SSNV133 - Uniaxial traction and compression. Mixed work hardening

Summary:

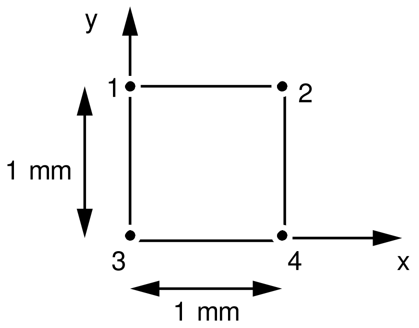
The purpose of this test is to validate the elastoplastic behaviors VMIS_ECMI_TRAC and VMIS_ECMI_LINE, which combines an isotropic work hardening (linear or given by a traction diagram) and a linear kinematic work hardening.

The geometrical and mechanical data make it possible to be in uniaxial situation (uniform constraints, only one nonworthless component). The reference solution is simple, analytical. This test simply makes it possible to check that the integration of the model of behavior is correct.

3 modelings make it possible to check the uniaxiality of the constraints: 3D, AXIS, C_PLAN.

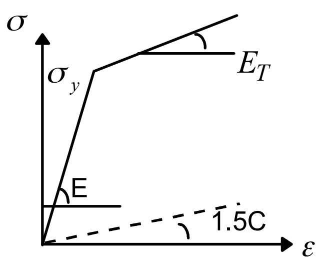
1 Problem of reference

1.1 Geometry



1.2 Material properties

Elastoplastic law of behaviour to mixed work hardening (isotropic linear and kinematic linear).



$C = 20000$ MPa
$E = 200000$ MPa
$\nu = 0.3$
$\sigma^Y = 400$ MPa
$E_T = 40000$ MPa

1.3 Boundary conditions and loadings

The plate is blocked according to Oy along the side [3.4], following Ox along the side [1.3] while being subjected to a displacement imposed in y : u_y^D along the side [1.2].

The way of loading is the following:

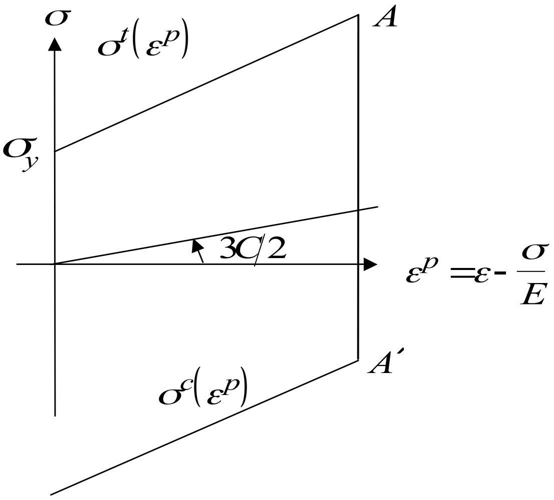
t	u_y^D (mm)
1	$2.\ 10^{-3}$
2	4.5d-3
3	0.1d-3
4	$-2.\ 10^{-3}$

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is obtained by an analytical calculation.

Imposed displacement u_y^D provides the deformation immediately $\varepsilon_{yy}=\frac{u_y^D}{1}$. Only this component (corresponding to the nonworthless component of the tensor of the constraints) interests us here.
In addition, to calculate the behavior, it is necessary to extract from the data the isotropic function of work hardening $R(p)$:



$$\sigma^t=F(\varepsilon)=\sigma_y+\frac{E.E_T}{E-E_T}p$$

$$R(p)=\sigma_y+\left(\frac{E.E_T}{E-E_T}-\frac{3}{2}C\right).p$$

2.1.1 T = 1: elastic behavior

Indeed, the behavior is elastic until $t=1$. For $t=1$, $\sigma_{yy}=E\varepsilon_{yy}=400MPa$ reached the threshold of plasticity just.

2.1.2 T = 2: elastoplastic load

When one reaches the criterion of plasticity (in load or discharge), one a:

$$\left|\sigma-\frac{3}{2}C\varepsilon^p\right|=R(p)$$

$$\sigma=E(\varepsilon-\varepsilon^p)$$

For the load, it is necessary to solve $\sigma^t=F(\varepsilon)=\sigma_y+\frac{E.E_T}{E-E_T}p=\sigma_y+\frac{E.E_T}{E-E_T}(\varepsilon-\frac{\sigma^t}{E})$

what gives again: $\sigma^t = \sigma_y + E_T(\varepsilon - \frac{\sigma_y}{E})$: one moves on the traction diagram up to point A such as:

$$\sigma_A{}^t = E\left(\varepsilon_A - \varepsilon_A^p\right)$$

2.1.3 T = 3: elastic discharge

The discharge is elastic up to the point A' :

$$-\sigma^{A'} + \frac{3}{2} C \varepsilon_A{}^p = R(p_A)$$

$$\sigma^{A'} = E\left(\varepsilon^{A'} - \varepsilon_A{}^p\right)$$

2.1.4 T = 4: elastoplastic load in compression

$$\sigma^c = \frac{3}{2} C \varepsilon^p - R(p)$$

2.2 Results of Reference

t	$u_y{}^D$ (mm)	σ_{yy} (MPa)
1	$2.\ 10^{-3}$	400
2	4.5d-3	500
3	0.1d-3	– 380
4	$-2.\ 10^{-3}$	– 464

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibiographic references

• Relation of behaviour to linear and isotropic work hardening kinematic nonlinear. Note [R5.03.16].

3 Modeling A

3.1 Characteristics of modeling

Modeling AXIS

3.2 Characteristics of the grid

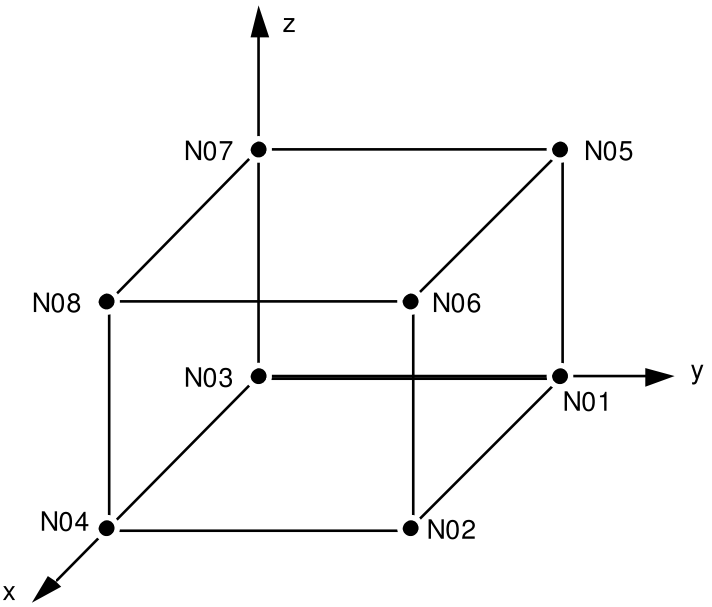
Many nodes: 4
Many meshs and types: 1 QUAD4

3.3 Sizes tested and results

Identification	Moments	Reference	Aster	% difference
σ_{yy}	1	400	400	0
σ_{yy}	2	500	500	0
σ_{yy}	3	– 380	– 380	0
σ_{yy}	4	– 464	– 464	0

4 Modeling B

4.1 Characteristics of modeling



4.2 Characteristics of the grid

Many nodes: 8
Many meshs and types: 1 HEXA8 + 4 QUAD4 (faces)

4.3 Sizes tested and results

Identification	Moments	Reference	*Aster*	% difference
σ_{yy}	1	400	400	0
σ_{yy}	2	500	500	0
σ_{yy}	3	– 380	– 380	0
σ_{yy}	4	– 464	– 464	0

5 Modeling C

5.1 Characteristics of modeling

Modeling C_PLAN

5.2 Characteristics of the grid

Many nodes: 4
Many meshs and types: 1 QUAD4

5.3 Sizes tested and results

Identification	Moments	Reference	*Aster*	% difference
σ_{yy}	1	400	400	0
σ_{yy}	2	500	500	0
σ_{yy}	3	– 380	– 380	0
σ_{yy}	4	– 464	– 464	0

6 Summary of the results

Results provided by *Code_Aster* coincide with the values of reference, because the test is uniaxial, and the stress and strain state is homogeneous.