SSNV192 - Test-tube with central crack with XFEM

Summary

This test sets up a central crack in a test-tube with $\mathrm{X\text{-}FEM}$. There are thus two distinct funds of crack. The objective is to validate the separate taking into account several funds of crack, and the relevance of the results on K_I on the various funds.

1 Problem of reference

1.1 Geometry

The structure is a plate $3D$ dimensions $L_X = B = 1\,m$, $L_Y = 2.W = 10\,m$ and $L_Z = 2.L = 20\,m$, comprising a crack central length planes $2.a = 2\,m$, centered compared to the test-tube according to Y and Z and emerging of the two with dimensions ones according to X (see Figure 1.1-1).

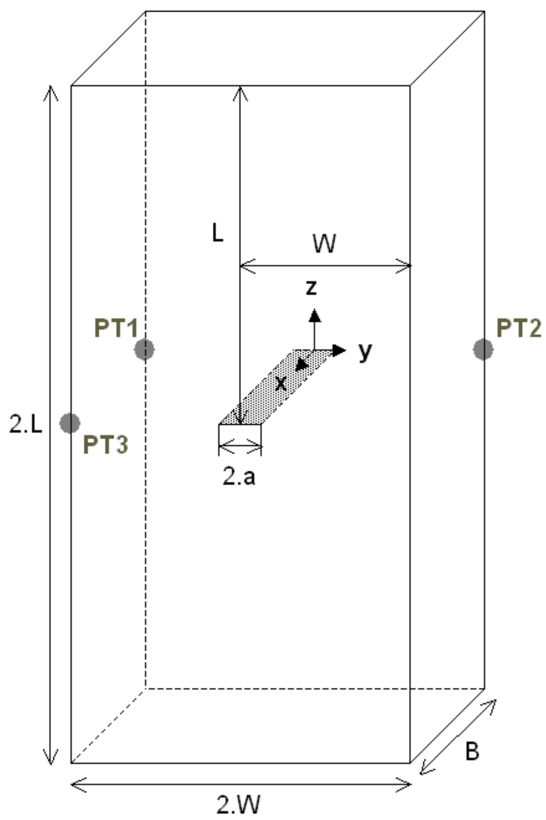

Figure 1.1-1 : Test-tube with emerging central crack

One will make use of the points $PT1(0;-W;0)$, $PT2(0;W;0)$ and $PT3(B;-W;0)$ to block the rigid modes.

1.2 Properties of material

Young modulus: $E = 1\,MPa$
Poisson's ratio: $\nu = 0$

2 Reference solution

2.1 Method of calculating

The analytical solution of the problem is:

$$K_I = \frac{P}{B\sqrt{W}} f\left(\frac{a}{W}\right)$$

with
$$f\left(\frac{a}{W}\right) = \sqrt{\frac{\pi a}{4\mathrm{W}\cos\left(\frac{\pi a}{2W}\right)}}\left[1-0.025\left(\frac{a}{W}\right)^2 + 0{,}06\left(\frac{a}{W}\right)^4\right]$$

and
$$P = \sigma \times 2\mathrm{W} \times B$$

2.2 Sizes tested and results

$$\begin{Bmatrix} \sigma = 1\,Pa \\ B = 1\,m \\ a = 1\,m \\ W = 5\,m \end{Bmatrix}$$

$$f\left(\frac{a}{W}\right) = 0{,}406$$
$$K_I = 1{,}81584\,Pa\,\sqrt{m}$$

2.3 Uncertainties on the solution

Analytical solution.

2.4 Bibliographical references

[1] GENIAUT S., MASSIN P.: Method X-FEM, Handbook of reference of *Code_Aster*, [R7.02.12]

3 Modeling A

It is a uniform case of traction. In this modeling, one seeks to validate the definition of multiple funds of crack with the operator DEFI_FISS_XFEM [U4.82.08] and the calculation of K_I in bottom of crack separately on a bottom and the other of the crack.
The central crack of half-length $a=1\text{m}$ is represented by the level sets:

$$\begin{cases} LSN=z \\ LST=|Y|-a \end{cases}$$

3.1 Characteristics of the grid

The structure is with a grid starting from elements HEXA and PENTA. The number of external elements is of 3 elements according to X, 10 elements according to Y, and 10 elements according to Z.
A central zone of dimension $1\times3\times2$ containing the crack ($-1{,}5<Y<1{,}5$ and $-1<Z<1$) is with a grid more finely exclusively with elements HEXA : 21 elements on Y, 15 elements on Z.
The full number of voluminal elements is: 564 PENTA and 2556 HEXA20.

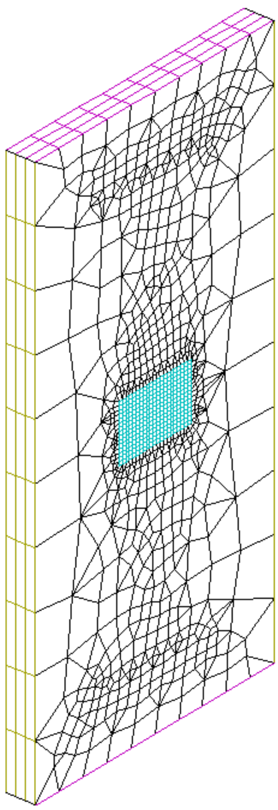

Figure 3.1-1 : Grid with central zone refined in HEXA8

3.2 Boundary conditions and loadings

One applies to the faces lower and higher a loading of traction by a left again pressure:

$$\sigma_{zz}=1\,\text{Pa}$$

The blocking of the rigid modes is applied to the points $PT1$, $PT2$ and $PT3$ (see Figure 1.1-1):

$$PT_1 \begin{cases} DX_1=0 \\ DY_1=0 \\ DZ_1=0 \end{cases}, \quad PT_2 \begin{cases} DX_2=0 \\ DZ_2=0 \end{cases} \quad \text{and} \quad PT_3 \{ DZ_3=0$$

3.3 Sizes tested and results

One tests the values of K_I on the two funds of crack separately for various crowns of integration. The values of the lower and higher rays of the torus are the following ones:

	Crown 1	Crown 2	Crown 3	Crown 4	Crown 5	Crown 6
Rinf	0.1	0.2	0.3	0.1	0.1	0.2
Rsup	0.2	0.3	0.4	0.3	0.4	0.4

Table 3.1-1

To test all the nodes of the bottom of crack in only once, one tests the minimal and maximum values of K_I on all the nodes of the bottom of crack.

Fund of crack 1:

Identification	*Aster*	Reference	% difference
Crown 1 : MAX (K_I)	1.85096	1.81584	1,934
Crown 1 : MIN (K_I)	1.84498	1.81584	1,605
Crown 2 : MAX (K_I)	1.81457	1.81584	-0,070
Crown 2 : MIN (K_I)	1.80860	1.81584	-0,399
Crown 3 : MAX (K_I)	1.80253	1.81584	-0,733
Crown 3 : MIN (K_I)	1.79653	1.81584	-1,063
Crown 4 : MAX (K_I)	1.83276	1.81584	0,932
Crown 4 : MIN (K_I)	1.82679	1.81584	0,603
Crown 5 : MAX (K_I)	1.82269	1.81584	0,377
Crown 5 : MIN (K_I)	1.81671	1.81584	0,047
Crown 6 : MAX (K_I)	1.80855	1.81584	-0,402
Crown 6 : MIN (K_I)	1.80257	1.81584	-0,731

Fund of crack 2:

Identification	*Aster*	Reference	% difference
Crown 1 : MAX (K_I)	1.84905	1.81584	1,828
Crown 1 : MIN (K_I)	1.84450	1.81584	1,578
Crown 2 : MAX (K_I)	1.81267	1.81584	-0,175
Crown 2 : MIN (K_I)	1.80813	1.81584	-0,425
Crown 3 : MAX (K_I)	1.80063	1.81584	-0,838
Crown 3 : MIN (K_I)	1.79607	1.81584	-1,089
Crown 4 : MAX (K_I)	1.83086	1.81584	0,827
Crown 4 : MIN (K_I)	1.82632	1.81584	0,577
Crown 5 : MAX (K_I)	1.81623	1.81584	0,272
Crown 5 : MIN (K_I)	1.82078	1.81584	0,021
Crown 6 : MAX (K_I)	1.80665	1.81584	-0,507
Crown 6 : MIN (K_I)	1.80210	1.81584	-0,757

3.4 Comments

The results are stable for the various crowns, and the various points of the funds of crack. They are sufficiently close to the expected values.

3.5 Remarks

In it CAS-test, tables resulting from DEFI_FISS_XFEM are printed in order to make sure that those are coherent with information of DEFI_FISS_XFEM in INFO=2. Thus tables FOND_FISS and NB_FOND_FISS are recovered while using RECU_TABLE and are then printed in using IMPR_TABLE. The value amongst funds of crack is recovered by EXTR_TABLE and is then used for the calculation of G (CALC_G) on all the funds of crack.

Moreover, impression of the grid of visualization X-FEM is also realized in order to make sure of the good construction of the nodes, meshs, groups of meshs and groups of nodes in bottom of cracks.

4 Summary of the results

The objective was to validate the separate taking into account several funds of crack, and the relevance of the results on K_I on the various funds. The test is conclusive.