SSNV133 - Uniaxial traction and compression. Mixed hardening

Abstract:

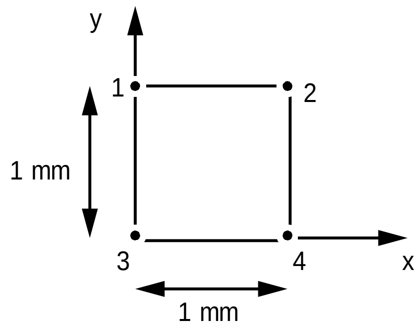
The purpose of this test is validating elastoplastic behaviors VMIS_ECMI_TRAC and VMIS_ECMI_LINE, which combine an isotropic hardening (linear or given by a curve of tension) and a linear kinematic hardening.

The geometrical and mechanical data make it possible to be in uniaxial situation (uniform stresses, only one non-zero 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 modelizations make it possible to check the uniaxiality of the stresses: 3D, AXIS, C_PLAN.

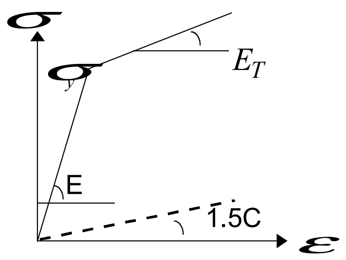
1 Problem of reference

1.1 Geometry



1.2 Material properties

Elastoplastic constitutive law to mixed hardening (isotropic linear and kinematical 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:

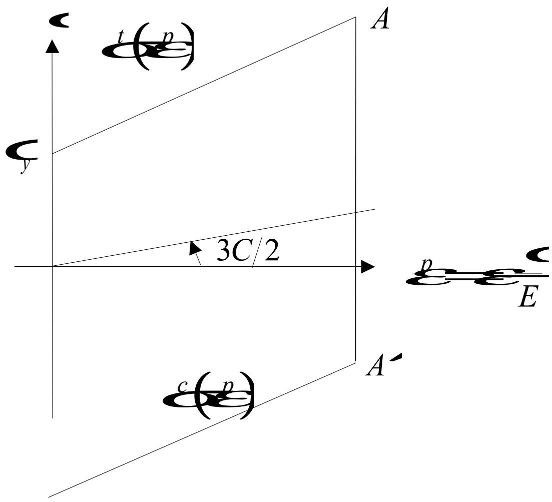
t	u_y^D (mm)
1	2. 10-3
	2.4.5d-3
	3.0.1d-3
4	– 2. 10-3

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is obtained by an analytical computation.

Imposed displacement u_y^D provides the strain immediately $\varepsilon_{yy} = \frac{u_y^D}{1}$. Only this component (corresponding to the non-zero component of the tensor of the stresses) interests us here.
In addition, to compute: the behavior, it is necessary to extract from the data the isotropic function of 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 $t=1$, $\sigma_{yy} = E\varepsilon_{yy} = 400 MPa$ reached the threshold of plasticity just.

2.1.2 T = 2: elastoplastic load

When the plasticity criterion is reached (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 curve of tension up to the point A such as:

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

2.1.3 T = 3: discharge elastic

the discharge is elastic until 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

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

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 analytical

solution Solution.

2.4 Bibiographic references

• Behavior model to linear and isotropic kinematic hardening nonlinear. Note [R5.03.16].

3 Modelization A

3.1 Characteristic of the modelization

Modelization AXIS

3.2 Characteristics of the mesh

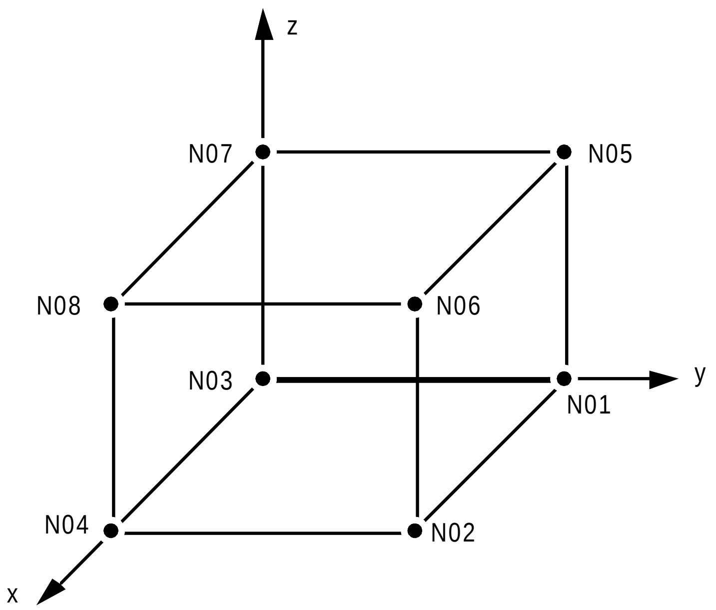
Many nodes: 4
Number of meshes and types: 1 QUAD4

3.3 Quantities tested and results

Identification	Times	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 Modelization B

4.1 Characteristic of the modelization



4.2 Characteristics of the mesh

Many nodes: 8
Number of meshes and types: 1 HEXA8 + 4 QUAD4 (sides)

4.3 Quantities tested and results

Identification	Times	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 Modelization C

5.1 Characteristic of the modelization

Modelization C_PLAN

5.2 Characteristics of the mesh

Many nodes: 4
Number of meshes and types: 1 QUAD4

5.3 Quantities tested and results

Identification	Times	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

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