SSND115 - Elastoplastic law of behavior with effect of nonradiality

Summary:

The problem is quasi-static non-linear in mechanics of the structures. The law tested, VISC_MEMO_NRAD, is a law of behavior with non-linear kinematic work hardening, isotropic work hardening, and memory of maximum work hardening, like taking into account of nonthe radiality (or not proportionality) of the loading.

One analyzes the answer in a material point, on a cyclic test of traction-torsion.

Modeling A makes it possible to validate the effects of memory and nonradiality in comparison with experimental results.

1 Problem of reference

1.1 Geometry

Not material

1.2 Properties of materials

Isotropic elasticity $E=184\,000\,MPa$ $\nu=0.3$

Isotropic work 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 work hardening (modeling A)

C1	182392 MPa	G1_0	3079
C2	16678 MPa	G2_0	178.7

Viscosity of LEMAITRE

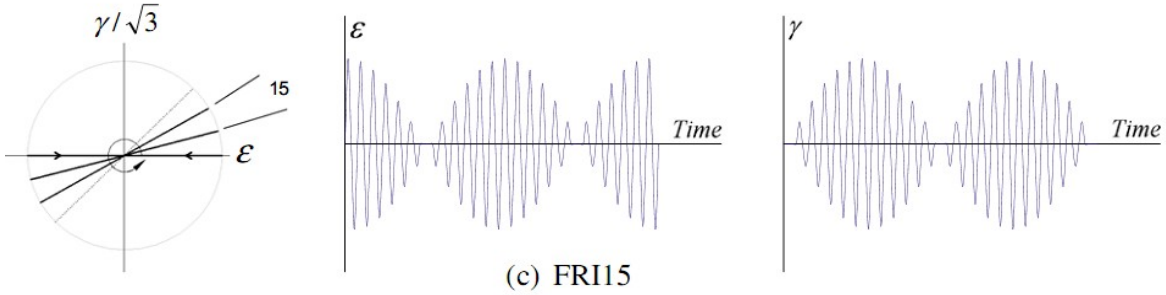
UN_SUR_K	$1/156.9\,(MPa\,S^{1/N})^{-1}$	NR	6,84

Effect of nonradiality

DELTA1	0.00306 2	DELTA2	0.01546

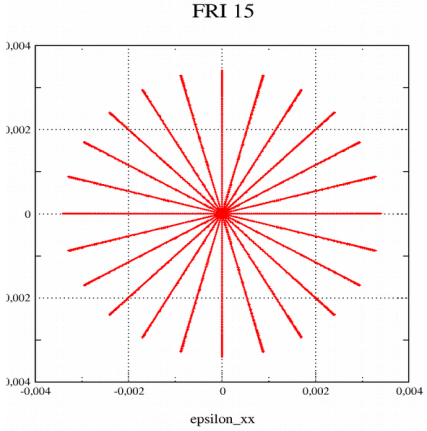
1.3 Boundary conditions and loadings

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



(c) FRI15

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



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

2 Reference solution

2.1 Results of reference

The results are experimental [ref. 1]. The measured values are them amplitudes of constraint 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

The following averages are thus obtained $\frac{\Delta \sigma_{xx}}{2} = 405.5\,MPa$ and $\frac{\Delta \sigma_{xy}}{2} = 234\,MPa$,

what, like $\sigma_{xx}moy = -5\,Mpa$, and $\sigma_{xx}moy = 0{,}5\,Mpa$ conduit with:

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

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

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 parameters material can be estimated at 5% to 10% (cf [ref. 2]).

2.3 Bibliographical references

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

[2] J.M.PROIX “ Comportement viscoplastic fascinating in account not proportionality of the loading” EDF R & D - CR-AMA12-284, 12/12/12

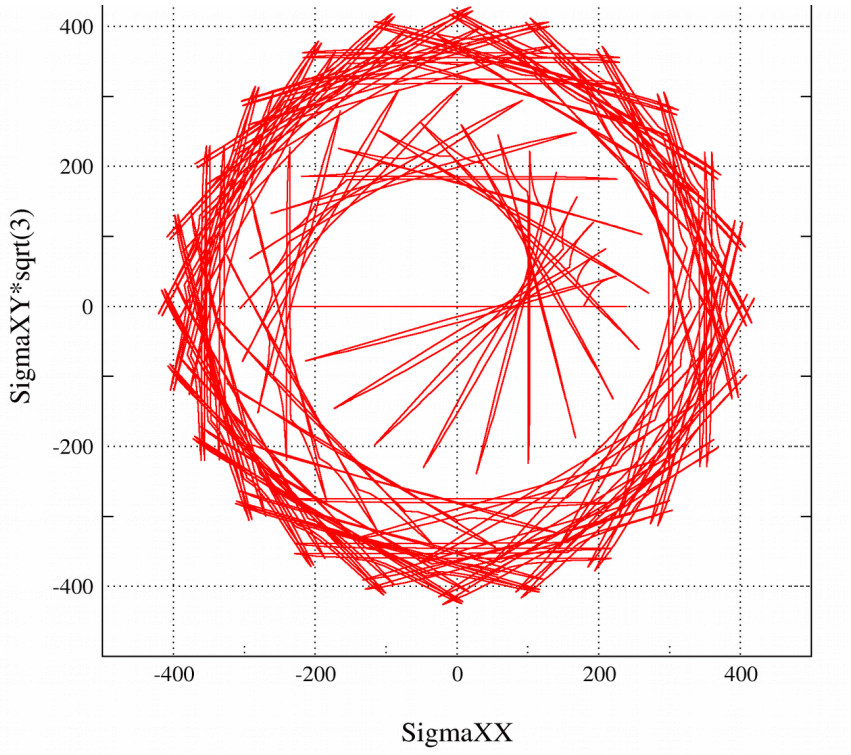
3 Modeling A

3.1 Characteristics of modeling

Not material, behavior VISC_MEMO_NRAD.
Each elementary cycle (a traction and compression for a given torsion) is discretized in 48 pas. Pour to carry out a full rotation on the preceding diagram it is necessary $360/15=24$ elementary cycles. One carries out in all 4 rotations full, that is to say on the whole $48\times24\times4=4608$ pas de time.

3.2 Sizes tested and results

The representation of the results in a diagram $\sqrt{3}\,\sigma_{xy}\,;\sigma_{xx}$ watch the stabilization of the answer



The extreme values of the constraints obtained at the end of the loading are

Identification	Reference	tolerance
$\sigma_{xx}max$	400,5	5%
$\sigma_{xx}min$	-410,5	3%
$\sigma_{xy}max$	234,5	6,00%
$\sigma_{xy}min$	-233,5	6,00%

4 Summary of the results

The results show the capacity of the model to take into account it on work 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 $100\,Mpa$ of less). The difference from 5 to 6% with the experiment can be regarded as acceptable.