HSNV105 - Plate in traction-shearing: élasto-viscoplasticity with metallurgy

Summary:

This test of nonlinear quasi-static mechanics consists in charging in traction-shearing a square plate. It is largely inspired by tests SSNP14 [V6.03.014] and SSNP15 [V6.03.015] from guide VPCS. The relation of behavior which one validates here is a élasto-viscoplastic relation of behavior which one introduced into *Code_Aster* for the mechanical analyses taking of account metallurgy. It is an isotropic law of Norton-Hoff type with an additive work hardening which can be restored.
The temperature and the metallurgical state are constant, one thus considers neither plasticity of transformation nor metallurgical restoration of work hardening. One does not consider either viscous restoration of work hardening.

The plate is modelled by a voluminal element (HEXA8).

Results got by *Code_Aster* are very close to the analytical solution of reference (variation $< 0.04\%$).

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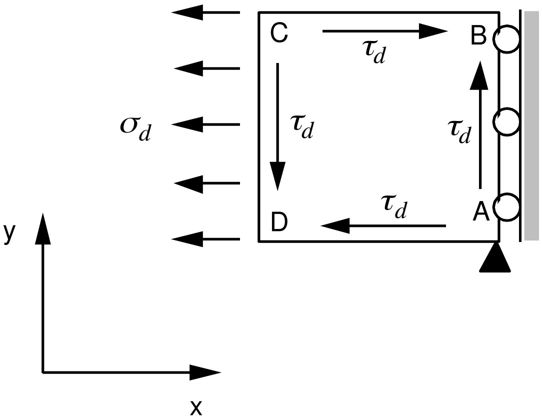
1 Problem of reference

1.1 Geometry

Square plate



1.2 Material properties

Isotropic elasticity

$E=195\,000\,MPa$

$\nu=0.3$

Relation of comprise élasto-viscoplastic.

$\eta=600\,MPa.s^n$

$n=3.5$

$\sigma_c=0.\,MPa$

$c=0.$ (not of viscous restoration of work hardening)

$m=20.$

1.3 Boundary conditions and loadings

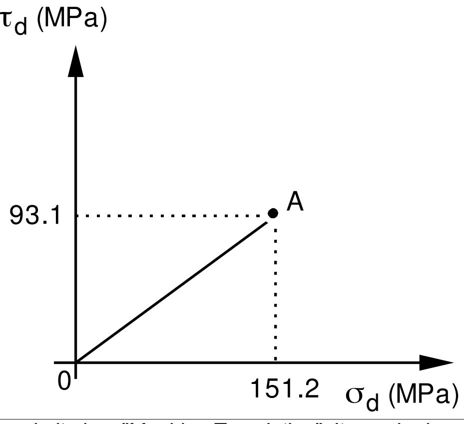
In A : $u_x=u_y=0$

On the side AB : $u_x=0$

One uniformly imposes on the structure a temperature $T=750\,°C$
and the TRC is such as the metallurgical state corresponding to this temperature is 100% ferritic.

Loading:

Way OA below of $t=0$ with $t=10\,s$ then maintenance in A until $t=60\,s$



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2 Reference solution

2.1 Method of calculating used for the reference solution

Being given the nature of the requests, the solution (forced σ, deformations ε and cumulated plastic deformation p) is homogeneous. In a point of the way of loading OA, one obtains:

$$\sigma_{xx} = \sigma_d$$
$$\sigma_{xy} = \tau_d$$
$$\sigma_{eq} = \sqrt{\sigma_d^2 + 3\tau_d^2}$$

The elastic strain is worth:

$$\varepsilon^e{}_{xx} = \frac{1}{E}\,\sigma_d$$
$$\varepsilon^e{}_{xy} = \frac{1+\nu}{E}\,\tau_d$$
$$\varepsilon^e{}_{yy} = -\nu\,\varepsilon^e{}_{xx}$$

The viscoplastic deformation is worth:

si $\sigma_{eq} - R - \sigma_c > 0$:

$$\dot{\varepsilon}_{xx}^{vp} = \dot{p}\;\frac{\sigma^D}{\sigma_{eq}}$$
$$\dot{\varepsilon}_{xy}^{vp} = \frac{3}{2}\,\dot{p}\;\frac{\tau^D}{\sigma_{eq}}$$
$$\dot{\varepsilon}_{yy}^{vp} = -\frac{1}{2}\,\varepsilon_{xx}^{vp}$$

avec $\dot{p} = \left(\frac{\sigma_{eq} - R - \sigma_c}{\eta}\right)^n$ où $R = R_0 p$

si $\sigma_{eq} \le \sigma_c$: $\dot{p} = 0$ $\dot{\varepsilon}_{xx}^{vp} = 0$ $\dot{\varepsilon}_{xy}^{vp} = 0$ $\dot{\varepsilon}_{yy}^{vp} = 0$

Lastly, the total deflection is:

$$\varepsilon_{xx} = \varepsilon^e{}_{xx} + \varepsilon^{vp}{}_{xx}$$
$$\varepsilon_{xy} = \varepsilon^e{}_{xy} + \varepsilon^{vp}{}_{xy}$$
$$\varepsilon_{yy} = \varepsilon^e{}_{yy} + \varepsilon^{vp}{}_{yy}$$

The reference solution is obtained by using a program written in FORTRAN which carries out a resolution step by step of the problem with an implicit diagram of discretization.

2.2 Results of reference

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One will be interested in the values of the constraints and the deformations at the point A way of loading at the moments $t=10\,s$ and $t=60\,s$

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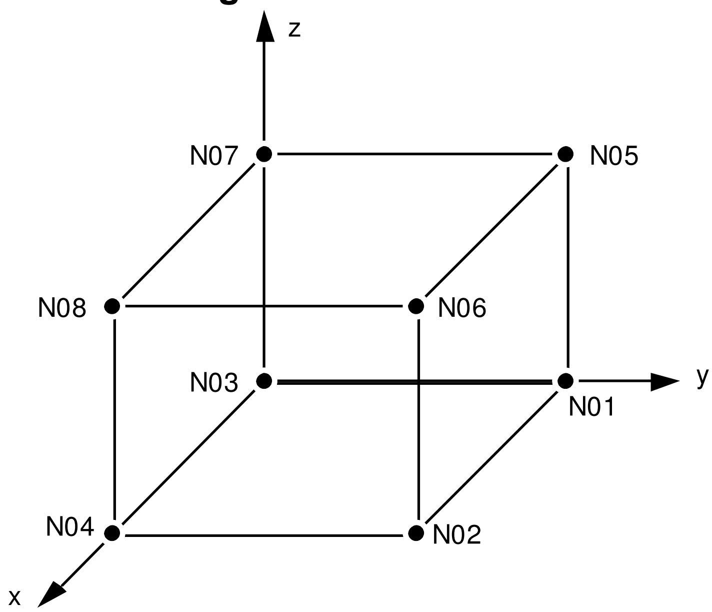
3 Modeling A

3.1 Characteristics of modeling



The loading and the boundary conditions are modelled by:

```
DDL_IMPO: (NODE: N04, DX: 0. , DY: 0.)
DDL_IMPO: (NODE: N08, DX: 0. , DY: 0. , DZ: 0.)
DDL_IMPO: (NODE: N02, DX: 0.)
DDL_IMPO: (NODE: N06, DX: 0.)
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FORCE_NODALE: (NODE: (N01 N03 N05 N07), FX: $-\frac{1}{4}\sigma_d(t)$, FY: $-\frac{1}{4}\tau_d(t)$)

FORCE_NODALE: (NODE: (N03 N04 N07 N08), FX: $-\frac{1}{4}\tau_d(t)$)

FORCE_NODALE: (NODE: (N02 N04 N06 N08), FY: $\frac{1}{4}\tau_d(t)$)

FORCE_NODALE: (NODE: (N01 N02 N05 N06), FX: $\frac{1}{4}\tau_d(t)$)

One imposes moreover one uniform temperature on the structure being worth at any moment: $T=750°C$ using the operator CREA_CHAMP.

3.2 Characteristics of the grid

Many nodes:	8
Number of meshs and type:	1 HEXA8

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3.3 Sizes tested and results

Variables	Moments (s)	Type of Reference	Reference	% tolerance
ε_{xx}	10	SOURCE_EXTERNE	2.4333E-2	0.10
ε_{yy}	10	SOURCE_EXTERNE	– 1.2011E-2	0.10
ε_{xy}	10	SOURCE_EXTERNE	2.2379E-2	0.10
ε_{xx}	30	SOURCE_EXTERNE	5.2103E-2	0.10
ε_{yy}	30	SOURCE_EXTERNE	– 2.5896E-2	0.10
ε_{xy}	30	SOURCE_EXTERNE	4.8027E-2	0.10
ε_{xx}	60	SOURCE_EXTERNE	5.9557E-2	0.10
ε_{yy}	60	SOURCE_EXTERNE	– 2.9624E-2	0.10
ε_{xy}	60	SOURCE_EXTERNE	5.4912E-2	0.10

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4 Summary of the results

Results got with *Code_Aster* are close to those of the reference solution (variations $< 0.05\%$)

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