# SSNP107 - Plate in tension-shears: viscoelasticity of Lemaître and isotropic hardening

**Abstract:**

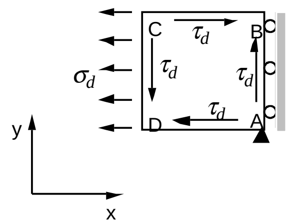
This test of nonlinear quasi-static mechanics consists in charging in tension-shears a square plate. One thus validates the sequence of several computations with alternatively a plastic constitutive law with isotropic hardening and a viscoelastic constitutive law of Lemaître, the value of the local variables (cumulated plastic strain and loadmeter (discharge) at the end of a computation being taken again at the beginning of following computation. The loading remains radial on the group of the test.

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

# 1 Problem of reference

## 1.1 Geometry

Plates square




## 1.2 Material properties

These properties vary according to the time interval considered:

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

$E = 178\,600\,MPa$

$\nu = 0.3$

Plasticity with linear isotropic hardening:

$\sigma_y = 120\ MPa$ $\quad$ D_SIGM_EPSI $= 1930\,MPa$

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

$E = 178\,600\,MPa$

$\nu = 0.3$

viscoelastic Behavior model of Lemaître:

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

## 1.3 Boundary conditions and loadings

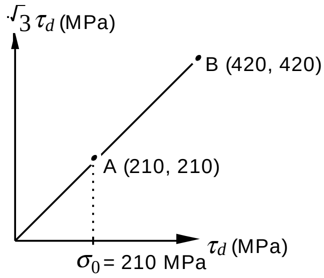
On $A$ : $u_x = u_y = 0$

On the side $AB$ : $u_x = 0$

Loading below ( $t = 0$ in $0$ )

Ways $OA$ and $AB$ , of period 30 seconds.

Time of maintenance in $A$ and $B$ 3600 seconds.



# 2 Reference solution

## 2.1 Method of calculating used for the explicit reference solution

Integration: the cumulated plastic strain $p$ 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 $R=\frac{E.\texttt{D\_SIGM\_EPSI}}{E-\texttt{D\_SIGM\_EPSI}}$

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

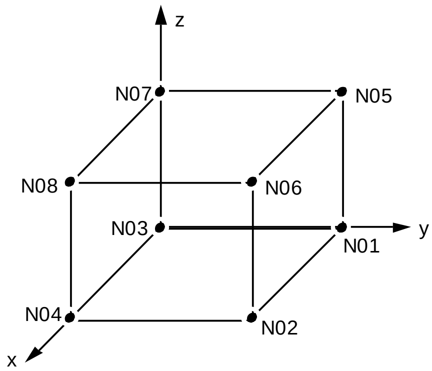
$\varepsilon_{p-xx}$ and $\varepsilon_{p-xy}$ at times $t=3630\,s$, $t=3660\,s$ and $t=3720\,s$

## 2.3 Uncertainty on the solution

No analytical solution.

# 3 Modelization A

## 3.1 Characteristic of the modelization




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

The loading and the boundary conditions are modelled by:

1) conditions of blocking adapted at the same time to prevent any rigid body motion 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 the 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 the nodes 1,2,5,6

## 3.2 Characteristics of the mesh

Many nodes: 8
Number of meshes and types: 1 Urgent

## 3.3 HEXA8 Quantities tested and

| Variable | results (S) | Reference | *Aster* | % difference |
|---|---|---|---|---|
| $\varepsilon_{p-xx}$ | 3630 | 9.06364 10-2 | 9.06373 10-2 | 0.001 |
| $\varepsilon_{p-xy}$ | 3630 | 7.84935 10-2 | 7.84942 10-2 | 0.001 |
| $\varepsilon_{p-xx}$ | 3660 | 1.71775 10-1 | 1.717749 10-1 | 7.69 10-5 |
| $\varepsilon_{p-xy}$ | 3660 | 1.48761 10-1 | 1.48761 10-1 | 2.68 10-4 |
| $\varepsilon_{p-xx}$ | 3720 | 2.80733 10-1 | 2.80909 10-1 | 0.063 |
| $\varepsilon_{p-xy}$ | 3720 | 2.43122 10-1 | 2.43274 10-1 | 0.063 |

# 4 Summary of the results

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