SSNP147 – Modeling of the starting of crack with the model ENDO_HETEROGENE

Summary:

This test represents the starting of a crack in a plate made up of materials heterogeneous. This plate undergoes a loading in the form of a slope of imposed displacements. Starting is modelled by the law ENDO_HETEROGENE using regularized constraints. This test aims to validate modeling D_PLAN_GRAD_SIGM and the law ENDO_HETEROGENE. It is about a case two-dimensional test of nonregression realized on a rectangular grid then triangular.
1 Problem of reference

1.1 Geometry

One represents a square of with dimensions \( l = 1 \text{m} \).

![Illustration 1: Geometry of the case test](image)

1.2 Properties of materials

Material:

Parameters of elasticity:
Young modulus \( E_1 = 20 \times 10^9 \text{MPa} \), Poisson's ratio \( \nu_1 = 0.25 \)

Parameters of the law ENDO_HETEROGENE:
Yield stress \( \sigma_y = 5 \text{MPa} \)
Module of Weibull \( m = 6 \)
Tenacity \( K_c = 1 \text{MPa.m}^{1/2} \)
Thickness of the sample \( e_p = 1 \text{m} \)
Seed \( GR = 121 \)

Parameter of the nonlocal model:
Characteristic length \( l_c = 0.2 \text{m} \)

1.3 Boundary conditions and loading

The lower edge is blocked in displacement according to the vertical direction, the side edges are subjected to a field of displacement which varies linearly in the height. That is to say:

In bottom:
\[ u_x(x, y=0) = 0 \]

On the right
\[ u_y(x=l, y) = c \cdot u_d(1-y/l) \]
with \( u_d = 0.0001 \)
On the right
\[ u_y(x=0, y) = -u_y(x=l, y) \]
\( c \) corresponds to a variable loading ramp between 0 and 1 over the time of simulation (1s).

1.4 Reference solution

There is no reference solution and the test is of type not regression. It use the mixing rate \texttt{ENDO\_HETEROGENE}, it even based on the regularized constraints.

The result is thus purely qualitative. It is a question of observing the starting of a crack following the side loadings.
2 Modeling A

2.1 Characteristics of modeling

The totality of the field is with a grid in quadrangular elements with 8 nodes. The grid comprises 225 rectangles and 30 segments.
1 time of $1s$ is modelled.

2.2 Results

One traces on the figures 4 and 3 respectively horizontal displacements $DX$ and the criterion of damage (variable internal $V1$) at the end of $1s$.
One sees a crack which starts with $2/3$ field (when $V1$ is equal to 1, the material is broken).

![Illustration 3: Variable of damage ($V1$), $t=1s$](image)

![Illustration 4: Horizontal displacements $DX$, $t=1s$](image)
### 2.3 Values tested

The value of displacement is tested at the point \( t_{e\text{stpn}} \) correspondent with a node which is with \( 2/3 \) length of with dimensions of the plate.

<table>
<thead>
<tr>
<th>Place</th>
<th>Component</th>
<th>moment</th>
<th>Value of nonregression</th>
<th>Tolerance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{e\text{stpn}} )</td>
<td>DX</td>
<td>1</td>
<td>9.876E5</td>
<td>1.E-3</td>
</tr>
</tbody>
</table>

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3 Modeling B

3.1 Characteristics of modeling

The totality of the field is with a grid in triangular elements with 6 nodes. The grid comprises 620 triangles and 64 segments.

1 pas de time of 1 S is modelled.

3.2 Results

One traces on the figures 5 and 6 respectively horizontal displacements $DX$ and the criterion of damage (variable internal $V_1$) at the end of 1s.

One sees a crack which starts with $2/3$ field (when $V_1$ is equal to 1, the material is broken). The form of the results is logically dependent on the grid.

Illustration 5: Horizontal displacements $DX$, $t=1s$
Illustration 6: Variable of damage ($V_1$), $t=1s$

3.2 Values tested

The value of displacement is tested at the point $testpn$ defined above.

<table>
<thead>
<tr>
<th>Place</th>
<th>Component</th>
<th>moment</th>
<th>Value of nonregression</th>
<th>Tolerance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$testpn$</td>
<td>$DX$</td>
<td>1</td>
<td>9.114E5</td>
<td>1.E-3</td>
</tr>
</tbody>
</table>
4 Summary of the results

This test represents modeling by means of the law `ENDO_HETEROGENE` starting of a crack in a plate made up of materials heterogeneous. This plate undergoes a loading in the form of a slope of imposed displacements. The place of starting is defined by chance (determined here by the choice of seed). The got results correspond well to the expected results.

Note: because of random generation of the thresholds of starting during the use of the law `ENDO_HETEROGENE`, the results of nonregression will be different according to the number of processors used for the execution.