SSNP101 - Plate in traction-shearing: viscoelasticity of Lemaître (D_PLAN)

Summary:

This test of nonlinear quasi-static mechanics consists in charging in traction-shearing a square plate.

One thus validates the relations of nonlinear behavior of viscoelasticity in plane deformations for a nonradial loading.

Modeling A validate in $2\mathrm{D}$ D_PLAN the law of Lemaître and the law VISC_ENDO_LEMA, for which the parameters are adjusted so that the damage is null.

Modeling B validate the law VISC_TAHERI in $2\mathrm{D}$ D_PLAN, in which the parameters are adjusted so that the effect of plasticity and ratchet are destroyed

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

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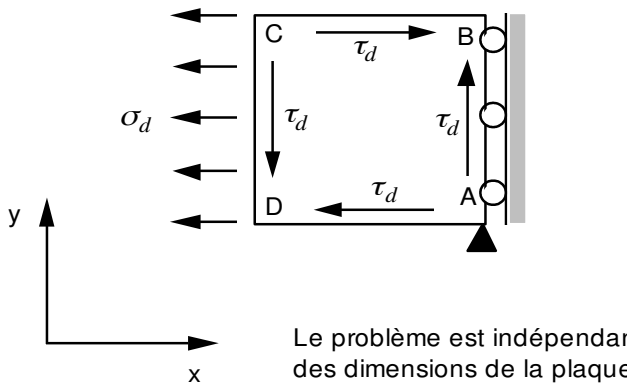
1 Problem of reference

1.1 Geometry

Square plate



1.2 Material properties

The isotropic elastic parameters of the model are:

$E=178\,600\,MPa \quad \nu=0.3$

Viscoelastic relation of behavior of Lemaître

$n=11 \qquad \frac{1}{K}=3.28410^{-4} \ (\ K=3045 \ ) \qquad \frac{1}{m}=0.17857 \quad (\ m=5.6 \ )$

Relation of behavior VISC_ENDO_LEMA (not of damage) $A_D=100000.0$

Relation of behavior VISC_TAHERI (not of plasticity)

$R_0=0.001 \quad \alpha=0 \ , \ M=1 \ , \ A=0 \ , \ B=0 \ , \ C_1=0 \ , \ C_{INF}=0 \ , \ S=900$

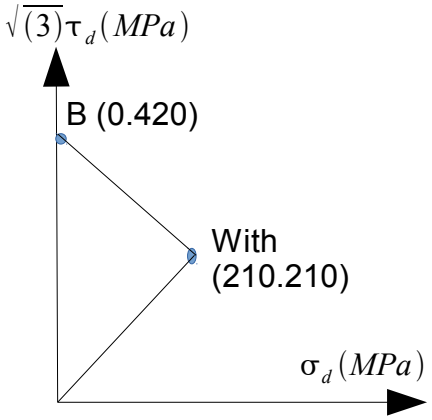
1.3 Boundary conditions and loadings

In A : $u_x=u_y=0$

On the side AB : $u_x=0$

Loading below: Ways OA and AB , of duration 30 seconds,

Time of maintenance in A and B from 3600 seconds.



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2 Reference solution

2.1 Method of calculating used for the reference solution

Calculation 3D of Code_Aster carried out with an element HEXA8 all the nodes have a displacement imposed no one according to Oz . That makes it possible to constitute a reference for the case of the plane deformations (in the plan (Ox, Oy)), where one does not have an analytical solution or results of other computer codes.

Operation in $3D$ non-linear viscoelasticity of Lemaître itself was validated using the test SSNP05A.

2.2 Results of reference

$\varepsilon_{v_{xx}}$ and $\varepsilon_{v_{xy}}$ at the moments $t=30\,s$, $t=3630\,s$, $t=3660\,s$ and $t=3720\,s$

2.3 Uncertainty on the solution

Uncertainty lower than 0.5%

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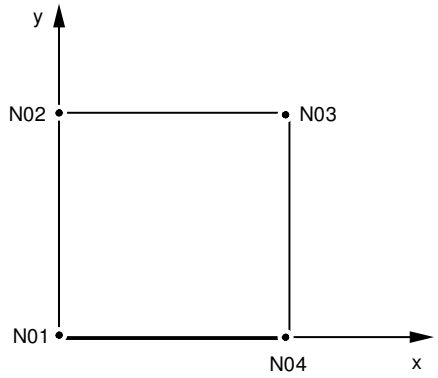
3 Modeling A

3.1 Characteristics of modeling

Only one element being pressed on a mesh QUAD4, in D_PLAN.



The loading and the boundary conditions are modelled by:

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DDL_IMPO: (NODE: N04, DX: 0. , DY: 0.)
DDL_IMPO: (NODE: N03, DX: 0.)
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FORCE_NODALE: (NODE; (N01 N02), FX: $-\frac{1}{2}\sigma_d(t)$, FY: $-\frac{1}{2}\tau_d(t)$)

FORCE_NODALE: (NODE; (N01 N04), FX: $-\frac{1}{2}\tau_d(t)$)

FORCE_NODALE: (NODE; (N03 N04), FY: $\frac{1}{2}\tau_d(t)$)

FORCE_NODALE: (NODE; (N02 N03), FX: $\frac{1}{2}\tau_d(t)$)

where $\sigma_d(t)$ and $\tau_d(t)$ are the higher definite positive functions [§1.3].

3.2 Sizes tested and results

Behavior LEMAITRE (THETA=0.5)

Variables	Moments (S)	Reference	*Tolerance*
$\varepsilon_{v_{xx}}$	30	1.7620 10^{-4}	0.5%
$\varepsilon_{v_{xy}}$	30	1.81585 10^{-4}	0.5%
$\varepsilon_{v_{xx}}$	3630	1.9030 10^{-3}	0.5%
$\varepsilon_{v_{xy}}$	3630	2.0789 10^{-3}	0.5%
$\varepsilon_{v_{xx}}$	3660	1.9130 10^{-3}	0.5%
$\varepsilon_{v_{xy}}$	3660	2.1906 10^{-3}	0.5%
$\varepsilon_{v_{xx}}$	3720	1.8740 10^{-3}	0.5%
$\varepsilon_{v_{xy}}$	3720	3.1813 10^{-3}	0.5%

Behavior VISC_ENDO_LEMA (with a temporal discretization 10 times finer)

Variables	Moments (S)	Reference	Tolerance
$\varepsilon_{v_{xx}}$	30	1,762 10^{-4}	0.7%

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$\varepsilon_{\nu_{xy}}$	30	$1{,}816\ 10^{-4}$	0.7%

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4 Modeling B

4.1 Characteristics of modeling

Identical to modeling A. Seule the law of behavior changes: here the law is VISC_TAHERI.

4.2 Sizes tested and results

Behavior VISC_TAHERI (with a temporal discretization 10 times finer than LEMAITRE)

Variables	Moments (S)	Reference	*Tolerance*
$\varepsilon_{v_{xx}}$	30	$1{,}762\ 10^{-4}$	1,00%
$\varepsilon_{v_{xy}}$	30	$1{,}816\ 10^{-4}$	1,00%
$\varepsilon_{v_{xx}}$	3630	$1.9030\ 10^{-3}$	1,00%
$\varepsilon_{v_{xy}}$	3630	$2.0789\ 10^{-3}$	1,00%
$\varepsilon_{v_{xx}}$	3660	$1.9130\ 10^{-3}$	1,00%
$\varepsilon_{v_{xy}}$	3660	$2.1906\ 10^{-3}$	1,00%
$\varepsilon_{v_{xx}}$	3720	$1.8740\ 10^{-3}$	1,00%
$\varepsilon_{v_{xy}}$	3720	$3.1813\ 10^{-3}$	1,00%

Note: one uses the method of Brent for the resolution of the law of behavior.

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5 Summary of the results

This test validates in $2D$ deformation planes the 3 laws of behavior LEMAITRE, VISC_ENDO_LEMA (without damage) and VISC_TAHERI (without plasticity) whose equations relating to viscosity are controls by the law of Lemaître. The differences between the models are lower than 1%.

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