SSLP313 - Crack inclined in an unlimited plate, subjected to a uniform tension ad infinitum

Summarized:

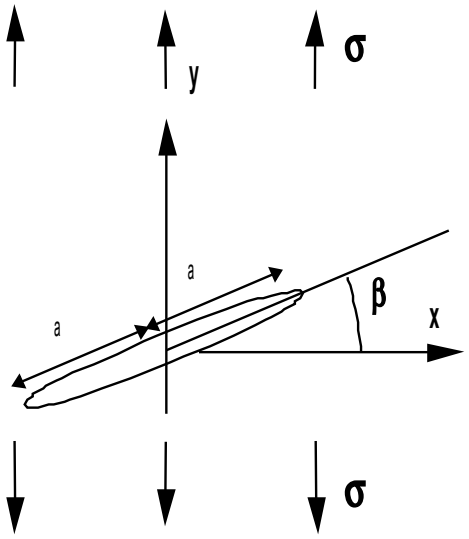
This test is resulting from the validation independent of version 3 of Code_Aster in fracture mechanics.

One calculates K_I, K_{II} and rate of energy restitution for a right crack, tilted of an angle b, in a large-sized plate subjected to a uniform tension. The model is two-dimensional in plane stresses. The material is elastic linear isotropic. This test of reference $2\mathrm{D}$ makes it possible some to check separability of K_I and K_{II} in a mixed mode.
The reference solution, given for a theoretically unlimited field, is analytical.

Besides the energy method (CALC_G), one tests the méthode de calcul of the factors of intensity of the stresses by extrapolation of displacements (POST_K1_K2_K3). The modelization B allows to test this last method with a kind of mesh recommended (nodes mediums with the quarter) to obtain a precise solution.

1 Problem of reference

1.1 Geometry



One allots an unspecified value to the slope $\beta = 37\,degrés$.
One chooses $a = 1.\mathrm{E}-3\,m$.

1.2 Properties of the material

the material is elastic linear isotropic, of Poisson's ratio and Young $E = 2.\mathrm{E}11\,Pa$ modulus $\nu = 0.3$.
Curve of tension is defined such as:

- the slope either equal to 3.
- the elastic limit or equalizes with $1.88\,GPa$.

The assumption of the plane stresses is applied.

1.3 Boundary conditions and arbitrary

•Limiting loadings of the field with a grid:

$-x_{max} \le x \le x_{max}$ with $x_{max} = 10\mathrm{a}$

$-y_{max} \le y \le y_{max}$ $y_{max} = 20\mathrm{a}$

•Boundary conditions:

In order to block the 3 plane rigid modes exclusively.

$UX = UY = 0$ with the left lower corner of the complete model.

$UY = 0$ with the corner lower right of the complete model.

On lower edge, we impose $UY = 0$

•Loading: uniform tension $\sigma_{yy} = \sigma_0$ on higher edge:

The value of σ_0 is worth $100\mathrm{MPa}$, in plane stresses.

2 Reference solution

2.1 Method of calculating used for the reference solution

Stress function of Airy.

2.2 Results of reference

$$K_I = \sigma_0 \sqrt{(\pi_0)} \cos^2 \beta$$

$$K_{II} = \sigma_0 \sqrt{(\pi_0)} \sin \beta \cos \beta$$

$$G_{ref} = \frac{1}{E}\left(K_I^2 + K_{II}^2\right) \text{ (in plane stresses)}$$

2.3 Uncertainty on the solution

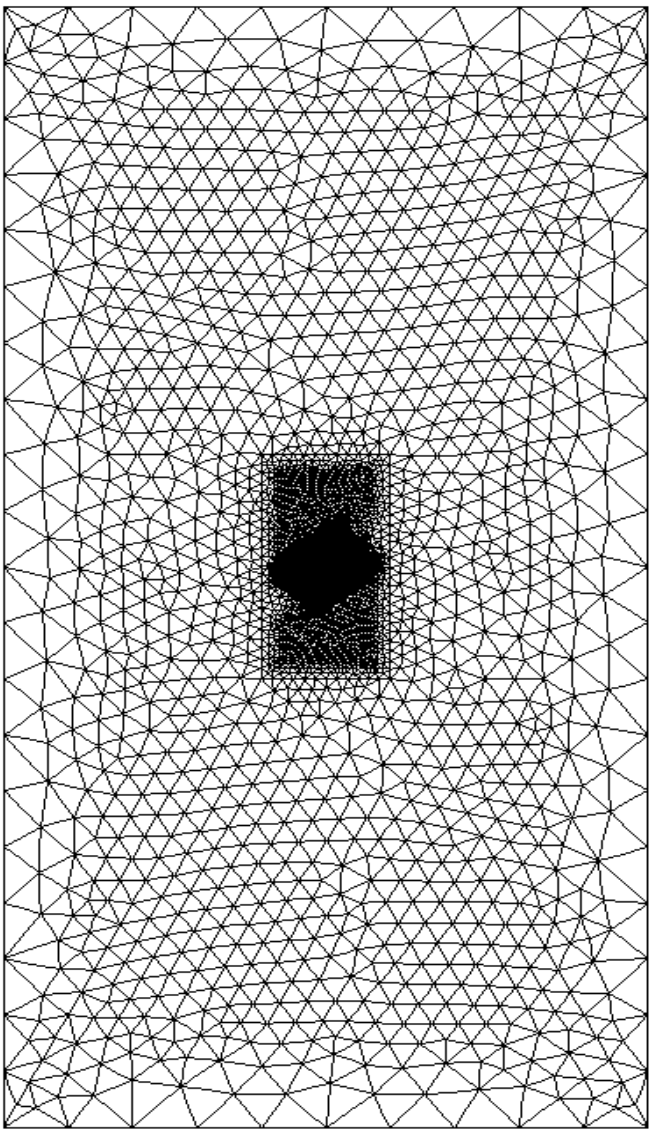
exact analytical Solution (Irwin) in unlimited medium.

2.4 Bibliographical references

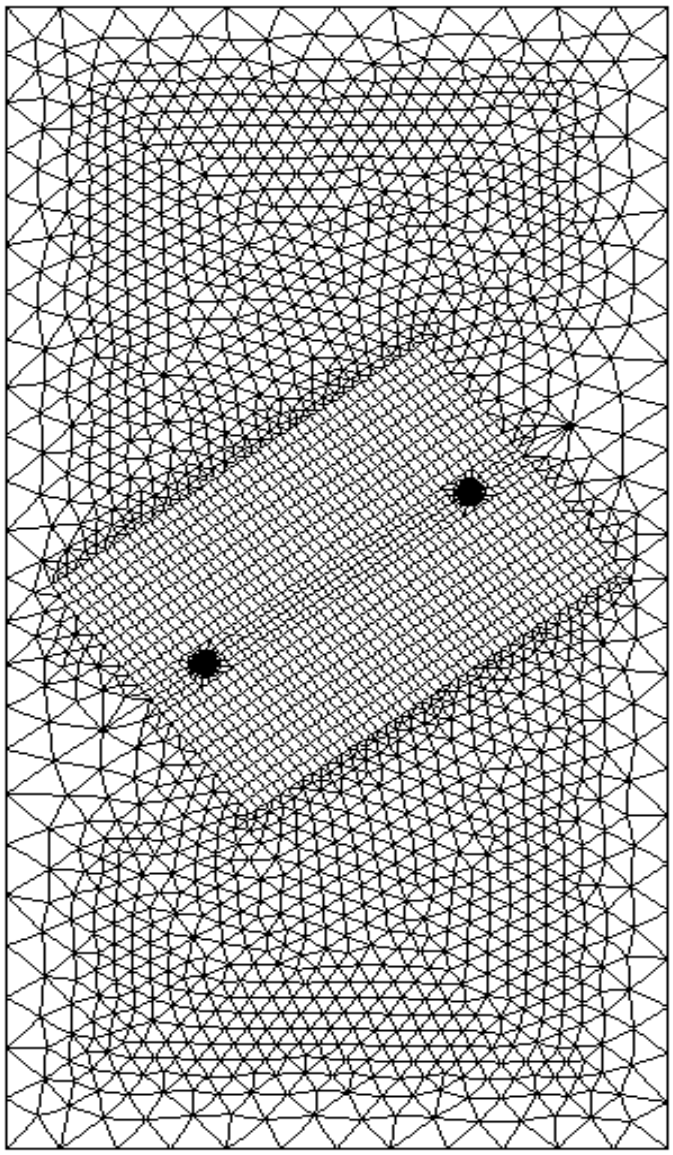
1 Y. MURAKAMI Stress intensity factors handbook, box 4.2, page 188. The Society of Materials Science, Japan, Pergamon Near, 1987.

3 Modelization A

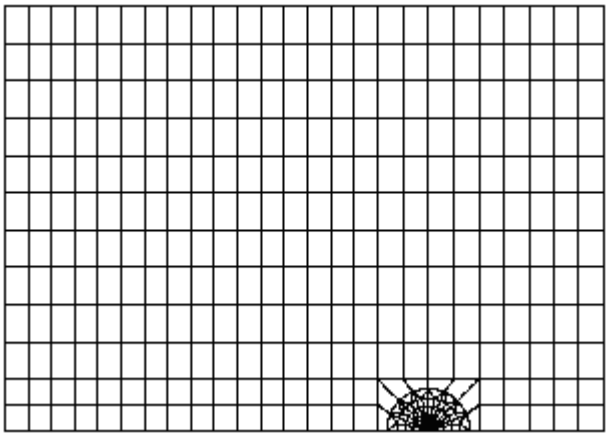
3.1 Characteristic of the Model



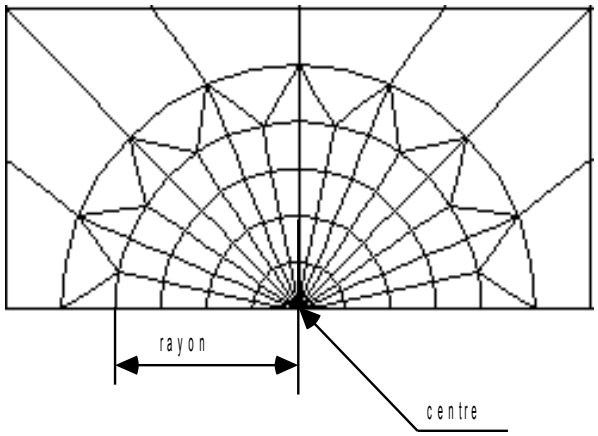
modelization complete



After symmetrization and directional sense



initial Block 2D



the radius is worth $7,5\text{E-}5\,m$

3.2 Characteristic of the mesh

The mesh consists of 14888 nodes and 6674 elements, including 1392 elements QUAD8 and 5282 elements TRIA6.

3.3 Quantities tested and Results

3.3.1 results got with CALC_G

Identification	Reference (analytical)	% tolerance
G	1,0019 102.2,0	
KI	3,5750 106.1,0	
KII	2,6939 106.1,0	

Table 3.3.1-1

3.3.2 Results got with POST_K1_K2_K3

Identification	Reference (analytical)	% tolerance
G	1,0019 102.4,0	
KI	3,5750 106.1,2	
KII	2,6939 106.3,0	

Table 3.3.2-1

values obtained with POST_K1_K2_K3 are also tested in NON-regression:

Identification	Reference (NON-regression)	% tolerance
G	96.85	0,1
KI	3,5379307159775 106.0,1	
KII	2,6179089643527 106.0,1	

Table 3.3.2-2

One also tests the possibility of directly giving to POST_K1_K2_K3 the arrays of the jumps of displacement, by making a test from ratio with the values previously obtained

Identification	Reference (another aster)	% tolerance
G	96.85	0,1
KI	3,5379307159775 106.0,1	
KII	2,6179089643527 106.0,1	

Table 3.3.2-3

4 Modelization B

4.1 Characteristic of the modelization

Even form of mesh that previously, but modification of the coordinates of the nodes mediums of the edges touching the crack tip, to move them with the quarter of these edges (method of Barsoum).

This modification of the coordinates of the nodes is carried out by an accessible procedure GIBI in card-indexing it data of mesh (SSLP313B.datg). Characteristics

4.2 of the mesh The mesh

consists of 14888 nodes and 6674 elements, whose 1392 elements QUAD 8 and 5282 elements SORTED 6. Quantities

4.3 tested and Results results

4.3.1 got with CALC_G Identification

Reference	(analytical) tolerance	% G
1,0019	102.2,0	KI
3,5750	106.1,0	KII
2,6939	106.1,0	Table

4.3 4.3.1-1

4.3.2 got with POST _K1_K2_K3 Identification

Reference	(analytical) tolerance	% G
1,0019	102.4,0	KI
3,5750	106.1,2	KII
2,6939	106.3,0	Table

4.3 4.3.2-1

5 of the results With

this choice of the limits of the field of computation, we about obtain variations on 1% the coefficients and K_I , K_{II} and rate of energy restitution. G With regard to

method POST _K1_K2_K3, the results are further away from the reference with a standard mesh (of with -1% -30% variation), on the other hand, with a mesh of the type Barsoum (nodes mediums with the quarter on the sides), recommended for this kind of method, the variations are understood enters and -3% , $+1.2\%$ which is relatively precise.