SSNA119 – Damage of a notched sample in AXIS

Summarized:

This test represents a computation of damage of a notched sample. It allows the validation of modelization GRAD_VARI and GVNO into axisymmetric, for the modelization AXIS_GVNO/AXIS_GRAD_VARI, which makes it possible to carry out the computations of damage regularized by the gradient of the damage, in taking into account of the degrees of freedom of displacement and damage to the nodes.
For GVNO the resolution of the criterion is total, unlike the modelization GRAD_VARI which carries out a local resolution, Gauss points by Gauss points. One validates simultaneously two constitutive laws ENDO_CARRE (which is for the moment the only model that one can use with modelization GVNO) and ENDO_SCALAIRE.

The various modelizations and constitutive laws damaging are tested:

- **Modelization a:** Modelization GVNO with constitutive law ENDO_CARRE
- **Modelization b:** Modelization GRAD_VARI with constitutive law ENDO_SCALAIRE

1 Problem of reference

1.1 Geometry

One considers a notched plate height $10\,dm$. Of width $3\,dm$ and radius of notch $1\,dm$.

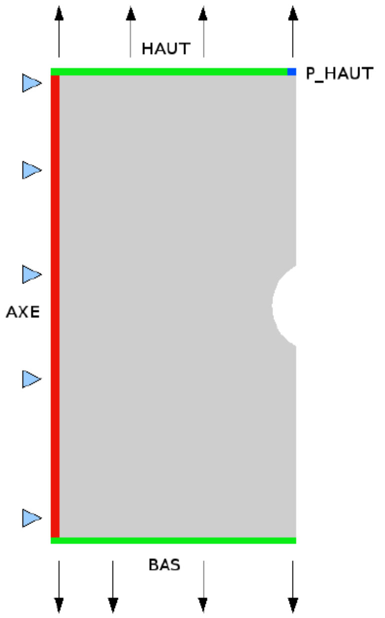

Figure 1 : Representation of the problem

1.2 common Properties of the material

the material considered is compared to the concrete (one works on a decimetre scale):

Elastic characteristics :

$E=3.\text{E}10\,\text{Pa}=3.\text{E}8\ \text{N/dm}^2$

$\nu=0.2$

Elastic limit in tension of the damage model:

$SY=3.\text{E}4\,\text{N/dm}^2=3.\text{E}6\,\text{Pa}$

Rate of energy restitution by crack surface (constant of Griffith):

$G_f=10\,\text{N/dm}=100\,\text{J/m}^2$

1.3 Boundary conditions and loadings

Blocking : $DX=0$ on a nodes group located in the middle of the axis ($x=0.$), in order to ensure the maintenance of structure.

Loading : Displacement imposed or controlled (varies according to the modelization) in the direction of tension.

2 Reference solution

This case test is a case of non regression. It is about a particularly unstable study, which quickly passes from a state slightly damaged to a state of fracture (damage equal to 1).

For modelization GVNO time step during which one crosses instability asks for several minutes of computations. One thus restricts oneself, for the validation of the case test, with the checking of the nodal damage in the center of the notch ($x=2., y=0.$), on two time step preceding the snap-back. The loadings are not analytical. The values of imposed displacements are simply empirical. In the same way, values of damage are found associated which are not exact values. For the reference, one will take the round-offs with the 5th decimal. One asks for the validation of the case test, an accuracy about 10^{-4} .

One does a complete calculation of snap-back with the technique of control per elastic prediction for modelization GRAD_VARI.

3 Modelization A

3.1 Characteristic of the modelization

One considers a modelization of damage GVNO, which makes it possible to carry out the computations of damage regularized by the gradient of the damage, in taking into account that degrees of freedom of displacement and damage to the nodes. This modelization does not accept control of loading by the elastic prediction.

3.2 Characteristics of the mesh

The mesh contains 263 elements TRIA6.

3.3 Damage model: material **ENDO_CARRE**

Characteristics standards of the concrete are previously defined.
Characteristics related to the NON-local damage model:
$c=1.5\,\mathrm{N}$ what corresponds to the zone of damage $1\mathrm{D}$ equal to $D=\sqrt{2c\,E/SY^2}=0.5\,\mathrm{dm}$

3.4 Boundary conditions and loadings

Loading : Vertical displacement imposed U on the horizontal edge top ($y=5.$) and $-U$ on that of bottom ($y=-5.$):
At time $t_1=6.5$: $DY=0.3675\times 6.5\,\mathrm{dm}$
At time $t_2=7.0$: $DY=0.3675\times 7.0\,\mathrm{dm}$

3.5 Quantities tested and results

NUME_ORDRE	REFERENCE	VALE_REF
1	"NON_REGRESSION"	0.04825
2	"NON_REGRESSION"	0.23794

Table 1: Value tested in GVNO

4 Modelization B

4.1 Characteristic of the modelization

One considers a modelization of damage GRAD_VARI, which is a Lagrangian mixed formulation of damage regularized by the gradient of the damage. She takes into account besides the degrees of freedom of displacement and damage to the nodes, the coefficients of Lagrange. This modelization accepts control of loading by the elastic prediction.

4.2 Characteristics of the mesh

The mesh contains 1034 elements TRIA6 and 462 elements QUAD8. The mesh in the center of the test-tube is directed except symmetry.

4.3 Damage model: material ENDO_SCALAIRE

Characteristics standards of the concrete are defines previously.
Characteristics related to the NON-local damage model:
$c=1.875\,\mathrm{N}$; $p=1.5$; $m=10$ what corresponds to the zone of damage $1\mathrm{D}$ equal to $D=0.5\,\mathrm{dm}$

the correspondence with the physical parameters is the following one:

$$c=3/8\,D\,G_f\,;\,m=\frac{3\,E\,G_f}{2\,D\cdot SY^2}\,;\,p=m/4-1\,;$$

4.4 Boundary conditions and loadings

Loading : The computation is done out of control by elastic prediction until the complete fracture of the test-tube, thanks to projection on the preset limits.

4.5 Quantities tested and results

NUME_ORDRE	REFERENCE	VALE_REF
1	"NON_REGRESSION"	DEPL (DY) =7.5E-04
1	"NON_REGRESSION"	SIEF_ELGA (SIXX) =-3.538
1	"NON_REGRESSION"	FORC_NODA (DY) =3435

Table 2: Value tested in GRAD_VARI

5 Summary of the results

By finding the results of references, one validates the modelization GVNO/GRAD_VARI and constitutive law ENDO_CARRE/ENDO_SCALAIRE into axisymmetric, for modelization AXIS_GVNO/AXI_GRAD_VARI.