of the type `TETRA4`.

### 8.3 Sizes tested and results

Two steps of propagation are carried out, then one extracts the position from the face of propagation at the end of this operation. The validation consists of a test of not-regression on the position of this face. In order to reduce the number of tests, the coordinates are tested  $Y$  and  $Z$  maximum and minimal along the face.

<i>Propag.i</i>	<i>Max(Y)</i>	<i>Min(Y)</i>	<i>Max(Z)</i>	<i>Min(Z)</i>
2	3.14	3.05	9.04	9.03

We represent in figure 8.3-a a sight of the deformation and stress field at the end of the second step of propagation. The crack tends to be rectified to propagate in a plan.





## 9 Modeling H

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### 9.1 Characteristics of modeling

The goal of this modeling is to validate in a total way the unit of the procedure of propagation *with cohesive elements*. Method `GEOMETRICAL` is thus used by `PROPA_FISS`, alternatively with the operations `DETEC_COHESIF` and `PROPA_COHESIF`, respectively to bring up to date the level-set tangent (and thus the face of propagation) and the level-set normal (and thus “the possible” surface of cracking).

### 9.2 Characteristics of the grid

One uses a structured grid, the initial crack being with a grid. It comprises 2032 elements of the type `PENTA6`.

### 9.3 Sizes tested and results

Two steps of propagation are carried out, then one extracts the position from the face of propagation at the end of this operation. The validation consists of a test of not-regression on the position of this face. In order to reduce the number of tests, the coordinates are tested  $Y$  and  $Z$  maximum and minimal along the face.

<i>Propag. i</i>	<i>Max(Y)</i>	<i>Min(Y)</i>	<i>Max(Z)</i>	<i>Min(Z)</i>
2	3.14	3.14	8.96	8.96

## 10 Modeling I

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### 10.1 Characteristics of modeling

The GEOMETRICAL method is used by PROPA\_FISS, with CRIT\_ANGL\_BIFURCATION = 'SITT\_MAX\_DEVER'. The angles of connection and discharge are calculated by taking of account the value of KIII. The rotation of discharge is activated.

### 10.2 Characteristics of the grid

One uses the same grid as that of modeling A.

### 10.3 Sizes tested and results

One extracts the level set normal (  $LSN$  ) and tangent (  $LST$  ) by using the operator POST\_RELEVE\_T and it is checked that the values maximum and minimal remain understood in the circle of capture of the nodes tested around the face of crack, that is to say 2/3 :

$Propag. i$	$Max LSN_i$	$Min LSN_i$	$Max LST_i$	$Min LST_i$
3	0,237	0,397	0,317	0,274

The got results show well that the level-sets remain lower than the ray in which the face of crack was localised. That means that the bottom of crack was correctly located by the method GEOMETRICAL with taking into account of KIII and the rotation of discharge.

## 11 Modeling J

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### 11.1 Characteristics of modeling

The GEOMETRICAL method is used by PROPA\_FISS, with CRIT\_ANGL\_BIFURCATION = 'ANGLE\_IMPO\_GAMMA'. The angle of connection BETA is calculated by taking of account the value of KIII and the angle dumping GAMMA is forced to zero.

### 11.2 Characteristics of the grid

One uses the same grid as that of modeling A.

### 11.3 Sizes tested and results

One extracts the level set normal (  $LSN$  ) and tangent (  $LST$  ) by using the operator POST\_RELEVE\_T and it is checked that the values maximum and minimal remain understood in the circle of capture of the nodes tested around the face of crack, that is to say 2/3 :

<i>Propag. i</i>	<i>Max LSN<sub>i</sub></i>	<i>Min LSN<sub>i</sub></i>	<i>Max LST<sub>i</sub></i>	<i>Min LST<sub>i</sub></i>
3	0,237	0,397	0,317	0,274

The got results show well that the level-sets remain lower than the ray in which the face of crack was localised. That means that the bottom of crack was correctly located by the method GEOMETRICAL with taking into account of KIII and rotation of discharge forced to zero.

## 12 Summary of the results

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All methods of propagation used (SIMPLEX, GRID, UPWIND AND GEOMETRICAL) of the operator PROPA\_FISS allowed to calculate the position of a crack well propagating in mixed mode in a structure 3D .