SSNV220 - Validation of modelization GVNO and constitutive law ENDO_CARRE in 3D

This test allows the validation of the modelization GVNO in $3D$, which makes it possible to carry out the computations of damage regularized by the gradient of the damage, in taking into account only of degrees of freedom of displacement and damage to the nodes. 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 constitutive law ENDO_CARRE, of quadratic formulation in damage, which is for the moment the model that one can use with modelization GVNO.

1 Problem of reference

1.1 Tallies theoretical

the unknowns of the problem are the degrees of freedom of nodal displacement and damage. It is then a question of minimizing an energy of the form:

$$\phi(u,\alpha)=\frac{1}{2}A(d)E\epsilon^2+\psi(d)+\frac{c}{2}\nabla\alpha.\nabla\alpha$$

Where E is the Young's modulus of the material, $A(d)$ the function of stiffness, $\psi(d)$ dissipation and c the nonlocal coefficient.

In the case of model ENDO_CARRE:

$$A(d)=(1-d)^2 \quad \text{and} \quad \psi(d)=\frac{\sigma_y^2}{E}d$$

the criterion corresponding to model ENDO_CARRE, for a homogeneous solution ($\nabla\alpha=0$), is thus written:

$$d=1-\left(\frac{W_y}{W_{el}}\right)$$

Where W_{el} is elastic strain energy and:

$$W_y=\frac{\sigma_y^2}{2E}$$

1.2 Geometry

One considers a cube on side $L=1\,\mathrm{m}$.

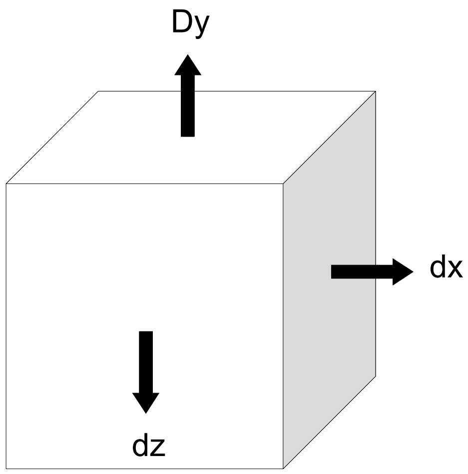

Figure 1 : Representation of the problem

1.3 Properties of the material

Damage model: elastic `material`

ENDO_CARRE Characteristics:
$E=1\,\mathrm{Pa}$
$\nu=0.$

Characteristics related to the damage model:
Elastic limit:
$SY=0.01\,\mathrm{Pa}$

NON-local characteristics:
$c=1.0\,\mathrm{N}$

1.4 Boundary conditions and loadings

Fixed support : Null imposed displacements `DY = 0` m . on the face of bottom ($y=0.$), `DX = 0` m . on the left face ($x=0.$) and `DZ = 0` m . on the back face ($z=0.$). See figure 1.

Loading 1 : Linear displacement imposed U_1 on the right face ($x=1.$):
$U_1=0.0\,\mathrm{m}$ for `INST=0`, $U_1=0.02\,\mathrm{m}$ `INST=1.0`.
Loading 1 : Linear displacement imposed U_2 on the right face ($y=1.$):
$U_2=0.0\,\mathrm{m}$ for `INST=0`, $U_2=0.02\,\mathrm{m}$ `INST=1.0`.
Loading 1 : Linear displacement imposed U_3 on the right face ($z=1.$):
$U_3=0.0\,\mathrm{m}$ for `INST=0`, $U_3=0.02\,\mathrm{m}$ `INST=1.0`.

2 Reference solution

the imposed loadings enable us to obtain a homogeneous solution. The clean principal directions being directions of the tensor of the strains, elastic strain energy results from the loadings defined previously in the following way:

$$W_{el}=\frac{\left(U_1^2+U_2^2+U_3^2\right)}{2L^2}$$

One extracts the associated values of damage analytically from them:

$$d=1-\left(\frac{2W_y L^2}{U_1^2+U_2^2+U_3^2}\right)$$

It is considered whereas the test is checked if Newton returns us well the same values of damage, with an accuracy of 10^{-6} .

3 Modelization

3.1 Characteristics of the modelization

One uses a modelization 3D_GVNO.

3.2 Characteristics of the mesh

The mesh contains 64 elements HEXA20.

3.3 Results

NUMERO	TYPE_REFERENCE	VALE_REF	TOLE
1	"ANALYTIQUE"		0.1.1.0E-4%
2	"ANALYTIQUE"		0.5.1.0E-4%
3	"ANALYTIQUE"		0.7.1.0E-4%
4	"ANALYTIQUE"	0.85	1.0E-4%

Table 1: Comparison of eigenvalues in room and NON-room

4 Summary of the results

We get the results of references, with the accuracy requested, which validates the modelization GVNO and constitutive law ENDO_CARRE in 3D.