SSNA120 – notched Test-tube axisymmetric (AE) with model CZM_TRA_MIX

Summarized:

This test of nonlinear static mechanics makes it possible to make sure of non regression of a functionality of Code_Aster in fracture mechanics and to compare it with a local approach (Rousselier). The functionality tested is the cohesive model for the ductility fracture: CZM_TRA_MIX [R7.02.11].

A notched axisymmetric test-tube is requested in tension. The evolution of the force and the diametrical contraction during the propagation of the ductility fracture is calculated. The modelization of the test-tube is realized with elements 2D (QUA8).
1 Problem of reference

1.1 Geometry and loading

One considers a notched axisymmetric test-tube of type \textit{AE4}. The cohesive zone represented by elements of interface is positioned on line \textit{AB}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{Geometry of the test-tube \textit{AE4}.}
\end{figure}

1.2 Properties of the material

To describe the behavior of the material of the axisymmetric test-tube (voluminal material), one uses one with an isotropic hardening elastoplastic constitutive law (model \textit{VMIS_ISOT.TRAC}). One takes: $E = 207 \text{ GPa}$ and $\nu = 0.3$ the curve of hardening retained is given below:

Warning: The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)
For the elements of interface the following parameters are used in model \texttt{CZM\_TRA\_MIX}:

\begin{align*}
\sigma_c &= 1200 \text{ MPa} \\
G_c &= 130 \text{ MPa\cdot mm} \\
\delta_p &= 0.01 \text{ mm} \\
\delta_p &= 0.07 \text{ mm} \\
\delta_c &= 0.157 \text{ mm}
\end{align*}

the model which results from this is schematized below.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Figure2.png}
\caption{Isotropic curve of hardening of the voluminal material.}
\end{figure}

NB: Only half of crack is modelled thanks to symmetry of the problem, the tenacity of the 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 line $AD$,
- imposed displacement $l$ following the direction $Y$ on line $DC$.

The evolution of displacement $l$ in the course of time is given in the following table:

<table>
<thead>
<tr>
<th>Time [s]</th>
<th>Displacement $l$ [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0,5</td>
</tr>
<tr>
<td>1</td>
<td>the 0.0,5</td>
</tr>
</tbody>
</table>

cohesive zone is represented by the elements of interface on 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 line $A'B'$.
2 Quantities and

2.1 result reference solution of reference

the displacement of the following $B$ node $X$ (DEPL) and the applied force on test-tube (REAC_NODA) were calculated.

A comparison is carried out with two different computations:

• a former execution of Code_Aster with model CZM_TRA_MIX, it acts of a case test of NON-regression;

• a former execution of Code_Aster where the ductility fracture is modelled with the model of Rousselier by model ROUSS_PR.

In the case of the modelization with the model of Rousselier, the parameters retained for this model are the following: $D=2$, $SIGM_1=460$ and $f_0=0,0005$
3 Modelization A

3.1 Characteristic of the modelization

The modelization of the ductility fracture is carried out with the modelization `AXIS_INTERFACE` and model `CZM_TRA_MIX`. The volume elements are modelled with the model `AXIS`.

3.2 Characteristics of the mesh

The mesh of entry is linear. It is transformed into a quadratic mesh 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 Quantities tested and Test

**results of non regression**: diametrical contraction \((-2 \times DX\) of the point \(B\)), tensile force (the resultant \(DY\) of `REAC_NODA` on \(CD\) multiplied by \(2\pi\)) according to the displacement of tension \(DY\) (on \(CD\)).

For a displacement of 0.3 \(mm\) according to \(Y\) on \(CD\):

<table>
<thead>
<tr>
<th>Quantity tested</th>
<th>Code_Aster</th>
<th>Tolerance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction ((mm))</td>
<td>0.605676</td>
<td>0.10</td>
</tr>
<tr>
<td>Force ((kN))</td>
<td>28.8696</td>
<td>0.10</td>
</tr>
</tbody>
</table>

For a displacement of 0.4 \(mm\) according to \(Y\) on \(CD\):

<table>
<thead>
<tr>
<th>Quantity tested</th>
<th>Code_Aster</th>
<th>Tolerance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction ((mm))</td>
<td>0.931629</td>
<td>0.10</td>
</tr>
<tr>
<td>Force ((kN))</td>
<td>23.6023</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Test of non regression on the computation carried out with the model of Rousselier: diametrical contraction \((-2 \times DX\) of the point \(B\)), tensile force (the resultant \(DY\) `REAC_NODA` on \(CD\) multiplied by \(2\pi\)) according to the displacement of tension \(DY\) (on \(CD\)).

For a displacement of 0.2 \(mm\) according to \(Y\) on \(CD\):

<table>
<thead>
<tr>
<th>Quantity tested</th>
<th>Code_Aster</th>
<th>Rousselier</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction ((mm))</td>
<td>0.333202</td>
<td>0.349885</td>
<td>4.8</td>
</tr>
<tr>
<td>Force ((kN))</td>
<td>29.3851</td>
<td>29.3597</td>
<td>0.087</td>
</tr>
</tbody>
</table>

For a displacement of 0.3 \(mm\) according to \(Y\) on \(CD\):

<table>
<thead>
<tr>
<th>Quantity tested</th>
<th>Code_Aster</th>
<th>Rousselier</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction ((mm))</td>
<td>0.605676</td>
<td>0.620591</td>
<td>2.4</td>
</tr>
<tr>
<td>Force ((kN))</td>
<td>28.8696</td>
<td>28.6069</td>
<td>0.92</td>
</tr>
</tbody>
</table>

For a displacement of 0.4 \(mm\) according to \(Y\) on \(CD\):

<table>
<thead>
<tr>
<th>Quantity tested</th>
<th>Code_Aster</th>
<th>Rousselier</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction ((mm))</td>
<td>0.605676</td>
<td>0.620591</td>
<td>2.4</td>
</tr>
<tr>
<td>Force ((kN))</td>
<td>28.8696</td>
<td>28.6069</td>
<td>0.92</td>
</tr>
<tr>
<td>Contraction (mm)</td>
<td>0.931629</td>
<td>0.954683</td>
<td>2.4</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------</td>
<td>----------</td>
<td>-----</td>
</tr>
<tr>
<td>Force (kN)</td>
<td>23.5744</td>
<td>22.6731</td>
<td>04/01/00</td>
</tr>
</tbody>
</table>
4 Summary of the results

Of the values of non regression are tested as well as tests of comparison with the model of Rousselier.