SSLV319 – Propagation planes of a semi-elliptic crack

Abstract:

The purpose of this test is validating the plane propagation of a crack by observing the displacement of the crack tip during the propagation.

This test brings into play a paving stone with an emerging crack semi-elliptic planes, subjected to a tensile force.

The crack is represented by the method X-FEM and the propagation simulated using command `PROPA_FISS`.

We will compare the results with an experimental solution.

This test contains two modelizations:

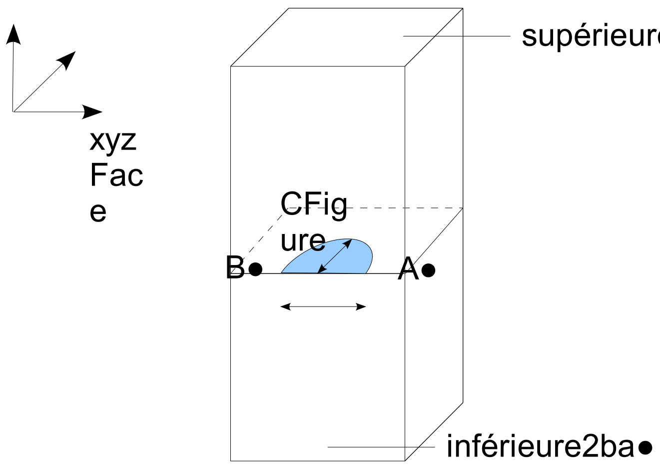
The modelization A uses MAILLAGE `the method` of operator `PROPA_FISS`.
The modelization B uses method `GEOMETRIQUE` of operator `PROPA_FISS`.

1 Problem of reference

1.1 Geometry

One considers a three-dimensional bar having for dimensions:
- height: LZ = 4 mm,
- with dimensions: LX = LY = 1 mm.

This bar comprises a plane, semi-elliptic crack. The crack is located in the plane Oxy . The characteristics of cracks are the following ones:
- equatorial radius: a = 119 µm
- half-small axis: b = 100 µm.



1.1-1: Geometry of initial crack

1.2 Material properties

the material is elastic isotropic whose properties are:
$E=200\,000\,MPa$
$\nu=0,3$

1.3 Boundary conditions and loadings

the structure is subjected to a loading of fatigue under constant amplitude: tension $\sigma_{max}=220\,MPa$ and a ratio $R=0,1$. The temperature is the room temperature. The frequency of loading is of $40\,Hz$. A loading of 4000 cycles is applied.

The tractive effort is applied to the sides higher and lower.

The blocking of the rigid modes is carried out in the following way:
- the point A is blocked in the directions Oy and Oz,
- the point B is blocked in the directions Oy and Oz ,
- the point C is blocked in the directions Ox and Oz .

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution was obtained by experimental way 3 . In this article, a computational simulation is also carried out.

2.2 Results of reference

the model of propagation in fatigue of the type Paris exits of the tests is the following one: $\frac{da}{dN}=C(\Delta K)^m$ with $C=10^{-9,2}$ and $m=3,5$. The values of the coefficients of the model of Paris are given for ΔK in $MPa.\sqrt{m}$ and a velocity $\frac{da}{dN}$ in $m/cycle$.

After 4000 cycles, the major point of the crack tip reached the coast in experiments $y=173\,\mu m$. Figure2.1 1 presents the crack tip experimental and calculated numerically after 4000 cycles.

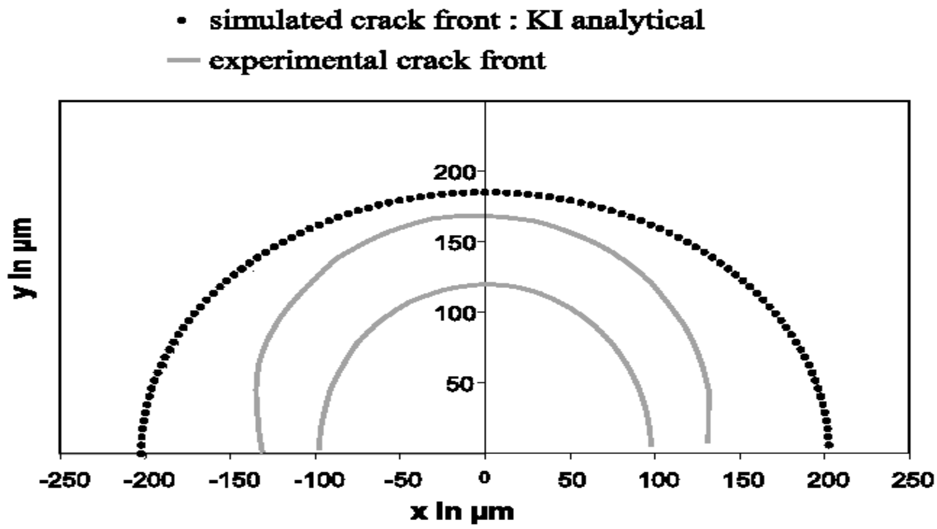


Figure2.1 1: Crack tip

2.3 bibliographical References

(1) E. Ferrié, J.Y. Buffière, W. Ludwig, A. Gravouil, L. Edwards, Fatigue ace propagation: In situ visualistion using X-Ray microtomography and 3D simulation using the extend finite element method, Recorded Materialia 54, pp. 1111-1122, 2006

3 Modelization a: Method MAILLAGE

3.1 Characteristic of the modelization

In this modelization, the crack is not with a grid. One uses the method X-FEM and a representation of crack by level sets. The update of the level sets is carried out by the operator PROPA_FISS, method MAILLAGE.

3.2 Characteristics of the mesh

The mesh initial as of structure is relatively coarse. It was carried out in modulus SMESH of Salomé, with Blsurf and GHS3D. The size defined for the surface mesh Blsurf is $2\,mm$.

unit of mesh: meters

Many nodes: 2268
Number of meshes and type: 10690 TETRA4

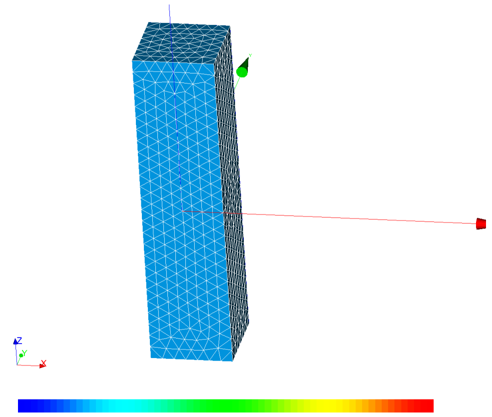
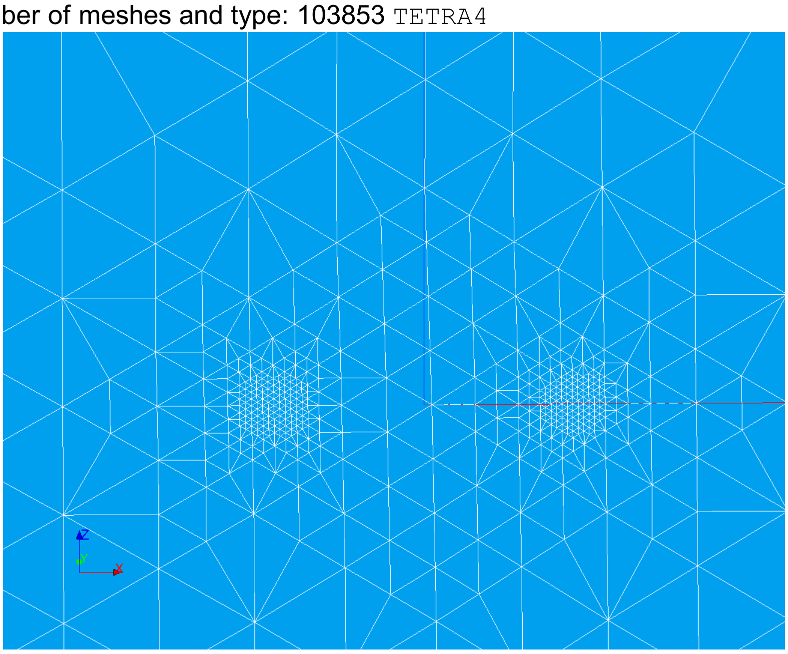
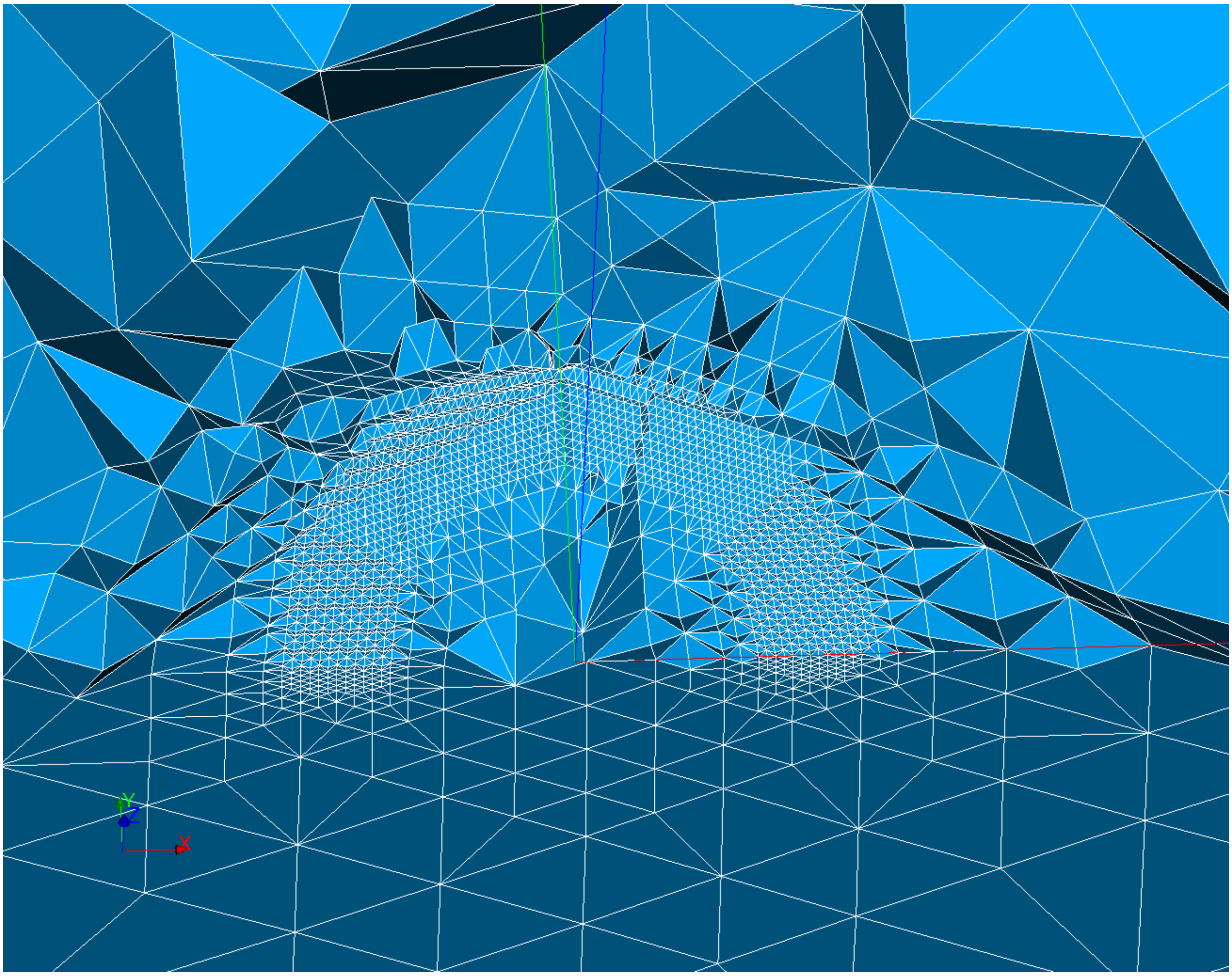


Figure 3.2-1:

An automatic procedure of refinement is installation. After refinement around the crack tip, the length characteristic of an element close to the crack tip is of $5\,\mu m$.
The mesh refined has the following characteristics:

- Many nodes: 18325
- Number of meshes and type: 103853 TETRA4





3.3 Boundary conditions and loadings

- a tractive effort is applied to the sides higher and lower and that of right;
- One blocks the rigid modes in the following way:

the node is outside the field of definition with a right profile of the EXCLU type node: A $DY=DZ=0$, the node is outside the field of definition with a right profile of the EXCLU type node: B $DY=DZ=0$, and the node is outside the field of definition with a right profile of the EXCLU type node: C $DX=DZ=0$

3.4 Quantities tested and results

One tests the position of the point of the major crack tip. That amounts testing the maximum coordinate along the axis Y of the points of the crack tip after a step of propagation.

Standard	identification of reference	Value of reference	% Tolerance
$max(Y)$	"SOURCE_EXTERNE"	173,3 10-6	5%

4 Modelization b: Method GEOMETRIQUE

4.1 Characteristics of the modelization

In this modelization, the crack is not with a grid. One uses the method X-FEM and a representation of crack by level sets. The update of the level sets is carried out by the operator PROPA_FISS, method GEOMETRIQUE.
The mesh initial, the boundary conditions and the loadings are identical to those of modelization A.

4.2 Grandeurs tested and results

One tests the position of the point of the major crack tip. That amounts testing the maximum coordinate along the axis Y of the points of the crack tip after a step of propagation.

Standard	identification of reference	Value of reference	% Tolerance
$max(Y)$	"SOURCE_EXTERNE"	173,3 10-6	5%

5 Summary of the results

This benchmark of the level sets validates the update following a step of plane propagation with the method MAILLAGE and method GEOMETRIQUE.