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

Summary:

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

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

Moreover, one uses these modelings in order to validate the use of the indicator of error in residue in mechanics 'ERME_ELEM' on a modeling 2D in the presence of rotations.

1 Problem of reference

1.1 Geometry

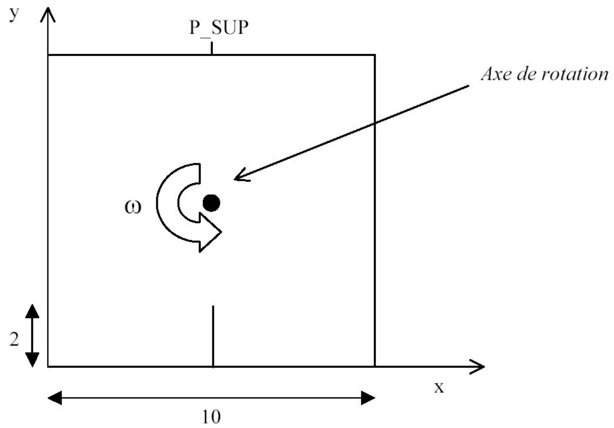

Figure 1.1-a: Geometry of the fissured plate

Geometrical dimensions of the fissured plate:

Square side on $D=10\,m$

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

1.2 Properties of material

Young 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 movement of body of the plate, one blocks the axis of rotation in DX , DY and one blocks P_SUP in DX .
The loading is only voluminal and induced by rotation, of pulsation $\omega=10$, of normal axis to the plan of the structure and of center $(5;5)$.

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

2 Reference solution

2.1 Method of calculating

One can calculate the factors of intensity of the constraints by using 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 $F(a/D)=\frac{1{,}122+0{,}140(a/D)-0{,}545(a/D)^2+0{,}405(a/D)^3}{(1-a/D)^{3/2}}$

$$G(a/D)=\frac{0{,}187[6-9(a/D)+5(a/D)^2]-7{,}35(a/D)^2\cdot(1-A/D)^4\cdot(1-0{,}5(a/D))}{(1-a/D)^{3/2}}$$

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

2.2 Bibliographical references

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

3 Modeling A

3.1 Characteristics of modeling

Method SIMPLEX is used by PROPA_FISS to solve the equations of propagation of the crack.

3.2 Characteristics of the grid

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

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

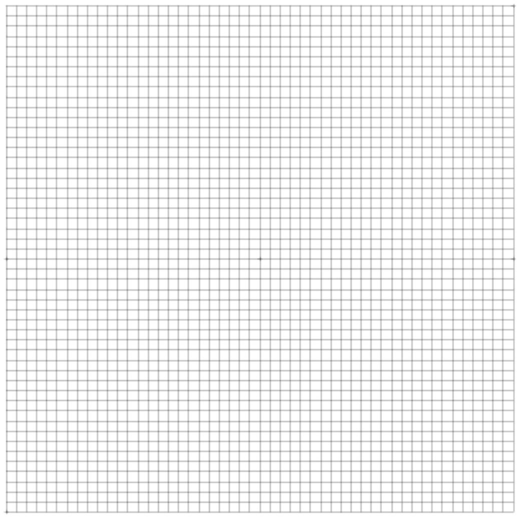

Figure 3.2-a: grid of the structure

3.3 Sizes tested and results

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

Size	Propagation	Type of reference	Value of reference ($Pa\sqrt{mm}$)	Tolerance (%)
K_I	1	'ANALYTICAL'	32030644.1127	5.0
K_I	2	'ANALYTICAL'	52126639.0648	5.0
K_I	3	'ANALYTICAL'	78186891.9838	5.0

One also tests the indicator of error in residue in mechanics 'ERME_ELEM' on the last step of propagation (in not-regression only) in order to validate the use of this indicator on modelings 2D with rotations.

4 Modeling B

4.1 Characteristics of modeling

Method GEOMETRICAL is used by PROPA_FISS to update the position of the crack.

4.2 Characteristics of the grid

One uses the same grid as that used for modeling A.

4.3 Sizes tested and results

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

Size	Propagation	Type of reference	Value of reference ($Pa\sqrt{mm}$)	Tolerance (%)
K_I	1	'ANALYTICAL'	32030644.112693	5.0
K_I	2	'ANALYTICAL'	52126536.927129	5.0
K_I	3	'ANALYTICAL'	78186936.734937	5.0

One also tests the indicator of error in residue in mechanics 'ERME_ELEM' on the last step of propagation (in not-regression only) in order to validate the use of this indicator on modelings 2D with rotations.

5 Summary of the results

The propagation of a radial crack under a loading of rotation is reproduced perfectly by modeling XFEM of Code_Aster.

The indicator of error in residue in mechanics 'ERME_ELEM' function correctly for modelings 2D containing rotations.