SSLP323 - Propagation of a radial crack leading to a disc in rotation

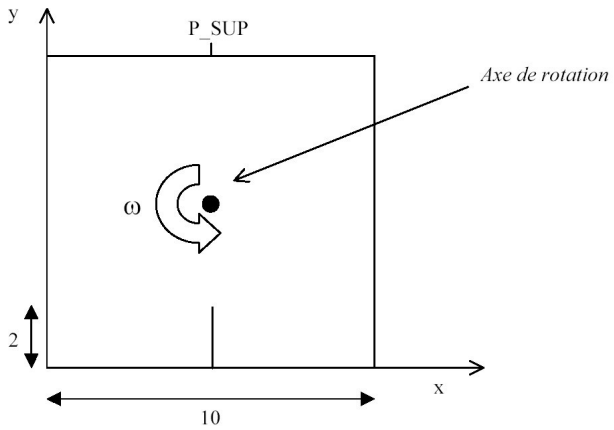
Summarized:

The goal of this test is to check that operator PROPA_FISS correctly treats the case of a crack propagation only caused by a loading in rotation.

It is checked that the factor of intensity of the stresses of cracks propagated is in conformity with the analytical solution.

1 Problem of reference

1.1 Geometry



Appears 1.1-a: Geometry of the fissured plate

geometrical Dimensions of the fissured plate:

Square side on $D=10\,m$

initial Length of crack: $a_0=2\,m$.
The crack emerges in the middle of a side ($L/2$).

1.2 Properties of the material

Young's modulus $E=206000\,MPa$
Poisson's ratio $\nu=0.33$
Density $\rho=7800\,kg/m^3$

1.3 Boundary conditions and loadings

In order to block the rigid body motion of the plate, one blocks the rotational axis in DX, DY and one blocks $\mathrm{P\_SUP}$ in DX.
The loading is only voluminal and induced by rotation, of pulsation $\omega=10$, normal axis to the plane of structure and of center $(5;5)$.

Three propagations are calculated by imposing a maximum advance of crack equalizes with $1\,mm$.

2 Reference solution

2.1 Method of calculating

One can by means of calculate the factors of intensity of the stresses the following equations [bib1]:

$$K_I = \frac{1+\alpha}{16}\rho\omega^2 D^2\sqrt{\pi a}\left(F(a/D) - \frac{3\alpha-1}{1+\alpha}G(a/D)\right)$$

with $F(a/D) = \frac{1{,}122 + 0{,}140(a/D) - 0{,}545(a/D)^2 + 0{,}405(a/D)^3}{(1-a/D)^{3/2}}$

$$G(a/D) = \frac{0{,}187[6 - 9(a/D) + 5(a/D)^2] - 7{,}35(a/D)^2\cdot(1-A/D)\ \cdot(1-0{,}5(a/D))}{(1-a/D)^{3/2}}$$

and $\alpha = \frac{1}{2}\left(\frac{1}{1-\nu}\right)$ in bibliographical

2.2 plane stresses References

[1] H. Tada, PC Paris, G.R. Irwin, “The Stress Analysis of Cracks Handbook -3rd ED. ”, ASME Close 2000

3 Modelization A

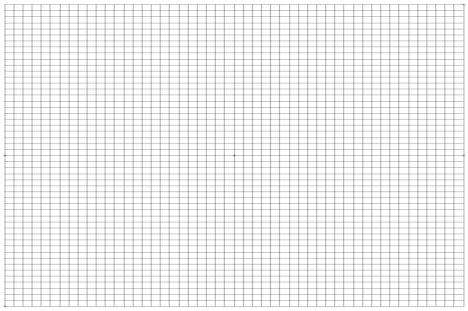
3.1 Characteristic of the modelization

method SIMPLEXE are used by PROPA_FISS to solve the equations of propagation of crack.

3.2 Characteristics of the mesh

the structure is modelled by a mesh made up of 2500 elements QUAD4 (see Appear 3.2-a).
The crack is not with a grid. It is modelled by the method XFEM and initially defined by two level-sets:

$$LSN = x - D$$
$$LST = y - a_0$$



Appear 3.2-a: mesh of the structure

3.3 Quantities tested and results

One tests the values of K_I with each step of propagation.

Propagation	K_I aster [$Pa\sqrt{mm}$]	K_I reference [$Pa\sqrt{mm}$]	Variation (%)
1	3.2071E+07	3.2304E+07	-0,72
2	5.1715E+07	5.0561E+07	2,28
3	7,7756E+07	7,6587E+07	1,53

4 Modelization B

4.1 Characteristic of the modelization

method GEOMETRIQUE is used by PROPA_FISS to update the position of crack.

4.2 Characteristics of the mesh

One uses the same mesh as that used for modelization A.

4.3 Grandeurs tested and results

One tests the values of K_I with each step of propagation.

Propagation	K_I aster [$Pa\sqrt{mm}$]	K_I reference [$Pa\sqrt{mm}$]	Variation (%)
1	3.2075E+07	3.2304E+07	0.747%
2	5.2244E+07	5.0561E+07	3.32%
3	7.8804E+07	7.6587E+07	2.88%

5 Summary of the results

the propagation of a radial crack under a loading of rotation is reproduced perfectly by the modelization XFEM of Code_Aster.