SSNA111 - Indentation of a solid mass by a punch

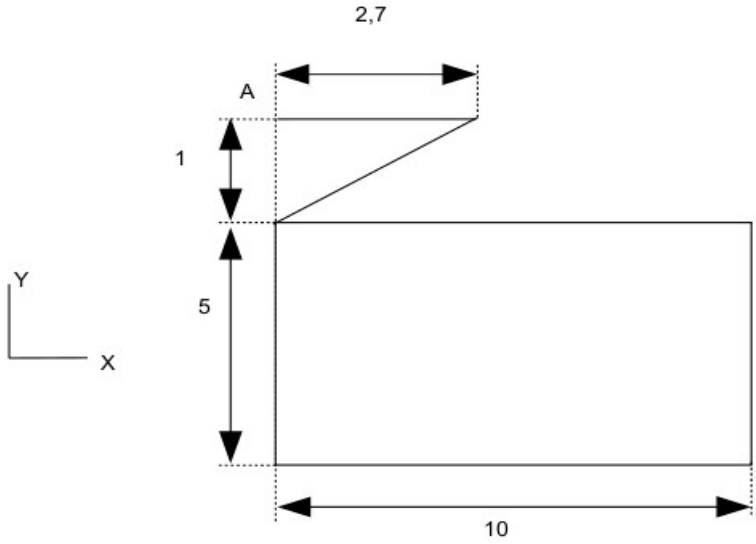
Summary:

This test relates to the study of a conical punch deforming an elastoplastic massive structure.

The unit is modelled with elements axisymmetric and subjected to an imposed displacement and contact.

1 Problem of reference

1.1 Geometry



The problem is axisymmetric (of axis Y). The punch consists of only one triangular element. It is supposed in initial contact with the solid mass at the point A, this point is thus topologically confused between the punch and the solid mass.

1.2 Material properties

The solid mass consists of an elastoplastic material with linear isotropic work hardening:

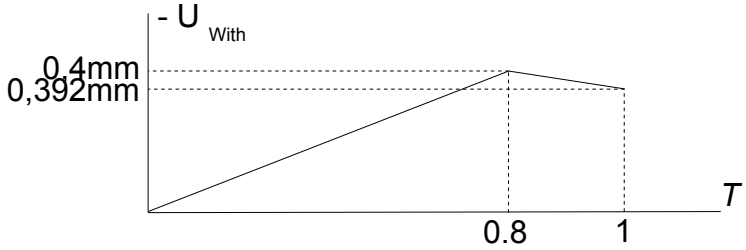
$$E = 2{,}0 \times 10^5 \,\mathrm{MPa}$$
$$\nu = 0{,}3$$
$$\sigma_y = 300 \,\mathrm{MPa}$$
$$E_T = 5000$$

The punch is supposed to be rigid and one approximates it by an elastic material with a large Young modulus:

$$E = 2{,}0 \times 10^9 \,\mathrm{MPa}$$
$$\nu = 0{,}3$$

1.3 Boundary conditions and loadings

The base of the solid mass is embedded and its left side is imposed on $DX=0$. Horizontal displacement is imposed on 0. The vertical displacement of the punch is imposed on $u_A=-0{,}4\,\mathrm{mm}$, then gone up $0{,}008\,\mathrm{mm}$ (elastic return) according to the following graph:



2 Reference solution

2.1 Results of reference

The results calculated in this CAS-test are displacements and rotations of node A (DEPL). It result from a former execution from *Code_Aster*. It is a case test of nonregression, except for the point A.

3 Modeling A

3.1 Characteristics of modeling

Modeling AXIS.

3.2 Characteristics of the grid

The grid consists of 1803 nodes and 1852 meshs of which a mesh TRIA3 for the rigid punch, and 1715 meshs QUAD4 for the solid mass (the rest of the meshs being meshs SEG2 for surface slave of the contact).

3.3 Characteristics of the behavior

Incremental elastic behavior for the punch (COMPORTEMENT/ELAS).
Elastoplastic behavior in great deformations with linear isotropic work hardening for the solid mass (COMPORTEMENT/VMIS_ISOT_LINE/SIMO_MIEHE).

3.4 Characteristics of the contact

Method of discrete contact with algorithm of the active constraints, pairing MAIT_ESCL and normal MAIT_ESCL.

3.5 Sizes tested and results

Value tested	Moment	Reference	Type	*Tolerance*
Displacement DY in A	0.5	-0.25	Analytical	-0.80%
	0.5	-0.24798	Not-regression	
Force of reaction DX in A	0.5	3.2482	Not-regression	
Force of reaction DY in A	0.5	-8.7703	Not-regression	
Displacement DY in A	1.0	-0.392	Analytical	-0.60%
	1.0	-0.38944	Not-regression	
Force of reaction DX in A	1.0	1.81357	Not-regression	
Force of reaction DY in A	1.0	-4.8966	Not-regression	

3.6 Remarks

The force of nodal reaction is in $\mathrm{N/rad}$ since the problem is axisymmetric. The difference on the analytical values of displacement come owing to the fact that the rigid punch is modelled by a material with a Young modulus of finished rigidity.

4 Modeling B

4.1 Characteristics of modeling

Modeling AXIS.

4.2 Characteristics of the grid

The grid consists of 1803 nodes and 1852 meshs of which a mesh TRIA3 for the rigid punch, and 1715 meshs QUAD4 for the solid mass (the rest of the meshs being meshs SEG2 for surface slave of the contact).

4.3 Characteristics of the behavior

Incremental elastic behavior for the punch (COMPORTEMENT/ELAS).
Elastoplastic behavior in great deformations with linear isotropic work hardening for the solid mass (COMPORTEMENT/VMIS_ISOT_LINE/SIMO_MIEHE).

4.4 Characteristics of the contact

Method of contact continues, pairing MAIT_ESCL, normal MAIT_ESCL and pairing is fixed, of normal $(0,-1,0)$. Integration with the nodes and coefficient of regularization of Lagrangian increased being worth 1000.

4.5 Sizes tested and results

Value tested	Moment	Reference	Type	*Tolerance*
Displacement DY in A	0.5	-0.25	Analytical	-0.80%
	0.5	-0.24798	Not-regression	
Force of reaction DX in A	0.5	3.2482	Not-regression	
Force of reaction DY in A	0.5	-8.7703	Not-regression	
Displacement DY in A	1.0	-0.392	Analytical	-0.60%
	1.0	-0.38944	Not-regression	
Force of reaction DX in A	1.0	1.81343	Not-regression	
Force of reaction DY in A	1.0	-4.8962	Not-regression	

4.6 Remarks

The force of nodal reaction is in $\mathrm{N/rad}$ since the problem is axisymmetric. The difference on the analytical values of displacement come owing to the fact that the rigid punch is modelled by a material with one Young modulus of finished rigidity.

5 Summary of the results

This example of nonregression shows a non-linear calculation with contact. The nodal forces are slightly different ($0,007\%$) between two modelings (discrete contact or continues), at the time of the elastic return.