SSLP101 - Rate of energy restitution in plane stresses

Summarized:

It is about a test of fracture mechanics in static for a two-dimensional problem. One considers a plate fissured in plane stresses, the features tested are:

- rate of energy restitution G ,
- the rate of energy restitution calculated starting from the computation of the coefficients of stresses K_1 and K_2 .

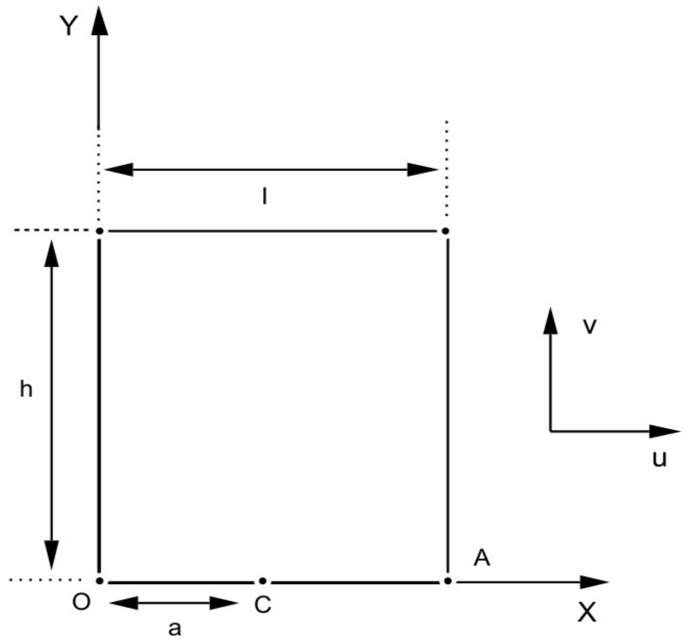
The interest of the test is to compare the value of G classic and the value of G (IRWIN) obtained from K_1 and K_2 . It also makes it possible to test the invariance of computation compared to integration contours.

This test contains 3 different modelizations: the modelization A which treated computation of the integral of Rice is supported more since version 3.

1 Problem of reference

1.1 Geometry

Plates rectangular with emerging OC crack.



For reasons of symmetry, the model is tiny room to half-structure $y\geq 0$.

Height plates: $h=250\,mm$

Width plates: $I=100\,mm$

Depth fissures: $a=37.5\,mm$ (OC)

1.2 Material properties

$E=200000\,MPa$ $\nu=0.3$

Assumption of the plane stresses.

1.3 Boundary conditions and loadings

- Forced imposed in $Y=h$: $\sigma=1\,MPa$
- Displacement for edge CA defined by: $a\leq X\leq l$ and $y=0$ $v=0.$
- Not fixes A : $u=v=0.$

For the modelization C one replaces the stress imposed by a pressure on the lips of crack.

2 Reference solution

2.1 Method of calculating used for STRAWLEY & the

reference solution Reference solution of BROWN [bib1]:

$J = F^2 \pi a \sigma^2 / E$ with $F = 1.98$

a in mm

σ and E N/mm^2

2.2 Results of reference for G

the results of reference $G = 1.98^2 \times \pi \times 37.5 \times 0.5\,10^{-5} = 2.3093\,10^{-3}\,Mpa.mm$

formula G (IRWIN) = $\frac{1}{E}\left(K_1^2 + K_2^2\right)$ led, like $K_2 = 0$, with $K_1 = 21.491\,MPa.mm^{1/2}$

2.3 Results of reference for derivatives G

While varying the Young modulus and the loading Fy, one notes that:

$G = \alpha F_Y^2$ with $\alpha = 2.3\,10^{-3}$ either $\frac{\partial G}{\partial F_Y} = 2\alpha F_Y$

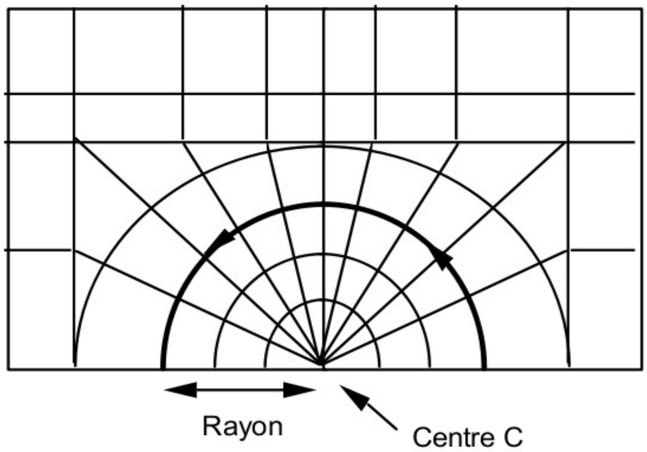
$G = \frac{\beta}{E}$ with $\beta = 460.$ or $\frac{\partial G}{\partial E} = -\frac{G}{E}$

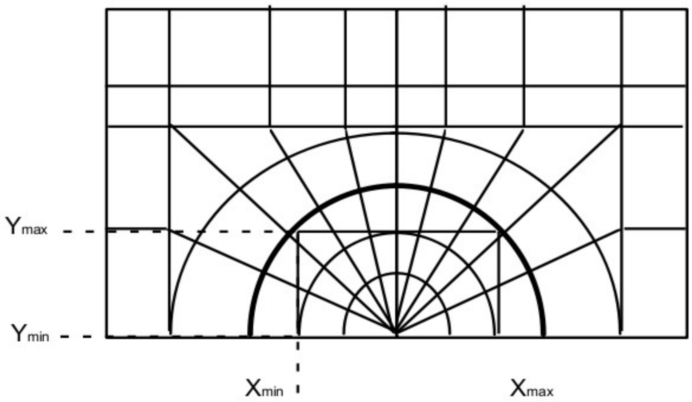
2.4 Bibliographical reference

1) Special BROWN-STAWLEY ASTM Technical Publication n° 410 (1966)

3 Modelization B

3.1 Characteristic of the modelization





One calculates the field θ. then rate of energy restitution G, the coefficients of stresses K_1 and K_2, the rate of energy restitution obtained by the formula of IRWIN, the direction of propagation of crack.

3.2 Characteristics of the mesh

Many nodes: 673

Number of meshes and types: 112 meshes `QUAD8` and 142 meshes `TRIA6`

3.3 Quantities tested and results

the values tested are the rate of refund of energy calculated by the method theta and the rate of refund of energy calculated by the formula of IRWIN starting from the coefficients of intensity of stresses K_1 and K_2.

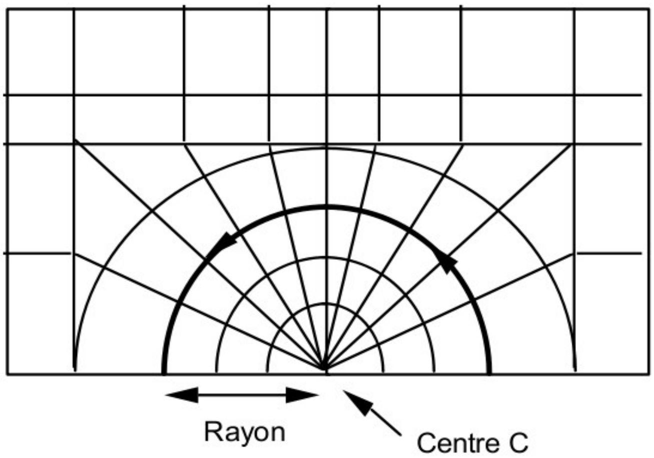
Identification	Reference	Tolerance
Contours 1 to 6 G	$2.3093\,10^{-3}$	<1%
Contours 1 to 6 G (IRWIN)	$2.3093\,10^{-3}$	<1%
Contours 1 to 6 K_1	24.491	<1%
Contours 1 to 6 K_2	$0.$	absolute

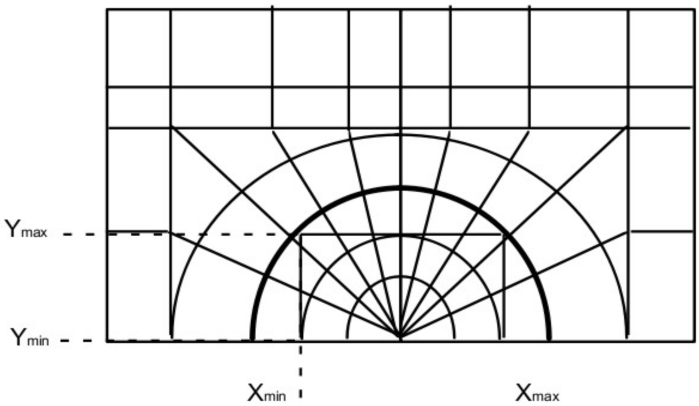
3.4 Remark

The computation of G K_1 K_2, G (IRWIN) $=\frac{1}{E}(K_1^2+K_2^2)$ was carried out from 6 different θ fields, corresponding each one to a circular ring centered in C.

4 Modelization C

4.1 Characteristic of the modelization





the loading differs:

- one relieves the stress imposed in $Y=h$,
- one imposes a pressure $p=-1$ on the lips of crack.

4.2 Characteristics of the mesh

Many nodes: 673

Number of meshes and types: 112 meshes `QUAD8` and 142 meshes `TRIA6`

4.3 Quantities tested and Values

results of G

Identification	**Reference**	**Tolerance**
Contours 1 to 6 G	$2.3093\,10^{-3}$	<1%
Contours 1 to 6 G (IRWIN)	$2.3093\,10^{-3}$	<1%
Contours 1 to 6 K_1	22.529	<1%
Contours 1 to 6 K_2	0.	absolute

4.4 Remark

The computation G K_1, K_2 and G (IRWIN) $=\frac{1}{E}(K_1^2+K_2^2)$ was carried out starting from the same fields θ as for the preceding modelization. The results are identical.

5 Modelization E

5.1 Characteristic of the modelization

the loading considered here is a variable loading along the lips of crack. One imposes a variable pressure on the lips of crack:

$$p=\frac{x-100}{37,5}.$$

One also imposes in a second resolution an equivalent force of contour on the lips. Theoretically, the results are the same ones.

5.2 Characteristics of the mesh

Mesh of the modelization C.

5.3 Quantities tested and Values

results of G resulting from CALC_G, option CALC_G.
Values of G, G_{IRWIN}, K_1 and K_2 exits of CALC_G, option CALC_K_G.

One tests these values for the 2 loadings quoted with the §5.15.1.

Identification	Reference	Tolerance
Contours 1 to 6 G	$6{,}0\,10^{-4}$	<0,5%
Contours 1 to 6 G (IRWIN)	$6{,}0\,10^{-4}$	<0,55%
Contours 1 to 6 K_1	10,95	<0,5%
Contours 1 to 6 K_2	0.	formulates

6 absolute Summary of

the results of G is not sensitive to the choice of the field of integration.