SSND115 - Constitutive law elastoplastic with effect of nonradiality

Summarized:

The problem is quasi-static nonlinear in structural mechanics. The model tested, VISC_MEMO_NRAD, are a constitutive law with nonlinear kinematic hardening, isotropic hardening, and memory of maximum hardening, like taking into account of nonthe radiality (or not proportionality) of the loading.

One analyzes the response in a material point, on a cyclic test of tension-torsion.

The modelization A allows to validate the effects of memory and nonradiality in comparison with experimental results.

1 Problem of reference

1.1 Geometry

Material point

1.2 Properties of the materials

isotropic Elasticity $E=184\,000\,MPa$ $\nu=0.3$

isotropic Hardening

R_0	$97.83\,MPa$	B	51.3

Memory

10		Q_0	$-86.2\,MPa$
ETA	0.14	Q_M	$270.5\,MPa$

Kinematic hardening (modelization A)

C1	182392 MPa	G1_0	3079
C2	16678 MPa	G2_0	178.7

Viscosity of LEMAITRE

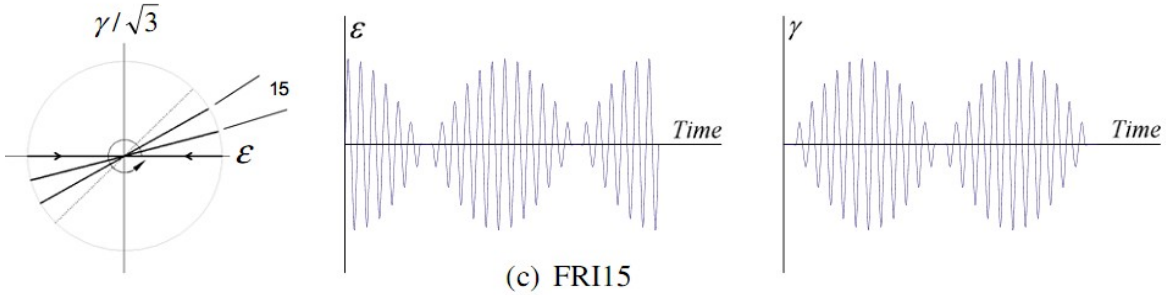
UN_SUR_K	$1/156.9\,(MPa\,S^{1/N})^{-1}$	N	6.84

Effect of nonradiality

DELTA1	0.00306 2	DELTA2	0.01546

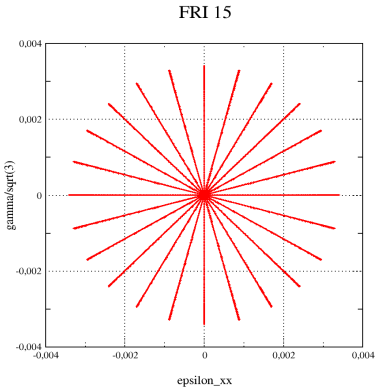
1.3 Boundary conditions and loadings

Loading nonproportional of tension-torsion, with imposed strain, with increments of 15 degrees, which amounts on a material point imposing the components ε_{xx} and ε_{xy} , with phase shift between these two components. P our each angle, the cycles are symmetric.



(c) FRI15

The representation of the loading in a plane $\frac{2}{\sqrt{3}}\varepsilon_{xy}$ - ε_{xx} is the following one:



To obtain an almost stabilized state, one applies the set of these cycles 4 times.

2 Reference solution

2.1 Results of reference

the results are experimental [ref. 1]. The measured values are the amplitudes of stress after stabilization:

Loading	$\frac{\Delta \varepsilon_{xx}}{2}$	ε_{moy}	$\frac{\Delta \sigma_{xx}}{2}$	σ_{moy}	$\frac{\Delta \gamma}{2}$	γ_{moy}	$\frac{\Delta \sigma_{xy}}{2}$	σ_{xymoy}
FRI15	0.0034	0	413	-5	0.0058	0	237	0
FRI15	0.0034	0	398	-5	0.0058	0	231	1

One thus obtains the following averages $\frac{\Delta \sigma_{xx}}{2} = 405.5\,MPa$ and $\frac{\Delta \sigma_{xy}}{2} = 234\,MPa$,

which, like $\sigma_{xx}moy = -5\,Mpa$, and $\sigma_{xx}moy = 0{,}5\,Mpa$ led to:

$\sigma_{xx}max = 400.5\,MPa$, $\sigma_{xx}min = -410.5\,MPa$

$\sigma_{xy}max = 234.5\,MPa$, $\sigma_{xy}min = -233.5\,MPa$

2.2 Uncertainty on the solution

the uncertainty which rises from the variability of the experimental results is of 2%. That which comes from the identification of the material parameters can be estimated at 5% to 10% (cf [ref. 2]).

2.3 Bibliographical references

[1] “Multiaxial tires evaluating using discriminating strain paths” Nima Shamsaei, Ali Fatemi, Darrell F. Socie International Newspaper of Fatigue 33 (2011) 597-609

[2] J.M.PROIX “Behavior viscoplastic taking into account it not proportionality of loading” EDF R & D - CR-AMA12-284, 12/12/12 Modelization

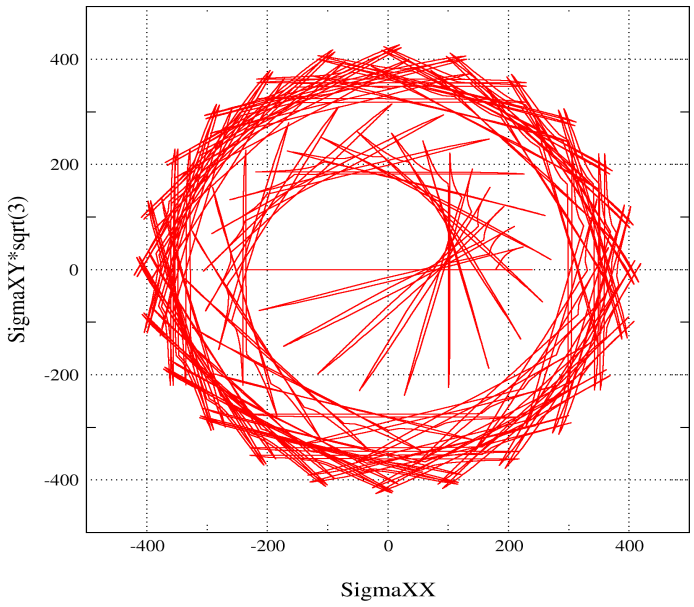
3 A Characteristic

3.1 of the modelization Material point

, behavior VISC_MEMO _NRAD. Each elementary
cycle (a traction and compression for a given torsion) is discretized in 48 steps. To carry out a full rotation on the preceding diagram one needs elementary cycles $360/15=24$. One carries out in all 4 rotations full, that is to say on the whole time step $48\times24\times4=4608$. Quantities

3.2 tested and results the representation

of the results in a diagram shows $\sqrt{3}\,\sigma_{xy};\sigma_{xx}$ the stabilization of the response the extreme



values of the stresses obtained at the end of the loading are Identification

Reference	tolerance	formulates
$\sigma_{xx}max$	400.5	
$\sigma_{xx}min$	-410.5	
$\sigma_{xy}max$	234.5	6.00%
$\sigma_{xy}min$	-233.5	6.00%

4 of the results the results

show the capacity of the model to take into account it on hardening due to nonthe radiality of the loading. Indeed, in the absence of terms related to nonthe radiality, the amplitudes obtained are much lower (approximately of less $100\,Mpa$). The difference from 5 to 6% with the experiment can be regarded as acceptable.