SSNP107 - Plate in traction-shearing: viscoelasticity of Lemaître and isotropic work hardening

Summary:

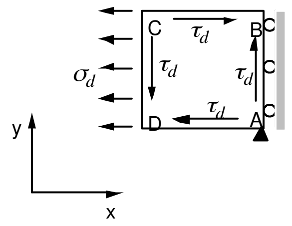
This test of nonlinear quasi-static mechanics consists in charging in traction-shearing a square plate. One thus validates the sequence of several calculations with alternatively a plastic law of behaviour with isotropic work hardening and a viscoelastic law of behavior of Lemaître, the value of the internal variables (cumulated plastic deformation and loadmeter (discharge) at the end of a calculation being taken again at the beginning of following calculation. The loading remains radial on the whole of the test.

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

1 Problem of reference

1.1 Geometry

Square plate



1.2 Material properties

These properties vary according to the time interval considered:

1) for $0 \leq t \leq 30\,s$ and $3630 \leq t \leq 3660\,s$

$E = 178\,600\,MPa$

$\nu = 0.3$

Plasticity with linear isotropic work hardening:

$\sigma_y = 120\,MPa$ $\quad$ $\text{D\_SIGM\_EPSI} = 1930\,MPa$

1) for $30 \leq t \leq 3630\,s$ and $3660 \leq t \leq 7260\,s$

$E = 178\,600\,MPa$

$\nu = 0.3$

Viscoelastic relation of behavior of Lemaître:

$$n = 11 \quad \frac{1}{K} = 8 10^{-4} \left(K = 1250\right) \frac{1}{m} = 0.17857 \left(m = 5.6\right)$$

1.3 Boundary conditions and loadings

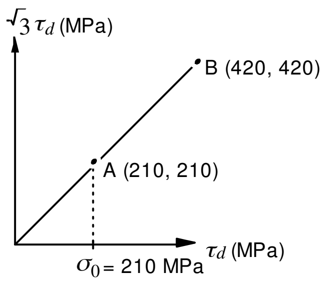
On A : $u_x = u_y = 0$

On the side AB : $u_x = 0$

Loading below ($t = 0$ in 0)

Ways OA and AB , of duration 30 seconds.

Time of maintenance in A and B from 3600 seconds.



2 Reference solution

2.1 Method of calculating used for the reference solution

Explicit integration: cumulated plastic deformation p is written:

à $t=30s$: $$p=\frac{\sigma_0\sqrt{2}-\sigma_y}{R}$$

$30\le t\le 3630$: $$p=\left[\left(\frac{\sigma_0\sqrt{2}}{K}\right)^n\frac{n+m}{m}(t-30)+\left(\frac{\sigma_0\sqrt{2}-\sigma_y}{R}\right)^{\frac{n+m}{m}}\right]^{\frac{m}{n+m}}$$

à $t=3660s$: $$p=\frac{2\sigma_0\sqrt{2}-\sigma_y}{R}$$

$3660\le t\le 7260$: $$p=\left[\left(\frac{2\sigma_0\sqrt{2}}{K}\right)^n\frac{n+m}{m}(t-3660)+\left(\frac{2\sigma_0\sqrt{2}-\sigma_y}{R}\right)^{\frac{n+m}{m}}\right]^{\frac{m}{n+m}}$$

avec $R=\frac{E.\mathrm{D\_SIGM\_EPSI}}{E-\mathrm{D\_SIGM\_EPSI}}$

At any moment t , one a:

$$\varepsilon_p(t)=p\frac{\sqrt{2}}{2}\begin{pmatrix}1 & \frac{\sqrt{3}}{2} & 0\\ \frac{\sqrt{3}}{2} & -\frac{1}{2} & 0\\ 0 & 0 & -\frac{1}{2}\end{pmatrix}$$

2.2 Results of reference

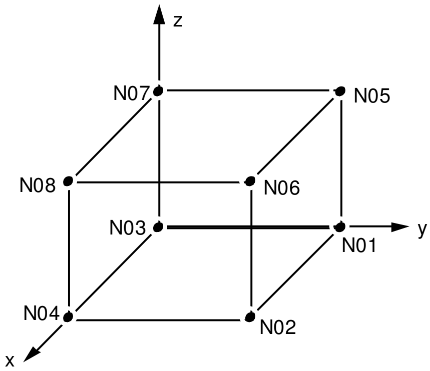
ε_{p-xx} and ε_{p-xy} at the moments $t=3630\,s$, $t=3660\,s$ and $t=3720\,s$

2.3 Uncertainty on the solution

No analytical solution.

3 Modeling A

3.1 Characteristics of modeling



All the fields being uniform (independent of space), one is taken HEXA8 and calculation is nevertheless equivalent to that of a plate in plane constraints.

The loading and the boundary conditions are modelled by:

1) conditions of blocking adapted at the same time to prevent any movement of rigid body and to allow the uniformity of the fields,
2) nodal forces:

FX: $-\frac{1}{4}\sigma_d(t)$, FY: $-\frac{1}{4}\tau_d(t)$ on nodes 1,3,5,7

FX: $-\frac{1}{4}\tau_d(t)$ on nodes 3,4,7,8

FY: $\frac{1}{4}\tau_d(t)$ on nodes 2,4,6,8

FX: $\frac{1}{4}\tau_d(t)$ on nodes 1,2,5,6

3.2 Characteristics of the grid

Many nodes: 8
Many meshs and types: 1 HEXA8

3.3 Sizes tested and results

Variables	Moments (S)	Reference	*Aster*	% difference
ε_{p-xx}	3630	$9.06364\ 10^{-2}$	$9.06373\ 10^{-2}$	0,001
ε_{p-xy}	3630	$7.84935\ 10^{-2}$	$7.84942\ 10^{-2}$	0,001
ε_{p-xx}	3660	$1.71775\ 10^{-1}$	$1.717749\ 10^{-1}$	$7.69\ 10^{-5}$
ε_{p-xy}	3660	$1.48761\ 10^{-1}$	$1.48761\ 10^{-1}$	$2.68\ 10^{-4}$
ε_{p-xx}	3720	$2.80733\ 10^{-1}$	$2.80909\ 10^{-1}$	0,063
ε_{p-xy}	3720	$2.43122\ 10^{-1}$	$2.43274\ 10^{-1}$	0,063

4 Summary of the results

Results got by *Code_Aster* are very close to the reference solution.