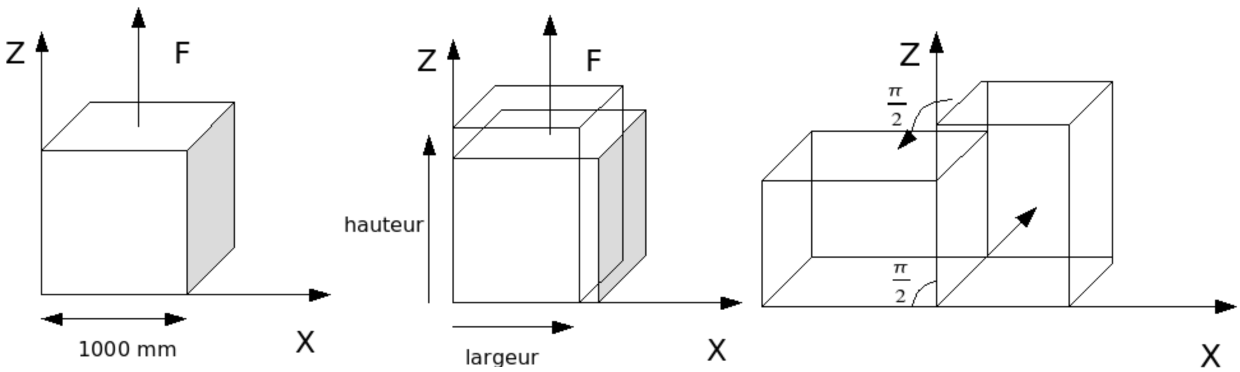
SSND108: Multiple tensions rotations in large deformations, élasto-viscoplastic constitutive laws.

Abstract:

This test models an element subjected to four cycles tension-rotation of rigid body of $45°$, with the constitutive laws élasto-visco-plastics (with isotropic, kinematical and mixed hardening) in hypoelastic large deformations (GDEF_HYPO_ELAS) and logarithmic curves (GDEF_LOG). It is checked that rotation does not modify the stress relaxation by viscosity, and that the values obtained with the various constitutive laws are identical. This test validates the objectivity of the frame of the hypoelastic large deformations in 5 viscoplastic cases as well as large deformations logarithmic curves in the viscoplastic case of type LEMAITRE.

1 Problem of reference

1.1 Figure1



Geometry: Problem of reference (for a rotation of $90°$)

One considers a cubic matter element on $1000\,mm$ side subjected alternatively to a tensile force then with an overall rotation of $45°$. It undergoes in all 4 cycles tension/rotation.

1.2 Material characteristics

One considers here 5 élasto-viscoplastic constitutive laws with isotropic hardening or kinematical/isotropic compound of type von Mises: `LEMAITRE`, `VISC_ENDO_LEMA`, `VISC_CIN2_MEMO`, `VISC_CIN1_CHAB` and `VISC_CIN2_CHAB`. Table below list parameters used; in order to reinforce the comparison, the parameters used lead to identical constitutive laws in the 5 cases.

Mot_Clé	Parameter	Value
ELAS	E	$200\,000\mathrm{MPa}$
	NU	$0,3$
LEMAITRE	UN_SUR_M	0
	N	$20\,MPa$
	UN_SUR_K	$1.\mathrm{E}-3$
MEMO_ECRO	MU	1
	Q_M	0
	Q_0	0
	ETA	0
CIN1_CHAB	C_I	0
	R_0	$1.\mathrm{E}-6\,MPa$
	R_I	$1.\mathrm{E}-6\,MPa$
	G_0	0

Mot_Clé	Parameter	Value
CIN2_CHAB	C1_I	0
	C2_I	0
	R_0	$1.E-6\,MPa$
	R_I	$1.E-6\,MPa$
	G1_0	0
	G2_0	0
VISC_ENDO_LEMA	S	0
	N	20
	UN_SUR_M	0
	UN_SUR_K	1,00E-003
	R_D	1
	A_D	1,00E+007

1.3 Boundary conditions and loadings

Two types of phases must be distinguished: phases of tension and the phases of rotation. Normal displacements of the front and back sides are blocked.

Phases of tension:
First phase of Standard

tension	Entity charges	Value
lower Face	FACE_IMPO	$DNOR=0$
Upper face	FACE_IMPO	$DNOR=500\text{mm}$
Centers rotation	DDL_IMPO	$DX=0$
front Face ($3D$)	FACE_IMPO	$DNOR=0$
Face back ($3D$)	FACE_IMPO	$DNOR=0$

following Tensions:

Standard	entity charges	Value
lower Face	LIAISON_OBLIQUE	$DZ=0$
Upper face	LIAISON_OBLIQUE	$DZ=200\text{mm}$
Side $X=0$; $Z=1\text{mm}$	LIAISON_OBLIQUE	$DX=0$
Centers rotation	DDL_IMPO	$DX=0, DZ=0$
front Face	DDL_IMPO	$DY=0$
back Face	DDL_IMPO	$DY=0$

Each phase of tension is made up of 5 identical increments.

Phase of rotation:
Limiting conditions

Standard	Entity charges	Value
Centers rotation	DDL_IMPO	$DX=0, DZ=0$
front Face	DDL_IMPO	$DY=0$
back Face	DDL_IMPO	$DY=0$

the loading of rotation is imposed via a macro named CHAR_ROTA ; one imposes an overall rotation from $45°$ phase, cut out in 5 increments of $9°$.

2 Results of reference

This test does not have result of reference. One compares the solutions provided for each model (they are supposed to be equivalent). Moreover, one checks for the model of Lemaître in hypoelastic large deformations that the tension stopped but without rotation leads to values of stresses identical to those obtained by carrying out rotations over periods equal to the stops of tension.

3 Modelization A

3.1 Characteristic of the modelization

The modelization used is `3D`

3.2 Characteristic of the mesh

The mesh consists of a linear hexahedral mesh (with 8 nodes).

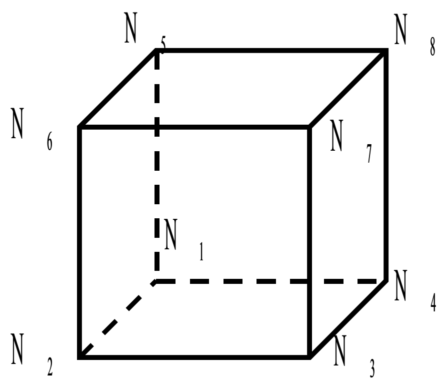


Figure 2: Mesh of the modelization A

3.3 Quantities tested and results

Behavior `LEMAITRE` strains `GDEF_LOG`

Displacement imposed	Quantities tested	Reference MPa	% Tolerance
$500\,mm$	`SIEQ_ELGA`	681.5	0,2
$700\,mm$	`SIEQ_ELGA`	680.4	0,1
$900\,mm$	`SIEQ_ELGA`	680.3	0,1
$1100\,mm$	`SIEQ_ELGA`	680.2	0,1

Behavior `LEMAITRE` strains `GDEF_HYPO_ELAS`

Displacement imposed	Quantities tested	Référenceformula MPa	% Tolerance
$500\,mm$	`SIEQ_ELGA`	681.5	0,2
$700\,mm$	`SIEQ_ELGA`	680.4	0,1
$900\,mm$	`SIEQ_ELGA`	680.3	0,1
$1100\,mm$	`SIEQ_ELGA`	680.2	0,1

Behavior `VISC_ENDO_LEMA` strains `GDEF_HYPO_ELAS`

Displacement imposed	Quantities tested	Reference MPa	% Tolerance
$500\,mm$	`SIEQ_ELGA`	681.5	0,2
$700\,mm$	`SIEQ_ELGA`	680.4	0,1
$900\,mm$	`SIEQ_ELGA`	680.3	0,1
$1100\,mm$	`SIEQ_ELGA`	680.2	0,1

Behavior VISC_CIN1_CHAB strains GDEF_HYPO_ELAS

Displacement imposed	Quantities tested	Reference MPa	% Tolerance
$500\,mm$	SIEQ_ELGA	681.5	0,2
$700\,mm$	SIEQ_ELGA	680.4	0,1
$900\,mm$	SIEQ_ELGA	680.3	0,1
$1100\,mm$	SIEQ_ELGA	680.2	0,1

Behavior VISC_CIN2_CHAB strains GDEF_HYPO_ELAS

Displacement imposed	Quantities tested	Reference MPa	%Tolérance
$500\,mm$	SIEQ_ELGA	681.5	0,2
$700\,mm$	SIEQ_ELGA	680.4	0,1
$900\,mm$	SIEQ_ELGA	680.3	0,1
$1100\,mm$	SIEQ_ELGA	680.2	0,1

Behavior VISC_CIN2_MEMO strains GDEF_HYPO_ELAS

Displacement imposed	Quantities tested	Reference MPa	% Tolerance
$500\,mm$	SIEQ_ELGA	681.5	0,2
$700\,mm$	SIEQ_ELGA	680.4	0,1
$900\,mm$	SIEQ_ELGA	680.3	0,1
$1100\,mm$	SIEQ_ELGA	680.2	0,1

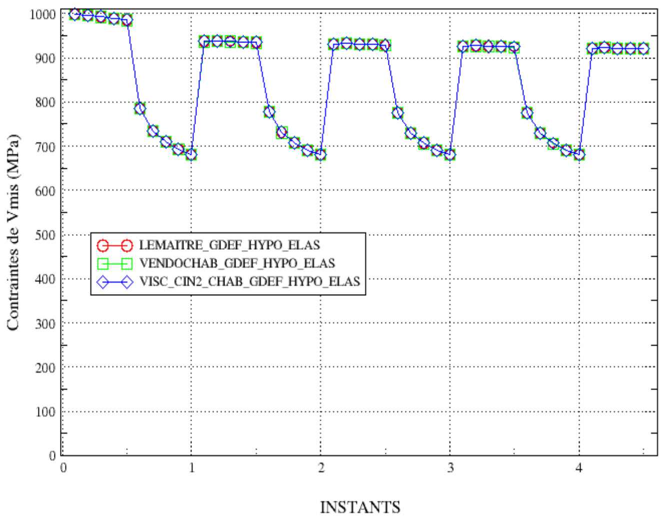


Figure 3: Curves forced/urgent for the 5 constitutive laws

4 Summary of the results

the got results are satisfactory. It is noted that all the constitutive laws lead well to identical results and that the rotation of rigid body does not generate any modification of the stress.