

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

Summary:

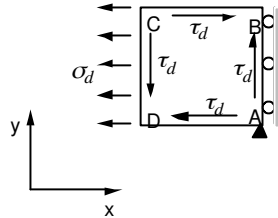
This test of nonlinear quasi-static mechanics consists in charging in traction-shearing a square plate. One thus validates the sequence of several calculations with alternatively a plastic law of behaviour with isotropic work hardening and a viscoelastic law of behavior of Lemaître, the value of the 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 $0 \leq t \leq 30 \text{ s}$ and $3630 \leq t \leq 3660 \text{ s}$

$$E = 178\,600 \text{ MPa}$$

$$\nu = 0.3$$

Plasticity with linear isotropic work hardening:

$$\sigma_y = 120 \text{ MPa} \quad D_SIGM_EPSI = 1930 \text{ MPa}$$

- 1) for $30 \leq t \leq 3630 \text{ s}$ and $3660 \leq t \leq 7260 \text{ s}$

$$E = 178\,600 \text{ MPa}$$

$$\nu = 0.3$$

Viscoelastic relation of behavior of Lemaître:

$$n = 11 \frac{1}{K} = 810^{-4} (K = 1250) \frac{1}{m} = 0.17857 (m = 5.6)$$

1.3 Boundary conditions and loadings

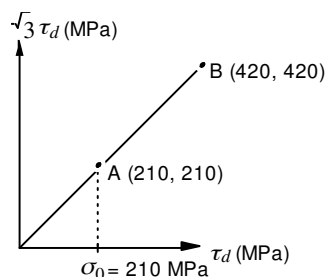
On A : $u_x = u_y = 0$

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:

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

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

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

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

$$\text{avec } R = \frac{E \cdot D_SIGM_EPSI}{E - D_SIGM_EPSI}$$

At any moment t , one a:

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

2.2 Results of reference

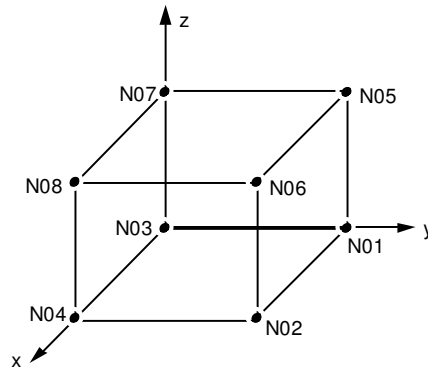
ε_{p-xx} and ε_{p-xy} at the moments $t=3630s$, $t=3660s$ and $t=3720s$

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:

$$F_X: -\frac{1}{4}\sigma_d(t) \quad , \quad F_Y: -\frac{1}{4}\tau_d(t) \quad \text{on nodes } 1,3,5,7$$

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

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

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

3.2 Characteristics of the grid

Many nodes: 8
Many meshes and types: 1 `HEXA8`

3.3 Sizes tested and results

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

4 Summary of the results

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