

FORMA07 - Practical works of the formation “advanced Use”: circular crack in infinite medium

Summary:

This test 3D into quasi-static, enters within the framework of the validation of postprocessings in linear elastic breaking process. The structure comprising a circular crack is put in traction.

1 Problem of reference

1.1 Geometry

One is interested in a cube subjected to a tractive effort comprising a horizontal circular crack of ray $a = 2\text{ m}$. A cube on side will be considered $10a$.

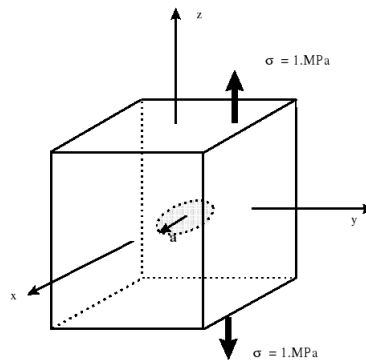


Figure 1.1-a: geometry

1.2 Material properties

One considers a linear elastic isotropic material homogeneous whose characteristics are the following ones:

- Young modulus $E = 200\,000\text{ Mpa}$,
- Coefficient of Fish $\nu = 0,3$.

1.3 Boundary conditions and loadings

The structure is in traction ($\sigma = 1\text{ MPa}$).

2 Reference solution

2.1 Method used for the reference solution

For a circular crack of ray a in an infinite medium, subjected to a uniform traction σ according to the normal with the plan of the lips, the rate of refund of energy room $G(s)$ is independent of the curvilinear X-coordinate along the face of crack s and expresses itself in the following way [1]:

$$G(s) = \frac{(1-\nu^2)}{\pi E} 4\sigma^2 a$$

The stress intensity factor $K_I(s)$ is given by the formula of Irwin:

$$G(s) = \frac{(1-\nu^2)}{E} K_I^2, \text{ that is to say } K_I(s) = \frac{2\sigma\sqrt{a}}{\sqrt{\pi}}$$

2.2 Results of reference

With the digital values of the statement, one finds: $K_I = 1,5957\text{ MPa} \cdot \sqrt{m}$ and $G = 11,59\text{ J.m}^{-2}$.

2.3 Bibliographical references

- H. Tada, P. Paris, G. Irwin, The stress analysis of aces handbook, 3rd edition, 2000

3 Modeling a: FEM 3D

3.1 Unfolding of the TP

3.1.1 Grid

The quadratic grid of the structure is provided to format MED: `forma07a.mmed`. By taking into account certain symmetries of the problem, only a quarter of the structure is represented. One could only represent $1/8^{\text{ème}}$ structure. The grid was generated with software GIBI, and of the tori are defined around the bottom of crack:

- ray of the smallest torus: $0,12\text{ m}$,
- ray of the largest torus: $0,53\text{ m}$.

The nodes mediums of the edges of the elements touching the bottom of crack are moved with the quarter of these edges.

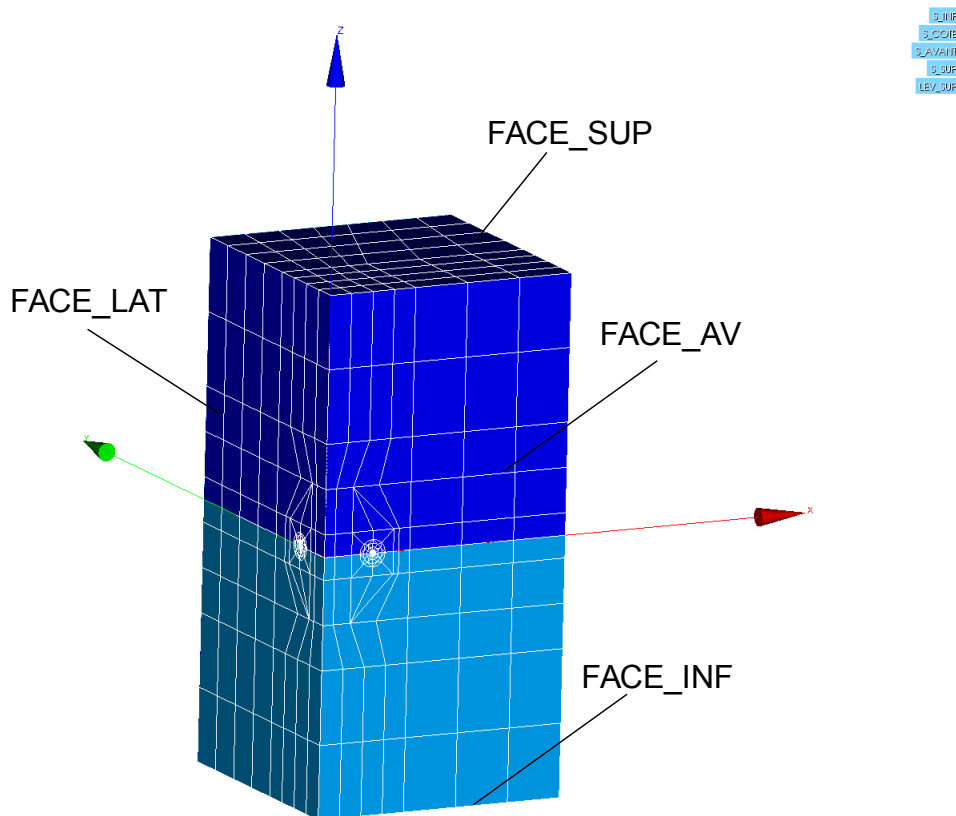


Figure 3.1.1-a: Grid

3.1.2 Calculation of the field of displacement

The command file with the model (3D), material (elastic linear), the loadings (traction) and the conditions of symmetry on the two side faces is provided: file `forma07a.comm`.

To visualize the fields of displacement and constraints obtained.

3.1.3 Calculation of K and G

In the provided file, the bottom of crack is already defined with `DEFI_FOND_FISS` starting from the groups of meshes of the bottom and lips. To calculate the rate of refund of energy room (smoothing by default) and total with `CALC_G` and to compare with the reference solution.

For the calculation of the factors of intensity of the constraints along the bottom of crack, to use POST_K1_K2_K3 and to compare the solution obtained with the reference solution.

3.1.4 Studies of influence

To study the influence of the options of smoothing in CALC_G (options CALC_G): degree of the polynomial of LEGENDRE , smoothing LAGRANGE and its alternatives...

One will compare the results got by plotting the curves.

(to save time, you can die-comment the last instructions of the file forma07a .comm)

3.2 Sizes tested and results

Identification	Reference	% tolerance
K_I of POST_K1_K2_K3	1.5957 10 ⁶	0.8%

4 Modeling b: X-FEM 3D

The problem considered is the same one as that studied in part II. However, contrary to the preceding part where the crack was with a grid, one considers in this part a healthy grid. The crack is thus not with a grid. For that, method X-FEM is used.

4.1 Unfolding of the TP

4.1.1 Grid

Starting from a relatively coarse healthy grid, to use LOBSTER to obtain a refined grid. To create the coarse grid with Salomé or to use that provided:

```
forma07b.mmed
```

A procedure of refinement to be supplemented is provided. She calls on Lobster in a loop python (file not éditable with Efficas). Note that to use it you must define the crack (see following paragraph):

```
forma07b.comm
```

If you wish to pass this stage, you can also directly use the provided refined grid:

```
forma07b.41
```

In the provided grids (visualize them in Salomé), the names of the groups of meshes are the following:

- group of nodes: D,
- groups of faces: FACE_AV, FACE_LAT, FACE_SUP, FACE_INF,
- group of volumes: CUBIC.

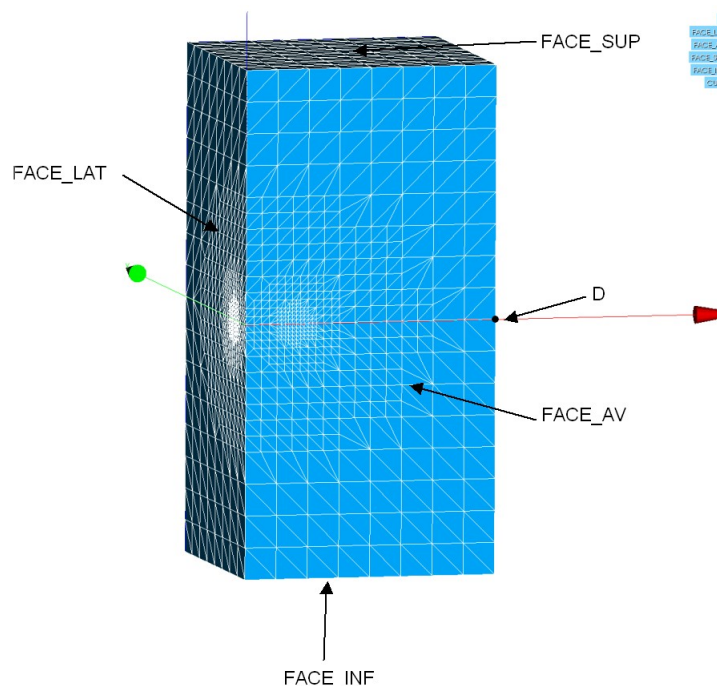


Figure 4.1.1-a: Groups defined on the provided grid

4.1.2 Definition of the crack and elements X-FEM

The crack is defined by the order `DEFI_FISS_XFEM`. Use the catalogue of cracks preferably. This order requires a grid and a model.

Elements X-FEM are then defined via a new model, by the order `MODI_MODELE_XFEM`.

4.1.3 Calculation of the field of displacement

The command file with the model (3D), material (elastic linear), the loadings (traction) and the conditions of symmetry on the two side faces is provided, it misses only the definition of the crack (a base is created to facilitate postprocessing - > to use astk): `forma07b.com1`

To visualize the fields of displacement and constraints obtained.

4.1.4 Calculation of K and G

In continuation, calculate G and K along the bottom of crack with the orders `CALC_G` and `POST_K1_K2_K3`. Compare the results with the analytical solution. Compare times between the 2 orders.

To test smoothing `LAGRANGE`. What does one observe T?

In order to improve the results, to test the uniform distribution of n points along the bottom of crack (`CALC_G/THETA/NB_POINT_FOND`) with various values of n .

Other tracks: refinement/enrichment on several layers

4.2 Sizes tested and results

Identification	Reference	% tolerance
K_I of <code>POST_K1_K2_K3</code>	1.5957 10 ⁶	13%