SSNV226 – Validation of the criterion of rupture in critical stress

Summary:

The problem is quasi-static non-linear in mechanics of the structures (one has nevertheless a modeling in non-linear dynamics by preoccupations with a validation).

One analyzes the answer of an element of volume, with a loading in traction and imposed displacement. As soon as the maximum principal constraint in the element reaches a critical stress, the rigidity of the element is decreased and the constraints are quasi cancelled.

Modeling A makes it possible to validate the criterion of rupture with the law `VISCOCHAB` in a case where work hardening is isotropic, for a simple traction.

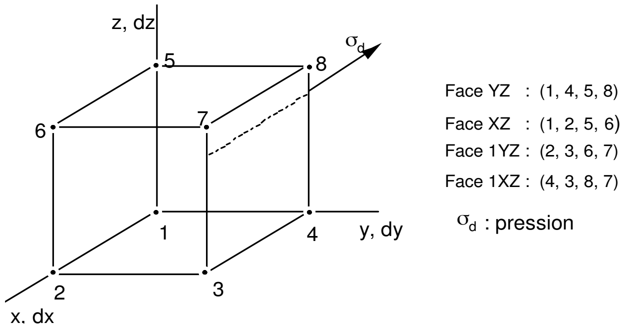
Modeling B makes it possible to validate the criterion of rupture with the law `VMIS_ISOT_TRAC` in a case where work hardening is purely isotropic, for a simple traction.

Modeling C makes it possible to validate the criterion of rupture with the law `VISC_ISOT_TRAC` in viscoplasticity in a case where work hardening is purely isotropic, for a simple traction.

Modeling D takes again modeling C by using the non-linear operator of dynamics `DYNA_NON_LINE`.

1 Problem of reference

1.1 Geometry



1.2 Properties of materials

Isotropic elasticity $E=2.E^{11} Pa \quad \nu=0.3$

Model viscoplasticity VISCOCHAB (modeling A), without kinematic work hardening:

k	$626.423911\, E^6 Pa$	Q_M	$3.982809551\, E^8 Pa$	C2	0
A_K	0.215443469	Q_0	$3.982809551\, E^8 Pa$	C1	0
B	11.53016	K_0	$k \times 0.21544\, Pa\, S^{1/N}$	G1_0	0
		N	12	G2_0	0

Elastoplasticity with isotropic work hardening (modeling B): model **VMIS**_ISOT_TRAC

Isotropic work hardening
R_0$=Sy$ $750\, E^6 Pa$
Traction diagram

ϵ_0	Sy/E	σ	Sy
ϵ	1.	σ	$1500\, E^6 Pa$

Viscoplasticity (modeling C): model VISC_ISOT_TRAC

Isotropic work hardening
R_0$=Sy$ $750\, E^6 Pa$
VISC_SINH

SIGM_0	$6167\, E^6 Pa$	EPSI_0	$3.31131121483\, E^{13} Pa$
M	6.76		

Traction diagram

ϵ_0	Sy/E	σ	Sy
ϵ	1.	σ	$1500\, E^6 Pa$

Parameters materials under CRIT_RUPT :

Critical stress: SIGMA_C$=7.8\, E^8 Pa$, $COEF=10000.$ [4]

1.3 Boundary conditions and loadings

Imposed deformation:

ϵ_{max}	0.05	speed	$1.E^{-4}$

Loading according to time:

$t_0=0.$	$\epsilon=0$	$tmax=\epsilon_{max}/vitesse$	$\epsilon=\epsilon_{max}$

Traction: $FACEYZ$ $Dz=1$

Blocking: $FACEXZ$ $Dy=0$ $FACEXY$ $Dz=0$
$FACEYZ$ $Dx=0$

2 Reference solution

2.1 Results of reference

As the state of stress is uniform and uniaxial, it is checked simply that the element of volume will break as soon as σ_{zz} is higher than $\mathrm{SIGMA\_C}=7.8\,E^8\,Pa$.

2.2 Bibliographical references

[1] R5.03.04 “Behaviors élasto-visco-plastics of J.L.Chaboche”.

[2] R5.03.02 “Integration of the elastoplastic relations of behavior of von Mises”

[3] R5.03.21 “elastoviscoplastic Modeling with isotropic work hardening in great deformations”

[4] A.Dahl “experimental Study and local approach of the stop of crack of cleavage in a bainitic steel” Thesis ECP January 2012

3 Modeling A

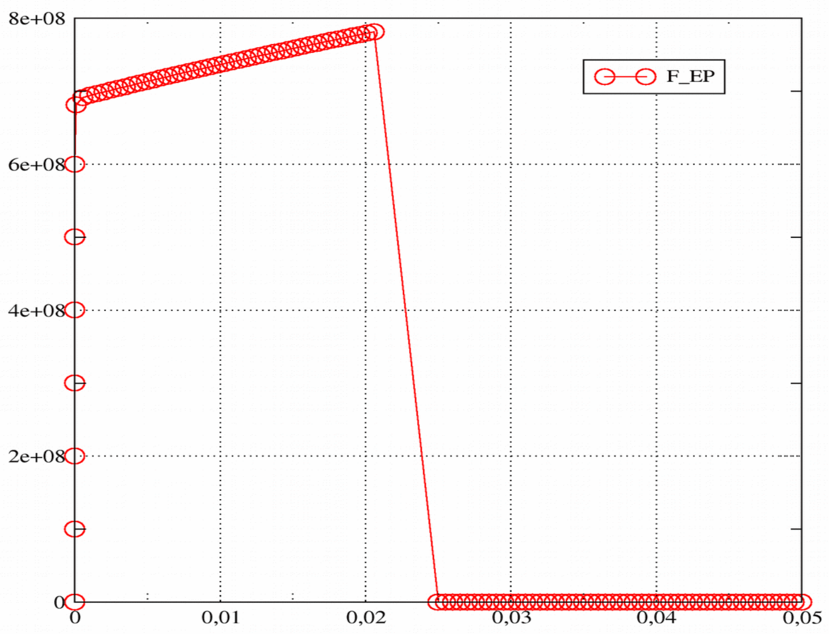
3.1 Characteristics of modeling

Modeling 3D, 1 hexa8. Simple traction with imposed traction diagram.

3.2 Sizes tested and results

The values tested are the maximum values of the principal constraints before and after the criterion is reached.

Moment	Identification	Reference
245.	σ_{zz}	$7.81319\,E^{8}$
250.	σ_{zz}	$1.\,E^{4}$



Note: the value SIGMA_C = $7.8\,E^{8}\,Pa$ is slightly exceeded because of explicit character of the criterion.
By refining the step of time (200 pas au place of 100) the maximum value of σ_{zz} is $7.8045\,E^{8}$

4 Modeling B

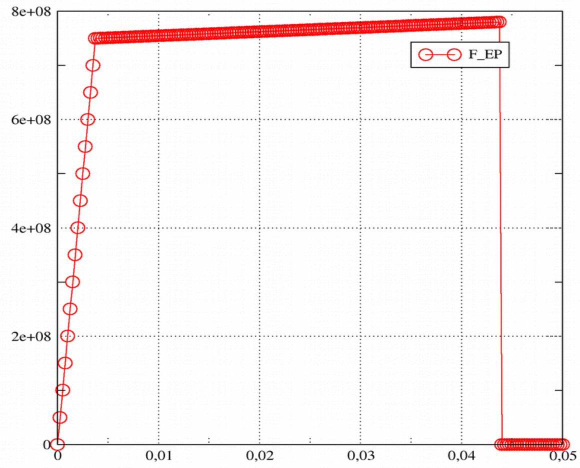
4.1 Characteristics of modeling

Modeling `3D`, 1 `hexa8`. Simple traction with imposed traction diagram.

4.2 Sizes tested and results

The values tested are the maximum values of the principal constraints before and after the criterion is reached.

Moment	Identification	Reference
437.5.	σ_{zz}	$7.80113 E^8$
440.	σ_{zz}	5000.0



5 Modeling C

5.1 Characteristics of modeling

Modeling `3D`, 1 `hexa8`. Simple traction with imposed traction diagram.

5.2 Sizes tested and results

The values tested are the maximum values of the principal constraints before and after the criterion is reached.

Moment	Identification	Reference
250.	σ_{zz}	$780.304\,E^{8}$
255.	σ_{zz}	$8.77866\,E^{4}$

6 Modeling D

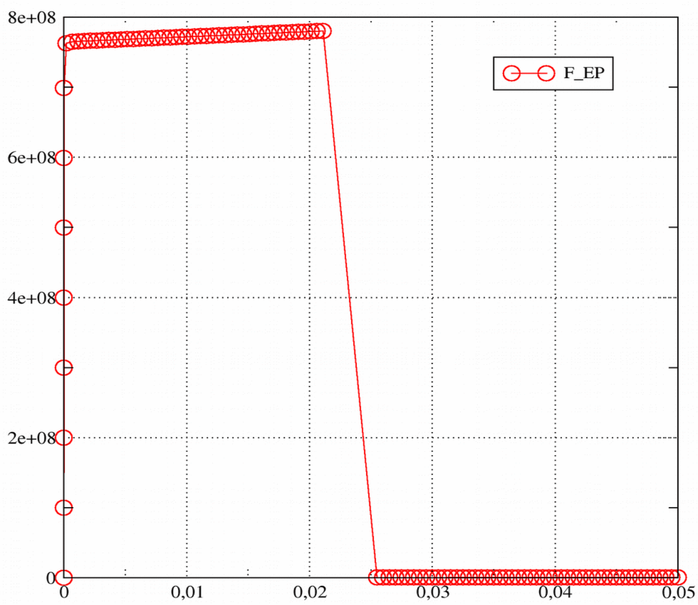
6.1 Characteristics of modeling

Modeling `3D`, 1 `hexa8`. Simple traction with imposed traction diagram. Non-linear dynamics.

6.2 Sizes tested and results

The values tested are the maximum values of the principal constraints before and after the criterion is reached.

Moment	Identification	Reference
250.	σ_{zz}	$780.304\,E^{8}$
255.	σ_{zz}	$8.77866\,E^{4}$



7 Summary of the results

Four modelings make it possible to validate, on a voluminal element, the criterion of rupture in critical stress with the viscoplastic behaviors **VISCOCHAB**, **VISC_ISOT_TRAC** and elastoplastic **VMIS_ISOT_TRAC**, into quasi-static and dynamics.