SSNA119 – Damage of a notched sample in AXIS

Summary:

This test represents a calculation of damage of a notched sample. It allows the validation of modeling GRAD_VARI and GVNO into axisymmetric, for modeling AXIS_GVNO/AXIS_GRAD_VARI, which makes it possible to carry out the calculations of damage regularized by the gradient of the damage, by taking into account degrees of freedom of displacement and damage to the nodes.
For GVNO the resolution of the criterion is total, unlike modeling GRAD_VARI who carries out a local resolution, points of Gauss by points of Gauss. Three laws of behavior are validated ENDO_CARRE (which is for the moment the only law that one can use with modeling GVNO), ENDO_SCALAIRE and ENDO_FISS_EXP.

Various modelings and laws of damaging behavior are tested:

- **Modeling A** : Modeling GVNO with the law of behavior ENDO_CARRE
- **Modeling B** : Modeling GRAD_VARI with the law of behavior ENDO_SCALAIRE
- **Modeling C** : Modeling GRAD_VARI with the law of behavior ENDO_FISS_EXP

1 Problem of reference

1.1 Geometry

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

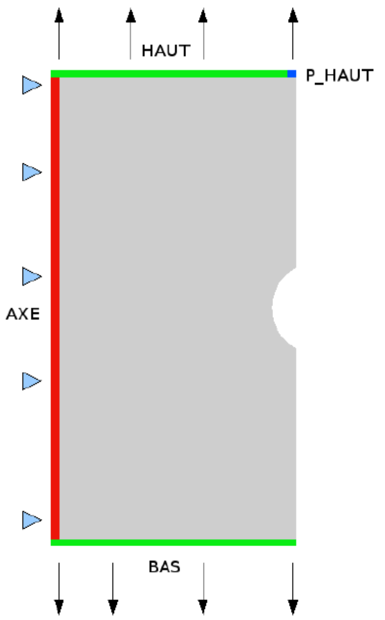

Figure 1 : Representation of the problem

1.2 Common properties of material

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

Characteristics rubber bands:

$E=3.\mathrm{E10\,Pa}=3.\mathrm{E8\ N/dm^2}$

$\nu=0.2$

Elastic limit in traction of the law of damage:

$SY=3.\mathrm{E4\,N/dm^2}=3.\mathrm{E6\,Pa}$

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

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

1.3 Boundary conditions and loadings

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

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

2 Reference solution

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

For modeling GVNO the step of time during which one crosses instability asks for several minutes of calculations. 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 steps of previous time 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, a precision about 10^{-4} .

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

3 Modeling A

3.1 Characteristics of modeling

A modeling of damage is considered GVNO, which makes it possible to carry out the calculations of damage regularized by the gradient of the damage, while taking into account that degrees of freedom of displacement and damage to the nodes. This modeling does not accept piloting of loading by the elastic prediction.

3.2 Characteristics of the grid

The grid contains 263 elements TRIA6.

3.3 Law of damage: material ENDO_CARRE

Characteristics standards of the concrete are previously defined.
Characteristics related to the not-local law of damage:
$c=1.5\,\mathrm{N}$ what corresponds to the zone of damage $1\mathrm{D}$ equalize with $D=\sqrt{2c\,E/SY^2}=0.5\,\mathrm{dm}$

3.4 Boundary conditions and loadings

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

3.5 Sizes tested and results

Test of nonregression on the variable of damage DAMG to the node $\mathrm{no\_test}$.

4 Modeling B

4.1 Characteristics of modeling

A modeling of damage is considered `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 modeling accepts piloting of loading by the elastic prediction.

4.2 Characteristics of the grid

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

4.3 Law of damage: material **`ENDO_SCALAIRE`**

Characteristics standards of the concrete are defines previously.
Characteristics related to the not-local law of damage:
$c=1.875\,\mathrm{N}\ ;\ p=1.5\ ;\ m=10$ what corresponds to the zone of damage $1\mathrm{D}$ equalize with $D=0.5\,\mathrm{dm}$

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 : Calculation is done in piloting by elastic prediction until the complete rupture of the test-tube, thanks to projection on the preset terminals.

4.5 Sizes tested and results

Test of nonregression on displacement at the point $\mathrm{P\_HAUT}$, the nodal force at the point $\mathrm{P\_HAUT}$ and the stress field at the point of Gauss 1 of the mesh $M160$.

5 Modeling C

5.1 Characteristics of modeling

A modeling of damage is considered 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 modeling accepts piloting of loading by the elastic prediction.

5.2 Characteristics of the grid

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

5.3 Law of damage: material ENDO_FISS_EXP

In addition to characteristics concrete defined in the § 1.2, one introduces a limit in compression of fc=30.E6 Pa, a parameter of form of the cohesive model p=1.5 and a half-width of band D=0.5 DM.

5.4 Boundary conditions and loadings

Loading : Calculation is done in piloting by elastic prediction until the complete rupture of the test-tube, thanks to projection on the preset terminals.

5.5 Sizes tested and results

Test of nonregression on displacement at the point P_HAUT , the nodal force at the point P_HAUT and the stress field as a whole (absolute sum).

6 Summary of the results

This test makes it possible to check in nonregression:

- Modeling GVNO with the law of behavior ENDO_CARRE
- Modeling GRAD_VARI with the law of behavior ENDO_SCALAIRE
- Modeling GRAD_VARI with the law of behavior ENDO_FISS_EXP