

SSNA120 – Axisymmetric test-tube notched (AE) with elements of joint and interface

Summary:

Modeling A makes it possible to make sure of nonthe regression of a functionality of `Code_Aster` in breaking process and to compare it with a local approach (Rousselier). The functionality tested is the cohesive law for the ductile rupture: `CZM_TRA_MIX` [R7.02.11].

A notched axisymmetric test-tube is requested in traction. The evolution of the force and the diametrical contraction during the propagation of the ductile rupture is calculated. The modeling of the test-tube is carried out with elements `2D` (`QUA8`).

In addition modeling B makes it possible to validate the elements of joint in axis (`AXIS_JOINT`) with the law `CZM_LIN_REG`.

1 Problem of reference

1.1 Geometry and loading

One considers a notched axisymmetric test-tube of type *AE4*. The cohesive zone represented by elements of interface (modeling A) or elements of joint (modeling B) is positioned on the line *AB*.

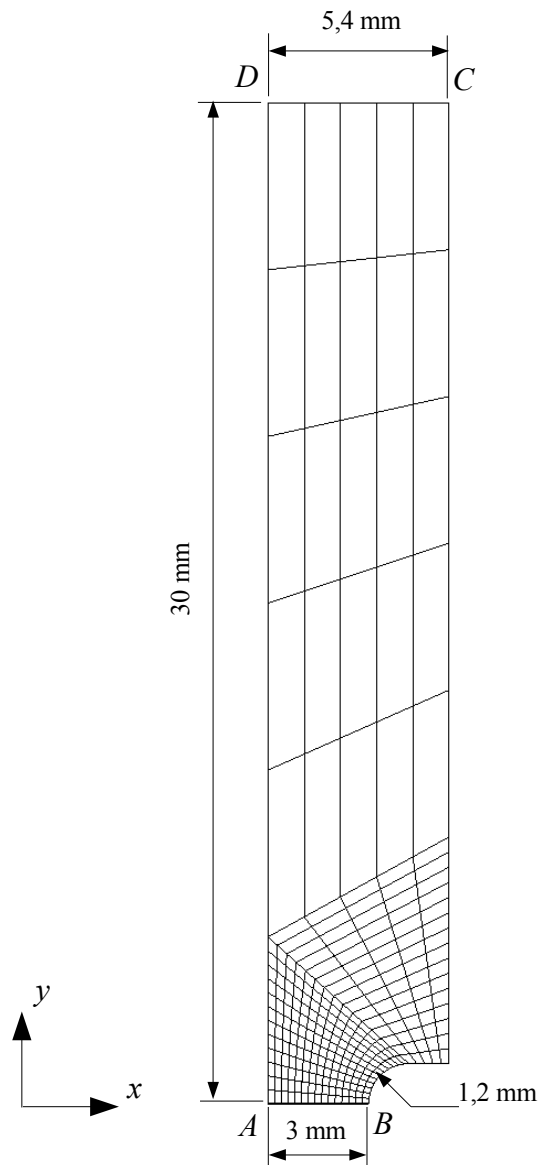


Figure 1 : Geometry of the test-tube *AE4*.

1.2 Properties of material

To describe the behavior of material of the axisymmetric test-tube (voluminal material), one uses an elastoplastic law of behaviour with an isotropic work hardening (law *VMIS_ISOT_TRAC*).

One takes: $E = 207 \text{ GPa}$ and $\nu = 0.3$ and the curve of work hardening retained is given below:

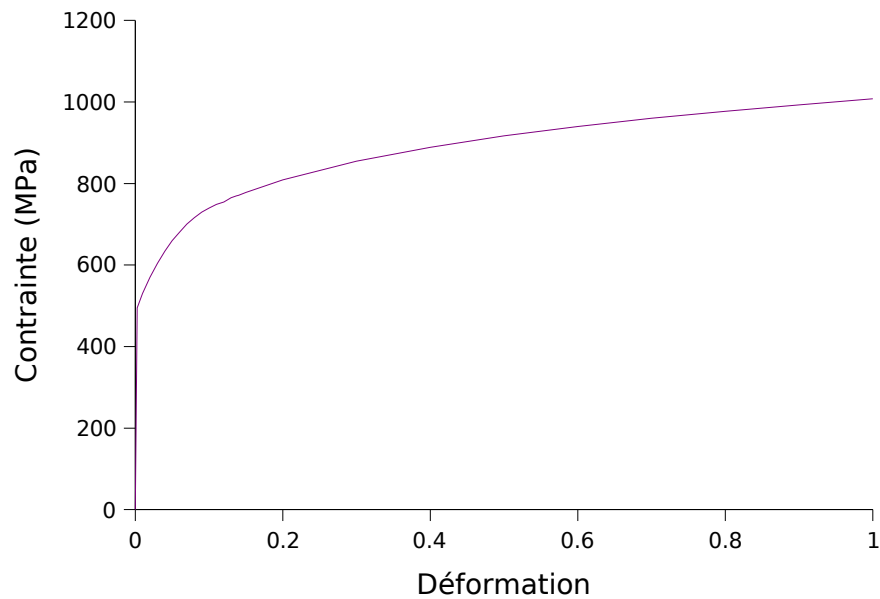


Figure 2 : Isotropic curve of work hardening of voluminal material.

One represents the crack with two different laws for modelings A and b:

Modeling a:

For the elements of interface the following parameters are used in the law `CZM_TRA_MIX` :

$\sigma_c = 1200 \text{ MPa}$, $G_c = 130 \text{ MPa}\cdot\text{mm}$, $\delta_e = 0.01 \text{ mm}$, $\delta_p = 0.07 \text{ mm}$, $\delta_c = 0.157 \text{ mm}$,
The law which results from this is schematized below.

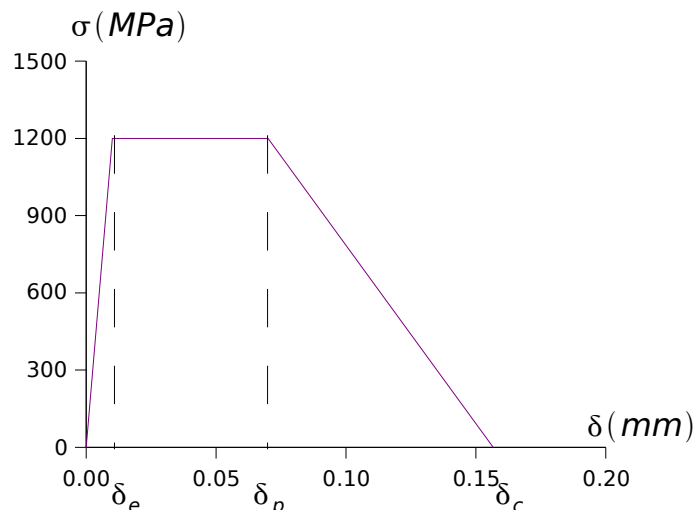


Figure 3 : Law of behavior of the elements of interface.

NB: Only half of the crack is modelled thanks to the symmetry of the problem, the tenacity of material is of $2G_c$.

Modeling b:

For the elements of joint the following parameters are used in the law `CZM_LIN_REG`:

$\sigma_c = 1200 \text{ MPa}$, $G_c = 130 \text{ MPa}\cdot\text{mm}$, $\text{pena adherence} = 1.E-5$

NB: Only half of the crack is modelled thanks to the symmetry of the problem, the tenacity of material is of $2G_c$.

1.3 Boundary conditions and loading

While referring to figure 1, the boundary conditions are the following ones:

- displacement in X blocked on the line AD ,
- imposed displacement l according to the direction Y on the line DC .

Evolution of displacement l in the course of time is given in the following table:

| | | |
|-----------------------|---|-----|
| Time [s] | 0 | 1 |
| Displacement l [mm] | 0 | 0.5 |

The cohesive zone is represented by the elements of interface on the line AB . The upper lip of the elements of interface is called AB and the lower lip is called $A'B'$. The boundary conditions on the elements of interface are:

- displacement in X imposed on the lips AB and $A'B'$: $DX_{AB} = DX_{A'B'}$
- displacement in Y blocked on the line $A'B'$.

2 Reference solution

2.1 Sizes and results of reference

The displacement of the node B according to X (DEPL) and forces it applied to the test-tube (REAC_NODA) were calculated.

For modeling a:

A comparison is carried out with two different calculations:

- a former execution of Code_Aster with the law CZM_TRA_MIX, it is about a case test of not-regression;
- a former execution of Code_Aster where the ductile rupture is modelled with the model of Rousselier by the law ROUSS_PR.

In the case of modeling with the model of Rousselier, the parameters retained for this model are the following: $D=2$, $SIGM_1=460$ and $f0=0,0005$

For modeling b: one carries out only tests of not-regression.

3 Modeling A

3.1 Characteristics of modeling

The modeling of ductile rupture is carried out with modeling `AXIS_INTERFACE` and the law `CZM_TRA_MIX`. The elements of volume are modelled with the model `AXIS`.

3.2 Characteristics of the grid

The grid of entry is linear. It is transformed into a quadratic grid by `LINE_QUAD` in `CREA_MAILLAGE`. After the transformation its characteristics are the following ones:

Many nodes: 962

Many elements: 280 `QUAD8`.

Many elements of interface: 15 `QUAD8`.

3.3 Sizes tested and results

Test of nonregression : diametrical contraction ($-2 \times DX$ point B), force of traction (the resultant DY of `REAC_NODA` on CD multiplied by 2π) according to the displacement of traction DY (on CD).

For a displacement of $0,3\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Tolerance (%) |
|----------------------|------------|-----------------|
| Contraction (mm) | 0.605676 | 0.10 |
| Force (kN) | 28.8696 | 0.10 |

For a displacement of $0,4\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Tolerance (%) |
|----------------------|------------|-----------------|
| Contraction (mm) | 0.931629 | 0.10 |
| Force (kN) | 23.6023 | 0.10 |

Test of nonregression on the calculation carried out with the model of Rousselier : diametrical contraction ($-2 \times DX$ point B), force of traction (the resultant DY of `REAC_NODA` on CD multiplied by 2π) according to the displacement of traction (DY on CD).

For a displacement of $0,2\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Rousselier | Error (%) |
|----------------------|------------|------------|-------------|
| Contraction (mm) | 0.333202 | 0.349885 | 4.8 |
| Force (kN) | 29.3851 | 29.3597 | 0,087 |

For a displacement of $0,3\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Rousselier | Error (%) |
|----------------------|------------|------------|-------------|
| Contraction (mm) | 0.605676 | 0.620591 | 2.4 |
| Force (kN) | 28.8696 | 28.6069 | 0.92 |

For a displacement of $0,4\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Rousselier | Error (%) |
|----------------------|------------|------------|-------------|
| Contraction (mm) | 0.931629 | 0.954683 | 2.4 |

Code Aster

Version
default

Titre : SSNA120 - Eprouvette axisymétrique entaillée (AE) [...]
Responsable : LAVERNE Jérôme

Date : 12/09/2013 Page : 7/9
Clé : V6.01.120 Révision :
c2c9de277f44

| | | | |
|----------------|---------|---------|----------|
| Force (kN) | 23.5744 | 22.6731 | 01/04/00 |
|----------------|---------|---------|----------|

4 Modeling B

4.1 Characteristics of modeling

Modeling into fragile is carried out with modeling `AXIS_JOINT` and the law `CZM_LIN_REG`. The elements of volume are modelled with the model `AXIS`.

4.2 Characteristics of the grid

The grid is linear.
Many elements: 280 `QUAD4`.
Many elements of interface: 15 `QUAD4`.

4.3 Sizes tested and results

Test of nonregression : diametrical contraction ($-2 \times DX$ point B), force of traction (the resultant DY of `REAC_NODA` on CD multiplied by 2π) according to the displacement of traction DY (on CD).

For a displacement of $0,6\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Tolerance (%) |
|----------------------|------------|-----------------|
| Contraction (mm) | 0.253835 | 0.10 |
| Force (kN) | 25.18191 | 0.10 |

For a displacement of $0,8\text{ mm}$ according to Y on CD

| Size tested | Code_Aster | Tolerance (%) |
|----------------------|------------|-----------------|
| Contraction (mm) | 0.254455 | 0.10 |
| Force (kN) | 7.112202 | 0.10 |

4 Summary of the results

Tests of nonregression are carried out for two modelings. One carries out besides the tests of comparison with the model of Rousselier for modeling A.