SSNV118 - Tensile test shearing with the viscoplastic model of Chaboche

Summary:

Nonlinear quasi-static problem of mechanics of the structures in transient.

Analysis of the response of an element of volume to a loading of traction-shearing which imposes a state of uniform stress-strain.

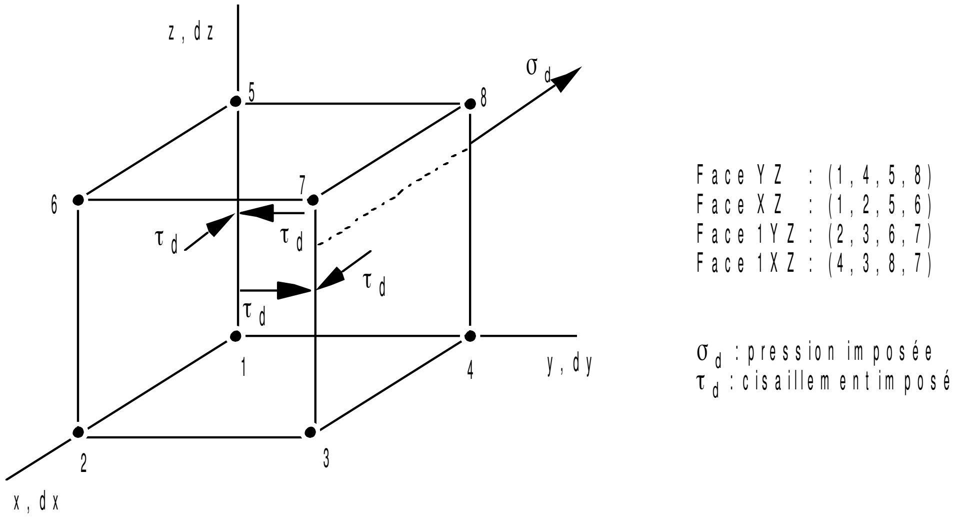
On an identical problem, one carries out 4 modelings:

- the first tests the behavior VISCOCHAB with implicit integration and constant coefficients material with a coherent tangent matrix with each iteration,
- the second tests the behavior VISCOCHAB with implicit integration and coefficients material depend on the temperature and integration with an elastic matrix,
- the third test the behavior VISCOCHAB with an explicit integration and constant coefficients,
- the fourth compares the behaviors VISCOCHAB and VISC_CIN2_MEMO, with implicit integration and coherent tangent matrix.

This test thus validates in particular the digital integration of the model of behavior elastoviscoplastic of fascinating Chaboche of account the phenomenon of memorizing of work hardening, for the two models VISCOCHAB and VISC_CIN2_MEMO.

1 Problem of reference

1.1 Geometry



1.2 Material properties

Isotropic elasticity $E=145\,000\,MPa$ $\nu=0.3$
Model viscoplasticity VISCOCHAB

k	$35\,MPa$	B	12	ETA	0.04
A_K	1.	M_R	2	$C1$	$1950\,MPa$
A_R	0.65	G_R	$2\,10^{-7}$	M_1	4
K_0	$70\,MPa\,S^{1/N}$	MU	19	$D1$	$0.397\,10^{-3}$
N	24	Q_M	460	G_{X1}	$2.\,10^{-13}\,MPa^{-m1}\,S^{-1}$
ALP	$0\,MPa$	Q_0	$40\,MPa$	$G1_0$	$50\,MPa$
		QR_0	$200\,MPa$		

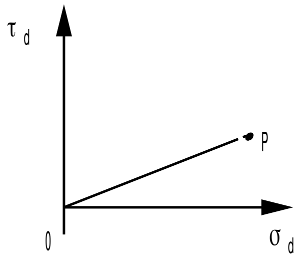
$C2$	$65000\,MPa$
M_2	4
$D2$	$0.552\,10^{-1}$
G_{X2}	$1.10^{-12}\,MPa^{-m1}\,S^{-1}$
$G2_0$	$1300\,MPa$
A_I	0.5

1.3 Boundary conditions and loadings

$N6$	$dx=dy=dz=0$	Face XZ : $FX=-\tau_d/4$
$N7$	$dx=dy=0$	Face YZ : $FY=-\tau_d/4, FX=-\sigma_d/4$
$N2$, $N3$	$dy=0$	Face 1XZ : $FX=\tau_d/4$
$N2$, $N3$, $N6$, $N7$	$dx=0$	Face 1YZ : $FY=\tau_d/4, FZ=\sigma_d/4$

1.4 Initial conditions

Worthless constraints and deformations with $t=0$.



$\sigma_d(t)$ and $\tau_d(t)$ linear, the point P being reached in $10\,s$ with $\sigma_d(10)=150\,MPa$ and $\tau_d(10)=60\,MPa$.

2 Reference solution

2.1 Method of calculating used for the reference solution

One uses to establish the reference solution the software SIDOLO which allows the simulation and the identification of laws of behavior.

The equations of the model are written by the user in FORTRAN in the form of a system of first order differential equations, solved by a method of Runge Kutta of order 4 with adaptive step.

2.2 Results of reference

$\sigma_{xx}, \sigma_{xy}, \varepsilon_{xx}, \varepsilon_{xy}, X1_{xx}, X2_{xx}, p, R, q, \xi_{xx}$ at the moment $P(t=10\,s)$ where $X1$ and $X2$ are the variables of kinematic work hardening, p deformation figure cumulated, $R(p,q)$ the isotropic variable of work hardening and ξ the internal variable allowing the taking into account of the memory of work hardening.

2.3 Uncertainty on the solution

Uncertainty of SIDOLO.

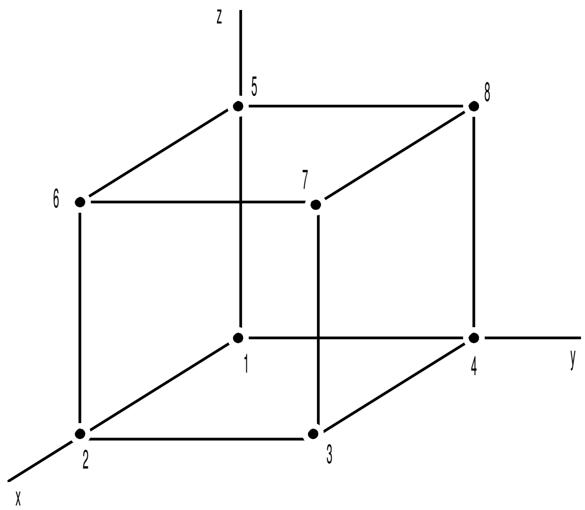
2.4 Bibliographical references

[1] SIDOLO, version 2.3, Note of use, École Nationale Supérieure of the Mines of Paris, Center of Materials, September 1995.

3 Modeling A

3.1 Characteristics of modeling

Modeling 3D, 1 hexa8



3.2 Sizes tested and results

Identification	Reference
σ_{xx}	150
σ_{xy}	60
ε_{xx}	1.49455 E-2
ε_{xy}	0.888452 E-2
$X1_{xx}$	12.4955
$X2_{xx}$	30.0352
p	1.69335 E-2
R	8.36836
q	6.76633 E-4
ξ_{xx}	1.33485 E-2

3.3 Remarks

One uses only 11 increments of time in *Aster*, but the step of time is redécoupé by 10 for the local integration of the equations of the model. SIDOLO uses several hundreds of step of times, calculated automatically.

4 Modeling B

4.1 Characteristics of modeling

This modeling is identical to modeling A, but with coefficients material defined as functions (constant) of the temperature, and the use of an elastic matrix instead of the tangent matrix.

4.2 Sizes tested and results

Identification	Reference
σ_{xx}	150
σ_{xy}	60
ε_{xx}	1.49455 E-2
ε_{xy}	0.888452 E-2
$X1_{xx}$	12.4955
$X2_{xx}$	30.0352
p	1.69335 E-2
R	8.36836
q	6.76633 E-4
ξ_{xx}	1.33485 E-2

4.3 Remarks

The precision of the results is of the same order as for modeling A with an elastic tangent matrix and a smaller recutting of the step of time for the local integration of the equations of the model.

5 Modeling C

5.1 Characteristics of modeling

Like modeling A, but with an integration clarifies (RUNGE_KUTTA).
The loading is this time at following imposed displacement Z on the face $FACE1XY$, such as:

0. moment 4s, $DZ=0.01\text{mm}$
1. moment 7s, $DZ=-0.01\text{mm}$

On the faces $FACEXY$ and $FACE1XY$, $DX=DY=0$.

5.2 Sizes tested and results

For this modeling, they are tests of nonregression.

Identification	*Code_Aster*
σ_{xx}	1147.8
σ_{yy}	1147.8
σ_{zz}	1329.4
ε_{zz}	1.0 E-2

6 Modeling D

6.1 Characteristics of modeling

Modeling is the same one as modeling A, but with 2 different behaviors (both integrated in an implicit way): VISCOCHAB and VISC_CIN2_MEMO, to validate the taking into account of the memory of greatest work hardening.

6.2 Sizes tested and results

Identification	Reference Aster (VISCOCHAB)	Aster (VISC_CIN2_MEMO)
σ_{xx}	150	150
σ_{yy}	60	60
ε_{xx}	1.67695E-2	1.676947E-2
ε_{xy}	9.978948E-3	9.978922E-3
p	1.914249E-2	1.9142436E-2
R	9.506173	9.506146
q	7.656996E-04	7.656974E-04
ξ_{xx}	1.5074149E-02	1.510558E-02

6.3 Remarks

The two behaviors give identical results on all the components, except for the internal variable ξ_{xx} (difference of 0.2%). This variation decreases when the temporal discretization is refined.

7 Summary of the results

The equations of the model being strongly nonlinear, it is necessary to use increments of small times to obtain a precise solution.

On this test presenting a geometry and boundary conditions simple, the recutting of the step of time at the local level makes it possible to improve the precision of the results without increasing the computing time too much.