SSNV192 - Test-tube with central crack with XFEM

Summarized

This test sets up a central crack in a test-tube with $\mathrm{X\text{-}FEM}$. There are thus two distinct crack tips. The purpose is to validate the separate taking into account several crack tips, 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 $3D$ of dimensions $L_X = B = 1\,m$, $L_Y = 2.\mathrm{W} = 10\,m$ and $L_Z = 2.\mathrm{L} = 20\,m$, comprising a crack planes central length $2.\mathrm{a} = 2\,m$, centered compared to the test-tube according to Y and Z emerging of the two with dimensions ones according to X (see Figure 1.1-1).

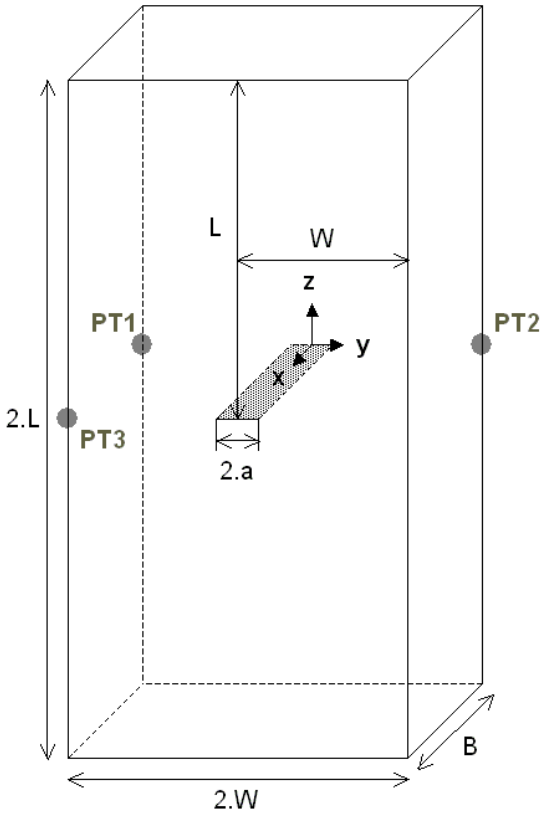

Figure 1.1-1 : Test-tube with emerging central crack

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 the material

Modulus Young: $E = 1\,MPa$
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 Quantities tested and Uncertainties

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

$$f\left(\frac{a}{W}\right) = 0{,}406$$

$$K_I = 1{,}81584\ Pa\sqrt{m}$$

2.3 results on the analytical

solution Solution.

2.4 Bibliographical references

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

3 Modelization A

It is a uniform case of tension. In this modelization, one seeks to validate the definition of multiple crack tips with the operator DEFI_FISS_XFEM [U4.82.08] and the computation of K_I in crack tip separately on a bottom and the other of 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 mesh

the structure is with a grid 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 $1 \times 3 \times 2$ containing crack ($-1,5 < Y < 1,5$ and $-1 < Z < 1$) is with a grid more finely exclusively with elements HEXA : 21 elements out of Y, 15 elements on Z.
The nombre total of voluminal elements is: 564 PENTA and 2556 HEXA20.

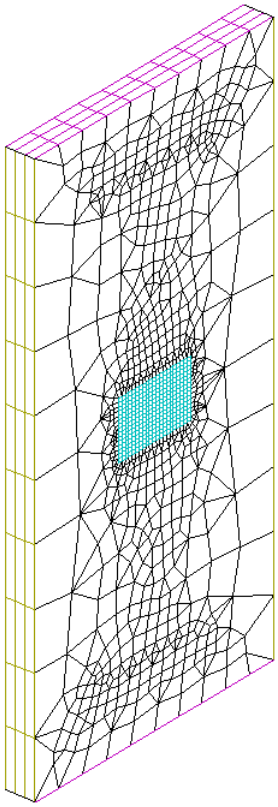

Figure 3.1-1 : Mesh with central zone refined in HEXA8

3.2 Boundary conditions and loadings

One applies to the lower and higher sides a loading of tension by a distributed 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):

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

3.3 Quantities tested and results

One tests the values of K_I on the two crack tips separately for various integration contours. The values of radius lower and superiors of the torus are the following ones:

	Crown 1	Contour 2	Crowns 3	Contour 4	Crowns 5	Contour 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 crack tip in only once, one on all the tests the minimal and maximum values K_I of nodes of the crack tip.

Crack tip 1:

Identification	*Aster*	Reference	% difference
Crowns 1: MAX (KI)	1.85096	1.81584	1.934
Contour 1: MIN (KI)	1.84498	1.81584	1.605
Contour 2: MAX (KI)	1.81457	1.81584	-0.070
Contour 2: MIN (KI)	1.80860	1.81584	-0.399
Contour 3: MAX (KI)	1.80253	1.81584	-0.733
Contour 3: MIN (KI)	1.79653	1.81584	-1.063
Contour 4: MAX (KI)	1.83276	1.81584	0.932
Contour 4: MIN (KI)	1.82679	1.81584	0.603
Contour 5: MAX (KI)	1.82269	1.81584	0.377
Contour 5: MIN (KI)	1.81671	1.81584	0.047
Contour 6: MAX (KI)	1.80855	1.81584	-0.402
Contour 6: MIN (KI)	1.80257	1.81584	-0.731

Crack tip 2:

Identification	*Aster*	Reference	% difference
Crowns 1: MAX (KI)	1.84905	1.81584	1.828
Contour 1: MIN (KI)	1.84450	1.81584	1.578
Contour 2: MAX (KI)	1.81267	1.81584	-0.175
Contour 2: MIN (KI)	1.80813	1.81584	-0.425
Contour 3: MAX (KI)	1.80063	1.81584	-0.838
Contour 3: MIN (KI)	1.79607	1.81584	-1.089
Contour 4: MAX (KI)	1.83086	1.81584	0.827
Contour 4: MIN (KI)	1.82632	1.81584	0.577
Contour 5: MAX (KI)	1.81623	1.81584	0.272
Contour 5: MIN (KI)	1.82078	1.81584	0.021
Contour 6: MAX (KI)	1.80665	1.81584	-0.507
Contour 6: MIN (KI)	1.80210	1.81584	-0.757

3.4 Comments

the results are stable for various contours, and the various points of the crack tips. They are sufficiently close to the expected values.

3.5 Remarks

In this case, the arrays 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 arrays FOND_FISS and NB_FOND_FISS are recovered by means of RECU_TABLE and are then printed by means of IMPR_TABLE. The value amongst crack tips is recovered by EXTR_TABLE and is then used for the computation of G (CALC_G) on all the crack tips.

Moreover, the printing of the mesh of visualization X-FEM is also carried out in order to make sure of the good construction of the nodes, of meshes, of the mesh groups and the nodes groups in crack tip.

4 Summary of the results

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