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

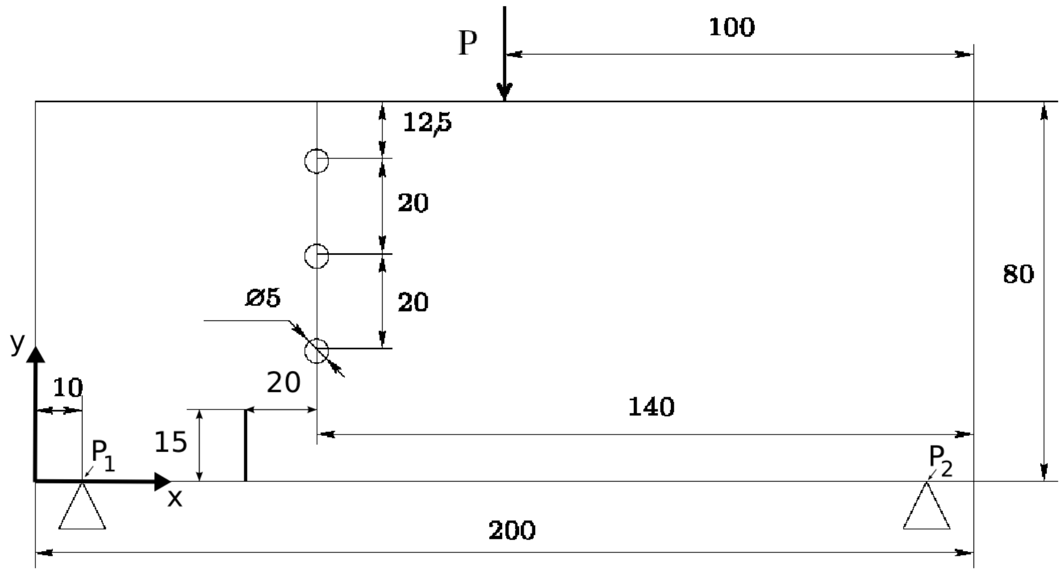
Summarized:

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

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

1 Problem of reference

1.1 Geometry



Appears 1.1-a: geometry of the fissured plate

All dimensions are expressed in millimetres.

1.2 Properties of the material

Young's modulus $E=200\,000\,MPa$
Poisson's ratio $\nu=0.3$

1.3 Boundary conditions and loadings

Boundary conditions:

Point: P_1 $\Delta X=\Delta Y=0$
Point: P_2 $\Delta Y=0$

Loading:

Force: $P=1000\,N$

The ratio of load is set equal to zero. The value of the force P given above is thus the maximum value of fatigue cycle.

2 Reference solution

2.1 Method of calculating

One to compute: uses the method network of PROPA_FISS (A modelization) the position of crack after four propagations.
On each call of PROPA_FISS the projection of crack is imposed equalizes with $2\,mm$.

2.2 Quantities and results of reference

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

Coordinated	Coordinated x	propagation y
4	42.13970	20.60376

Table 2.1 - Reference solution

This position is used as position of reference.

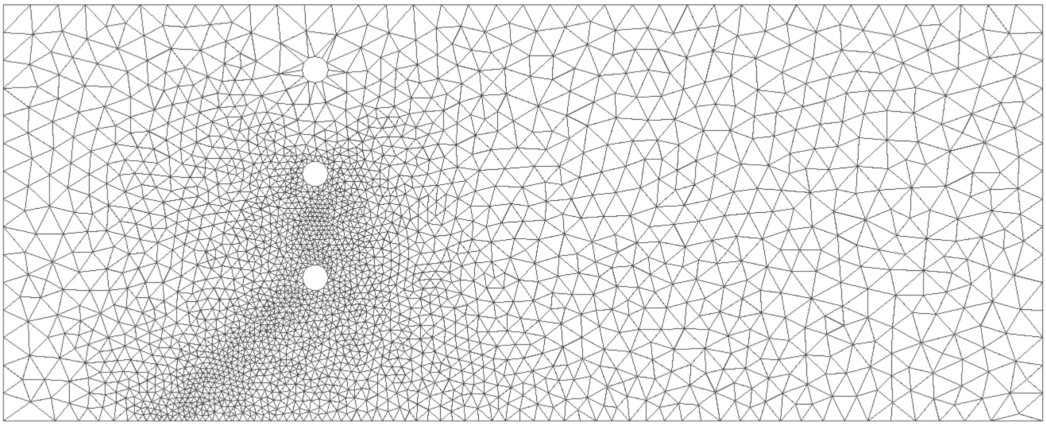
3 Modelization A

3.1 Characteristic of the modelization

the method MAILLAGE is used by PROPA_FISS to compute: the new position of the bottom of crack. The factors of intensity of the stresses are calculated by means of operator CALC_G.

3.2 Characteristics of the mesh

the structure is modelled by a mesh made up of 4464 elements TRIA3 (see Appear 3.2-a).



Appear 3.2-a: mesh of structure

The mesh is refined more in the zone of propagation. In this zone the dimension of the smallest edge of the elements is equal to $1.5 mm$.

3.3 Quantities tested and results

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

Coordinated	Coordinated x	propagation y
4	42.13970	20.60376

Table 3.3-1

3.4 Remarks

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

4 Modelization B

4.1 Characteristic of the modelization

the method MAILLAGE is used by PROPA_FISS to compute: the new position of the bottom of crack. The factors of intensity of the stresses are calculated by means of operator POST_K1_K2_K3.
The same model that described for the modelization A is used.

4.2 Characteristics of the mesh

One uses the same mesh as that of modelization A.

4.3 Grandeurs tested and results

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

Coordinated	Coordinated x	propagation y
4	42.05	20.62

One tests the NON-regression of these values with a relative accuracy of 0,1%.

For information, one can compared to the calculate the error on coordinated crack tip reference solution (modelization 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 the modelizations C , D and E , it be-A-to say $2.0\,mm$ (see these modelizations for more details).
One can consider here that the position of the bottom calculated by this modelization 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 crack tip calculated by the method mesh plus POST_K1_K2_K3 is very close to that of reference.

5 Modelization C

5.1 Characteristic of the modelization

method UPWIND is used by PROPA_FISS to solve the equations of propagation of crack. **Auxiliary grid** is used because the type of mesh of the mesh of structure is not usable by method UPWIND.
The same model that described for the modelization A is used.

5.2 Characteristics of the mesh

For structure the same mesh is used as that of modelization A.
auxiliary grid used is made up of 952 elements QUAD4 (see figure 5.2-a).

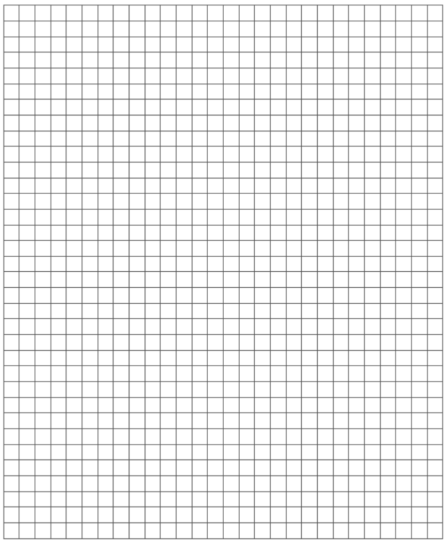


Figure 5.2-a : 5.2-a auxiliary grid

the dimension of the element is $0.5\times0.5\,mm$.
The grid is extended to the only zone of structure interested by the propagation of crack.

5.3 Quantities 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 method UPWIND 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 crack tip and each node of this element is given by the value of the level sets and one can say that the crack tip 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 of level sets. uses this value as tolerance on the value

The value of the level sets with each node can be recovered in the command file by means of operator POST_RELEVE_T:

Node	LSN [mm]	LST [mm]
$N304$	-0.716	-1.376
$N1040$	1.270	-1.885
$N1512$	0.931	-0.354

5.4 Remarks

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

6 Modelization D

6.1 Characteristic of the modelization

method SIMPLEXE is used by PROPA_FISS to solve the equations of propagation of crack.
The same model that described for the modelization A is used.

6.2 Characteristics of the mesh

One uses the same mesh as that of modelization A.

6.3 Grandeurs 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 method SIMPLEXE 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 crack tip and each node of this element is given by the value of the level-sets and one can say that the crack tip 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 of level sets. uses this value as tolerance on the value
The value of the level sets with each node can be recovered in the command file by means of operator POST_RELEVE_T:

Node	LSN [mm]	LST [mm]
$N304$	-0.810	-1.339
$N1040$	1.161	-1.855
$N1512$	0.819	-0.342

6.4 Remarks

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

7 Modelization E

7.1 Characteristic of the modelization

method SIMPLEXE is used by PROPA_FISS to solve the equations of propagation of crack. **Auxiliary grid** is used for the representation of the level-sets.
The same model that described for the modelization A is used.

7.2 Characteristics of the mesh

the same mesh is used that of modelization A. One uses the same one auxiliary grid as that of the modelization C.

7.3 Quantities 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 method SIMPLEXE 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 crack tip and each node of this element is given by the value of the level sets and one can say that the crack tip 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 of level sets. uses this value as tolerance on the value

The value of the level sets with each node can be recovered in the command file by means of operator POST_RELEVE_T:

Node	LSN [mm]	LST [mm]
$N304$	-0.660	-1.345
$N1040$	1.337	-1.687
$N1512$	0.991	-0.286

7.4 Remarks

All the values tested respect the tolerance used. That means that the position of the crack tip calculated by method SIMPLEXE plus auxiliary grid is very close to that of reference.

8 Modelization F

8.1 Characteristic of the modelization

method GEOMETRIQUE is used by PROPA_FISS to update the position of crack. **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 method UPWIND (modelization C) for a direct comparison.
The same model that described for the modelization A is used.

8.2 Characteristics of the mesh

the same mesh is used that of modelization A. One uses the same one auxiliary grid as that of the modelization C.

8.3 Quantities tested and results

the position of the crack tip cannot be recovered in the command file and thus one cannot check directly if the solution calculated by method GEOMETRIQUE is coherent with the reference solution. One can however check that the crack tip is in the same element as that which contains the crack tip of the reference solution. In fact, the distance between the crack tip and each node of this element is given by the value of the level sets and one can say that the crack tip 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 of level sets. uses this value as tolerance on the value

The value of the level sets with each node can be recovered in the command file by means of operator POST_RELEVE_T:

Node	**LSN** [mm]	**LST** [mm]
$N304$	-0.757	-1.356
$N1040$	1.213	-1.844
$N1512$	0.847	-0.321

8.4 Remarks

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

9 Summary of the results

All the methods used (MAILLAGE CALC_G, MAILLAGE POST_K1_K2_K3, UPWIND, SIMPLEXE, SIMPLEXE auxiliary grid, GEOMETRIQUE) made it possible 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 operator PROPA_FISS.