

SSNP153 - Deformable-deformable contact rubbing 2D in great deformations (shallow ironing)

Summary:

This test models the indentation of a solid mass by a punch. The 2 bodies are elastic, deformable and obey a kinematics of great deformations. This test checks the taking into account of friction in 2D.

1 Problem of reference

1.1 Geometry

One considers the geometry described with the figure 1 where dimensions in mm are the following ones:

$$d_1=0.2 \quad d_2=1.2 \quad d_3=10.6 \quad r=0.75 \quad h_1=0.95 \quad h_2=4 \quad a_1=0.3 \quad a_2=0.2$$

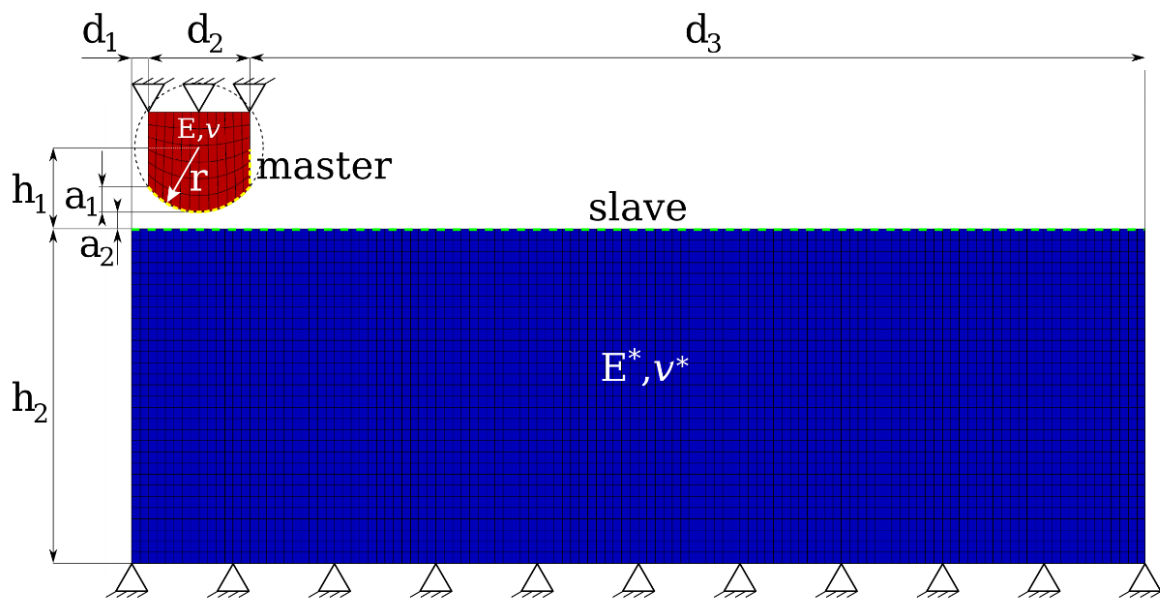


Illustration 1: Geometry of the problem (image coming from [1])

1.2 Properties of material

The 2 materials are elastic isotropic whose properties are:

- $E=68.96E8 \text{ MPa}$ $\nu=0.32$
- $E^*=6.896E8 \text{ MPa}$ $\nu^*=0.32$

They are both represented in great deformations according to the model of Simo and Miehe.

1.3 Boundary conditions and loadings

The lower edge of the solid mass is embedded.

The higher edge of the punch is subjected to an imposed displacement given by:

$$t \in [0,1] \quad u_x=0 \quad u_y=t$$

$$t \in [1,2] \quad u_x=10(t-1) \quad u_y=1$$

For the contact, the punch is Master and the massive slave. One considers a friction of Coulomb with a coefficient $\mu=0.3$.

1.4 Initial conditions

Nothing

2 Reference solution

2.1 Method of calculating

One does not have of an analytical solution but curves obtained by various research teams published in [1], [2] and [3].

2.2 Sizes and results of reference

One tests the normal of contact and tangential forces of friction.

2.3 Bibliographical references

- [1] Vladimir Yastrebov, “ *Computational contact mechanics: geometry, detection and numerical technical* ”, thesis, Paristech Mines, 2011
- [2] K.A. Fischer & P. Wriggers, “ *Mortar based frictional contact formulation for higher order interpolations using the moving friction cone* ”, Methods Computer in Applied Mechanics and Engineering, vol. 195, pages 5020 – 5036.2006
- [3] S. Hartmann, J. Oliver, J.C. Lay, R. Weyler & J.A. Hernández, “ *With contact domain method for broad deformation frictional contact problems. Share 2: Numerical aspects* ”, Methods Computer in Applied Mechanics and Engineering, vol. 198, pages 2607-2631, 2009

3 Modeling A

3.1 Characteristics of modeling

A modeling is used D_PLAN.

3.2 Characteristics of the grid

The grid contains:

- 276 SEG2
- 3672 QUAD4

3.3 Sizes tested and results

One tests the normal of contact and tangential forces of friction.

Normal forces:

Identification ('INST')	Type of reference	Value of reference	Tolerance
5.00000E-01	'NON_REGRESSION'	-9.453879E+07	2.0E-05%
6.00000E-01	'NON_REGRESSION'	-1.345568E+08	2.0E-04%
7.00000E-01	'NON_REGRESSION'	-1.784029E+08	6.0E-05%
8.00000E-01	'NON_REGRESSION'	-2.255709E+08	2.0E-04%
9.00000E-01	'NON_REGRESSION'	-2.755546E+08	2.0E-04%
1.00000E+00	'NON_REGRESSION'	-3.298982E+08	3.0E-05%
1.00200E+00	'NON_REGRESSION'	-3.324050E+08	3.0E-05%
1.00400E+00	'NON_REGRESSION'	-3.348981E+08	5.0E-05%
1.00600E+00	'NON_REGRESSION'	-3.373779E+08	2.0E-04%
1.00800E+00	'NON_REGRESSION'	-3.398438E+08	2.0E-04%
1.01000E+00	'NON_REGRESSION'	-3.422963E+08	2.0E-04%

Tangential forces:

Identification ('INST')	Type of reference	Value of reference	Tolerance
5.00000E-01	'NON_REGRESSION'	1.835915E+07	3.0E-05%
6.00000E-01	'NON_REGRESSION'	2.667997E+07	2.0E-04%
7.00000E-01	'NON_REGRESSION'	3.598949E+07	5.0E-05%
8.00000E-01	'NON_REGRESSION'	4.608191E+07	5.0E-05%
9.00000E-01	'NON_REGRESSION'	5.688549E+07	5.5E-05%
1.00000E+00	'NON_REGRESSION'	6.902044E+07	6.0E-05%
1.00200E+00	'NON_REGRESSION'	7.269331E+07	4.0E-05%
1.00400E+00	'NON_REGRESSION'	7.637172E+07	1.0E-05%
1.00600E+00	'NON_REGRESSION'	8.005592E+07	1.0E-05%
1.00800E+00	'NON_REGRESSION'	8.374614E+07	3.0E-05%
1.01000E+00	'NON_REGRESSION'	8.744260E+07	3.0E-05%

Moreover, if one compares the curves obtained with those of the literature, one obtains the graph of the figure 2.

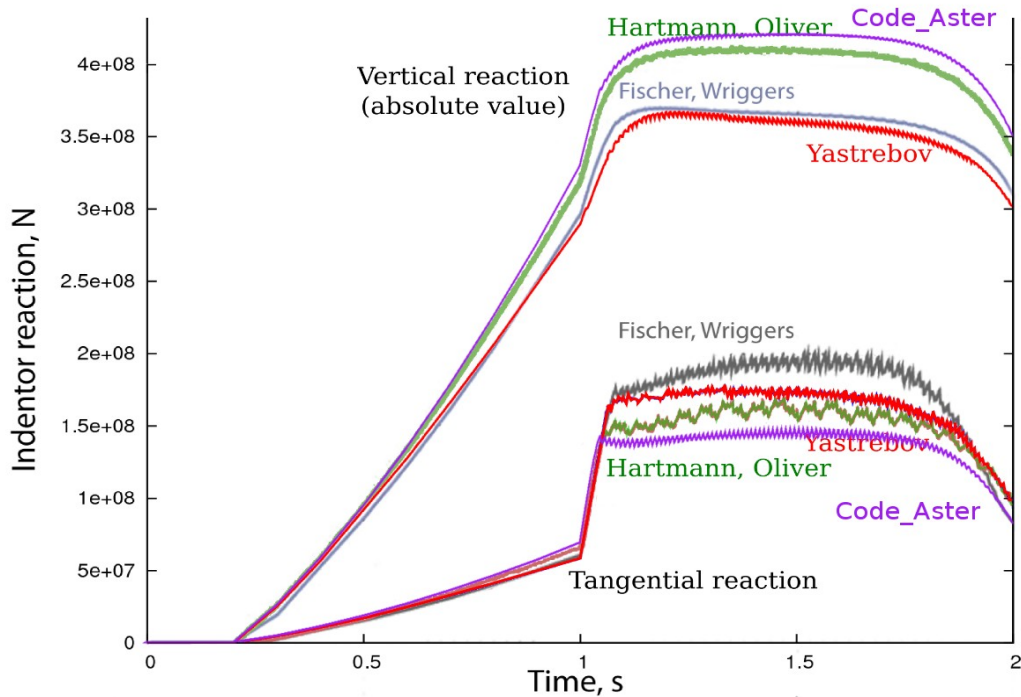


Illustration 2: Comparison of the results of various teams (image coming initially from [1])

4 Summary of the results

This test is regarded as very difficult in the international literature. The figure 2 watch the comparison of the forces of contact and friction obtained by various teams. One notes a notable dispersion of these results in which the results fit satisfactorily of *Code_Aster*.