SSNV257 – Validation law of damage GTN with gradient with simulations tests on notched samples

Summary:

This CAS-test makes it possible to validate the algorithm of integration of the law of damage of Gurson – Tvergaard – Needleman (GTN) with gradient with the standard finite elements under-integrated or mixed in great deformations. One models there a notched sample (AE) in simple traction.

Various treated modelings are:

- **Modeling With** (2D): AXIS_GRAD_VARI
- **Modeling B** (2D): AXIS_GRAD_INCO
1 Problem of reference

1.1 Geometry

A notched sample (AE or in English NT) is modelled. The dimension of this one is given in Figure 1.1-1.

1.2 Properties of material

Elasticity:

\[ E = 190000 \text{ MPa} \]
\[ \nu = 0.3 \]

Module of Young

Poisson’s ratio

Curve of work hardening:

\[ R(\kappa) = 488.36 + 57.13(1 - \exp(-8613\kappa)) + 238.73(1 - \exp(-10.39\kappa)) \]

Ductile law of damage GTN:

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Parameter of the model GTN

Parameter of the model GTN

Porosity initial

Parameter of germination

Porosity of coalescence

Coefficient of acceleration related to coalescence

Nonlocal parameter

Parameter of penalization of Lagrange

In **DEFI_MATERIAU**, following information must be indicated:

<table>
<thead>
<tr>
<th>ELAS</th>
<th>ECRO_NL</th>
<th>GTN</th>
<th>NON_LOCAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>E = 190000</td>
<td>R0 = 488.361123569</td>
<td>Q1 = 1.5</td>
<td>C_GRAD_VARI = 1</td>
</tr>
<tr>
<td>NAKED = 0.3</td>
<td>R1 = 57.1333673502</td>
<td>Q2 = 1.07</td>
<td>PENA_LAGR = 5000</td>
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<td></td>
<td>GAMMA_1 = 8613</td>
<td>PORO_INIT = 0.0002</td>
<td></td>
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<tr>
<td></td>
<td>R2 = 238.731127339</td>
<td>COAL_PORO = 0.05</td>
<td></td>
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<td></td>
<td>GAMMA_2 = 10.386585592</td>
<td>COAL_ACCE = 3</td>
<td></td>
</tr>
</tbody>
</table>

### 1.3 Boundary conditions and loadings

For modeling **2D** (axisymmetric), vertical displacements for the side **DE** are controlled:

\[ u_x = 2 \text{ mm} \]

Horizontal displacements for the side **AE** and vertical displacements for the side **AB** are blocked because of symmetry. (see Figure 1.1-1 for the geometry and the grid of the AE4).

The loading is imposed using 500 identical pas de time. The pseudo-time of calculation is 1.

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2 Reference solution

2.1 Results of reference

The reference solutions are obtained by carrying out same calculations in the code of calculation by finite elements Z-T (developed by Mines ParisTech and ONERA).
3 Modeling A

3.1 Characteristics of modeling

Modelisation **AXIS_GRAD_VARI**.

3.2 Characteristics of the grid

The grid is obtained by SALOMÉ.
Many nodes: 4596.
Number and types of meshes: 1469 **QUAD8**.

3.3 Sizes tested and results

One recovers the following values at moment 0.1: the constraint \( \sigma_{yy} \) (**SIEF_ELGA**, **SIYY**), the variable of work hardening \( \kappa \) (**VARI_ELGA**, 'V1') and porosity \( f \) (**VARI_ELGA**, 'V2') of two points of integration. The first point of integration is that nearest to node **A** (it is noted \( G_1 \)), the second is that being in the middle of the side **AB** (it is noted \( G_2 \)).

The following table rassemble lbe values obtained by the computation software by finite elements Z-set.

<table>
<thead>
<tr>
<th>INST</th>
<th>Not integration</th>
<th>Identification</th>
<th>Value of Référence</th>
<th>Type</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>G1</td>
<td>IFYY</td>
<td>1202.612</td>
<td>EXTERNAL SOURCE</td>
<td>RELATIVE - 1%</td>
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<tr>
<td>0.1</td>
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<td>IFYY</td>
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<td>V2</td>
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<td>RELATIVE - 1%</td>
</tr>
</tbody>
</table>
4  Modeling B

4.1  Characteristics of modeling

Modelisation AXIS _ GRAD_ INCO.

4.2  Characteristics of the grid

The grid is obtained by SALOMÉ.
Many nodes: 4596.
Number and types of meshes: 1469 QUAD8.

4.3  Sizes tested and results

One recovers the following values at moment 0.1: the constraint $\sigma_{yy}$ ("SIEF_ELGA","SIYY"), the variable of work hardening $\kappa$ ("VARI_ELGA","V1") and porosity $f$ ("VARI_ELGA","V2") of two points of integration. The first point of integration is that nearest to node $A$ (it is noted $G_1$), the second is that being in the middle of the side $AB$ (it is noted $G_2$).

The following table rassemble Lbe values obtained by the computation software by finite elements Z-set.

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<thead>
<tr>
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<th>Value of Référence</th>
<th>Type</th>
<th>Tolerance</th>
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<td>EXTERNAL SOURCE</td>
<td>RELATIVE - 1%</td>
</tr>
<tr>
<td>0.1</td>
<td>G2</td>
<td>V1</td>
<td>0.06932499</td>
<td>EXTERNAL SOURCE</td>
<td>RELATIVE - 1%</td>
</tr>
<tr>
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<td>G1</td>
<td>V2</td>
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<td>EXTERNAL SOURCE</td>
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<td>V2</td>
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5 Summary of the results

This CAS-test is carried out on a notched sample into axisymmetric. The reference solutions are obtained by carrying out same calculations in the computer code by finite elements Z-set (developed by Mines ParisTech and ONERA). One has one good agreement between the calculated results and Lbe solutionS of reference.