SSNL138 - Validation of the algorithm of optimization under stress of inequalities of Summarized `option`

DDL_STAB:

This test allows the validation of option `DDL_STAB` of `CRIT_STAB`, which evaluates the stability of the states of equilibrium found by the computational simulation of the nonconservative problems like the problems of damage. What requires to apply an algorithm of optimization under stresses of inequalities. The option can be applied to a list containing any degree of freedom available in *Code_Aster.*

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1 Problem of reference

1.1 Tallies theoretical

One defines the unicity of the solution of a problem of discretized damage, by the positivity of the following quotient, written from the tangent operator K :

$$\underset{x=(u,a)}{Min}\left(\frac{x^T.Kx}{x^T.x}\right)>0$$ **Equation 1.1**

where u indicates the degrees of freedom of displacement and *has* the degrees of freedom of damage. When this criterion is not checked any more, it can exist several solutions with the problem discretized by the finite element method, which consists in checking the conditions first of equilibrium. It is then necessary to discuss the stability of the solution, by checking the positivity of derivative second of energy, in the direction of the increasing damages (condition of irreversibility on the damage):

$$\underset{x=(u,a\geq 0)}{Min}\left(\frac{x^T.Kx}{x^T.x}\right)\geq 0$$ **Equation 1.2**

the unicity and the stability of the homogeneous solution of a bar in tension were analytically studied (Pham, Amor, Marigo and Maurini*, "Gradient ramming models and to their use to approximate brittle fracture",* 2009) and the criteria were written as of the relationship between the damage *has* bar, its length L and the internal length l *.* One is interested here more particularly in the following energy formulation, which corresponds to constitutive law `ENDO_CARRE` for modelization `GVNO` :

$$\phi=\frac{1}{2}(1-a)^2 E_0\varepsilon(u)^2+\frac{{\sigma_M}^2}{E_0}a+\frac{E_0 l^2}{2}\nabla a.\nabla a$$ **Equation 1.2**

where E_0 and σ_M are respectively the healthy stiffness of the material and the ultimate stress and where $\varepsilon(u)$ is the strain of the bar associated with displacement u *.*

The criterion of unicity is defined then by the inequality:

$$L^2<\frac{2\pi^2 E_0^2(1-a)}{6\sigma_M^2}l^2$$ **Equation 1.4**

and the stability criterion, by the inequality:

$$L^2\leq\frac{128\pi^2 E_0^2(1-a)}{216{\sigma_M}^2}l^2$$ **Equation 1.5**

By observing the two inequalities presented (equations 1.4 and 1.5), one sees that the loss of unicity occurs before the loss of stability. The purpose of the case test is then to estimate the criterion of stability, initially between the loading of loss of unicity and that of loss of stability (the value of the minimum of the quotient of Rayleigh (1,2) must then be positive), and in the second time after the loading of loss of stability (the calculated minimum must then be negative).

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1.2 Geometry

One considers a bar 2D length $L=100\,\text{m}$ is height $h=1\,\text{m}$.

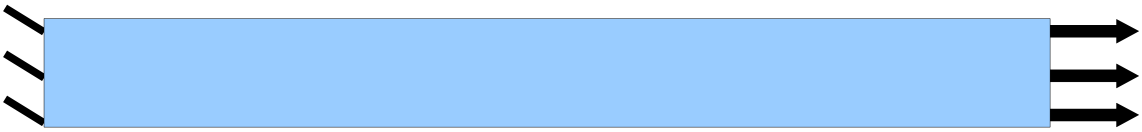

Figure 1 : Representation of the problem

1.3 Properties of the material

1.3.1 elastic

Characteristic Material parameters:
$E=1\,\text{Pa}$
$\nu=0$
Characteristic of the damage model:
$\sigma_M=0.01\,\text{Pa}$
Nonlinear characteristic:
$l=1\,\text{m}$

1.4 Boundary conditions and loadings

Fixed support : Null displacements imposed $DY=0\,m$ on the nodes of the bottom of the bar ($y=0.$), like on the nodes top ($y=1.$). Displacement imposed no one $DX=0\,m$ on the left face ($x=0.$). See figure1.

Loading 1 : Linear displacement imposed $U=2\times t\,\text{m}$ on the right face ($x=100.$).

2 Reference solution

the value of the estimate of the minimum of the quotient of Rayleigh under stresses of inequalities (1.2), obtained from option `DDL_STAB` of operator `CRIT_STAB` with like parameters: `NB_FREQ = 25` and `COEF_DIM_ESPACE = 2`, is of $3.430938\,E-8$ with the first time step for which the homogeneous solution is still stable and of $-5.598244\,E-9$ to the second time step where the solution is theoretically unstable. These values are used as references and the case test is a case of non regression.

It is seen that one finds well with option `DDL_STAB` , an estimate of the criterion of positive stability for the first time step, then negative for the second. The results are thus in agreement with the theory, which validates the developed algorithm.

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3 Modelization A

3.1 Characteristic of the modelization

One uses modelization D_PLAN_GVNO.

3.2 Characteristics of the mesh

The mesh contains 1416 elements QUAD8.

3.3 Results

NUMERO	TYPE_REFERENCE	VALE_REF	TOLE
1	“NON_REGRESSION”	3.430938 E-08	5.0E-5%
2	“NON_REGRESSION”	-5.598244 E-09	5.0E-5%

Table 1: Comparison of the estimate of the criterion of stability with the value of reference

4 Summary of the results

One finds the results of reference and that allows the validation of the developments of the algorithm of optimization under stresses of inequalities available with option DDL_STAB of CRIT_STAB.

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