SSND106: Multiple tensions rotations in large deformations, isotropic hardening

Abstract:

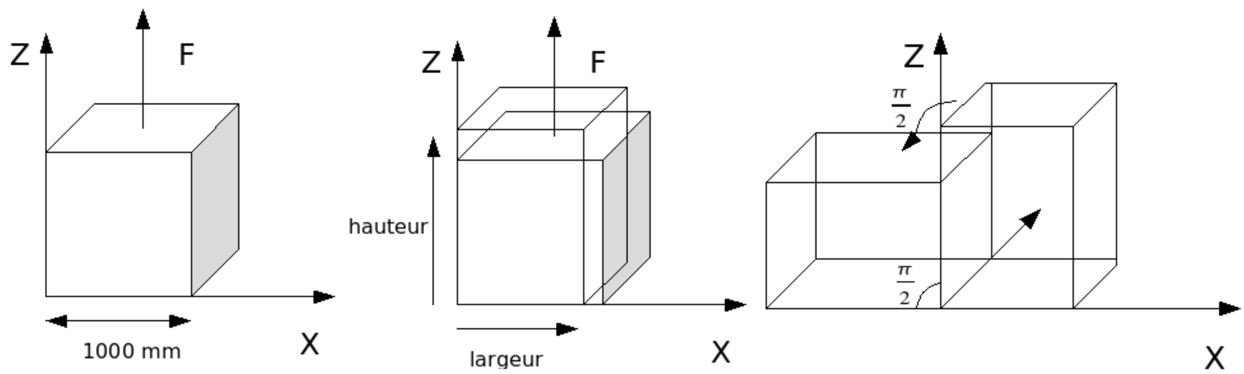
This test models a material point subjected to four cycles tension-rotation of rigid body of $45°$, with an elastoplastic constitutive law of Von Mises with isotropic hardening in large deformations (hypoelastic formulation GDEF_HYPO_ELAS, formulation with logarithmic strain GDEF_LOG). One checks on the one hand the invariance of the equivalent stress of Von Mises during the phases of rotation, and on the other hand his values during the tensions while comparing with the modelization of SIMO_MIEHE.

The modelizations A and B deal with the problem in plane strains, either in 3D (A), or in D_PLAN (B).

The modelizations C and D deal with the problem in plane stresses, either in 3D (C), or in C_PLAN (D).

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 the elastoplastic constitutive law with isotropic hardening of type von Mises: VMIS_ISOT_LINE. Table below list parameters used; in order to reinforce the comparison, the parameters used lead to identical constitutive laws in the 2 cases (linear isotropic hardening).

Young modulus:	$200\,000\ MPa$
Poisson's ratio	$0{,}3$
linear	$200\ MPa$
Elastic limit Hardening modulus	$2\,000\ MPa$

1.3 Boundary conditions and loadings

In the modelization A , in 3D one blocks normal displacements of the front and back sides, in order to compare the results with modelization B 2D (D_PLAN).
In the modelization C , also in 3D one leaves free displacements of the front and back sides, in order to compare the results with modelization D 2D (C_PLAN).

Two types of phases must be distinguished: phases of tension and the phases of rotation.
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 ($3D$)	DDL_IMPO	$DY=0$
Face back ($3D$)	DDL_IMPO	$DY=0$

Phase of rotation:

Boundary conditions

Standard	Entity charges	Value
Centers rotation	DDL_IMPO	$DX=0, DZ=0$
front Face ($3D$)	DDL_IMPO	$DY=0$
Face back ($3D$)	DDL_IMPO	$DY=0$ or free

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

the results of reference are got by carrying out same computation with the model of large deformations of Simo-Miehe (DEFORMATION = "SIMO-MIEHE"), validated in addition.

Behavior VMIS_ISOT_LINE with SIMO_MIEHE, in plane strain:

Displacement imposed	Quantity tested	Reference (MPa)
$500\,mm$	SIEQ_ELGA	1125
$700\,mm$	SIEQ_ELGA	1411
$900\,mm$	SIEQ_ELGA	1664
$1100\,mm$	SIEQ_ELGA	1891.7

One compares the values of the equivalent stresses of von Mises at the end of the phases of tension and one checks their invariance during the phases of rotation.

Behavior VMIS_ISOT_LINE with SIMO_MIEHE in plane stress

Displacement imposed	Quantity tested	Reference (MPa)
$500\,mm$	SIEQ_ELGA	1019.57
$500\,mm$ after rotation	SIEQ_ELGA	1019.57
$700\,mm$	SIEQ_ELGA	1271

One checks finally the quality of the tangent matrix by comparison with a tangent matrix obtained by disturbance. One obtains with SIMO_MIEHE, a difference quasi null (norm of the difference: about $1.E-20$). One will thus check the difference obtained on the tangent matrix for the formalisms in large deformations tested here.

3 Modelization A

3.1 Characteristic of the modelization

The modelization is 3D.

3.2 Characteristics of the mesh

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

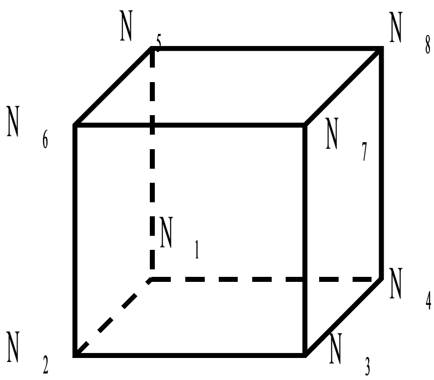


Figure 2: Mesh of the modelization A

3.3 Quantities tested and results

Behavior VMIS_ISOT_LINE with GDEF_HYPO_ELAS

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
$500\,mm$	SIEQ_ELGA	1125	0,2
$700\,mm$	SIEQ_ELGA	1411	0,2
$900\,mm$	SIEQ_ELGA	1664	0,2
$1100\,mm$	SIEQ_ELGA	1891.7	0,2

Behavior VMIS_ISOT_LINE with GDEF_LOG

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
$500\,mm$	SIEQ_ELGA	1125	0,2
$700\,mm$	SIEQ_ELGA	1411	0,2
$900\,mm$	SIEQ_ELGA	1664	0,2
$1100\,mm$	SIEQ_ELGA	1891.7	0,2

4 Modelization B

4.1 Characteristic of the modelization

The modelization used is two-dimensional. One The mesh uses elements

4.2 D_PLAN Characteristics of

the mesh consists of a linear quadrangular mesh (with 4 nodes).

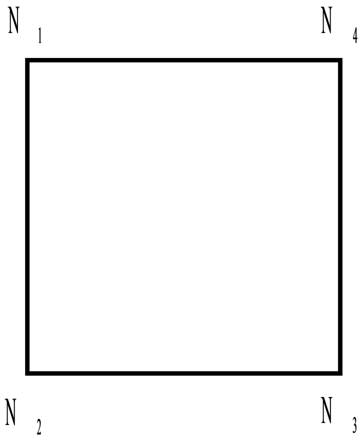


Figure 3: Mesh of the modelization B

4.3 Quantities tested and results

Behavior VMIS_ISOT_LINE with GDEF_HYPO_ELAS

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
500mm	SIEQ_ELGA	1125	0,2
700mm	SIEQ_ELGA	1411	0,2
900mm	SIEQ_ELGA	1664	0,2
1100mm	SIEQ_ELGA	1891.7	0,2

Behavior VMIS_ISOT_LINE with GDEF_LOG

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
500mm	SIEQ_ELGA	1125	0,2
700mm	SIEQ_ELGA	1411	0,2
900mm	SIEQ_ELGA	1664	0,2
1100mm	SIEQ_ELGA	1891.7	0,2

5 Modelization C

5.1 Characteristic of the modelization

The modelization is 3D, and simulates a plane stress state. One considers here only one tension, a rotation and a new tension.

5.2 Characteristics of the mesh

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

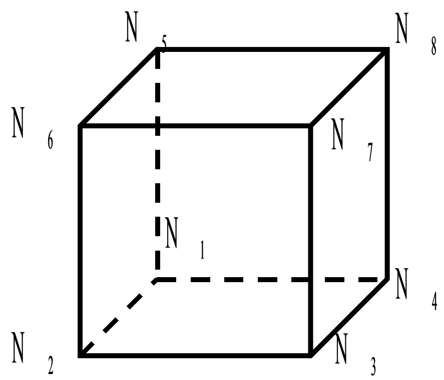


Figure 4: Mesh identical to that of the modelization A

5.3 Quantities tested and results

Behavior VMIS_ISOT_LINE with GDEF_LOG

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
$500\,mm$	SIEQ_ELGA	1019.57	2
$500\,mm$ after rotation	SIEQ_ELGA	1019.57	2
$700\,mm$	SIEQ_ELGA	1271	2

Behavior VMIS_ISOT_LINE with GDEF_HYPO_ELAS

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
$500\,mm$	SIEQ_ELGA	1019.57	2
$500\,mm$ after rotation	SIEQ_ELGA	1019.57	2
$700\,mm$	SIEQ_ELGA	1271	2

6 Modelization D

6.1 Characteristic of the modelization

The modelization used is two-dimensional in plane stress (C_PLAN). The goal of this modelization is to validate the algorithm of large deformations GDEF_LOG in C_PLAN. One thus compares the results with those obtained by GDEF_LOG in the modelization C , which treats in 3D an equivalent problem.

6.2 Characteristics of the mesh

The mesh consists of a linear quadrangular mesh (with 4 nodes).

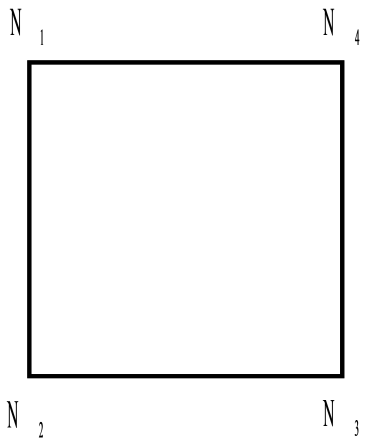


Figure 5: Mesh identical to that of the modelization B

6.3 Quantities tested and results

Behavior VMIS_ISOT_LINE with GDEF_LOG

Displacement imposed	Quantity tested	Reference (MPa)	Tolerance (%)
$500\,mm$	SIEQ_ELGA	1006.9	0,1
$500\,mm$ after rotation	SIEQ_ELGA	1006.9	0,1
$700\,mm$	SIEQ_ELGA	1256.1	0,1

7 Summary of the results

the got results are satisfactory, as well in $3D$ as in $2D$. One notes a maximum change lower than $0{,}2\%$ between SIMO_MIEHE (taken as reference) and the formalisms GDEF_HYPO_ELAS and GDEF_LOG.

This test also validates the correct operation of GDEF_LOG in plane stresses.

Moreover, for all the modelizations, the equivalent stress remains constant during the phases of rotations.