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

Summarized:

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

1 Problem of reference

1.1 Geometry

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

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

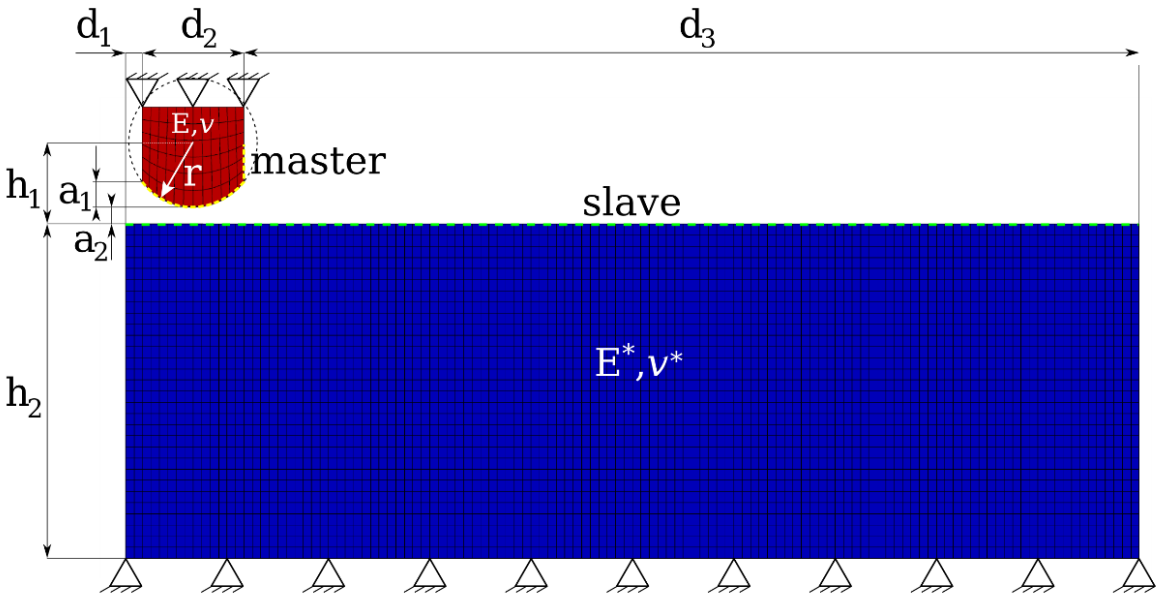

Illustration 1: Geometry of the problem (image coming from [1])

1.2 Properties of the material

the 2 materials are elastic isotropic whose properties are:

- $E=68.96\text{E}8\ MPa \qquad \nu=0.32$
- $E^*=6.896\text{E}8\ MPa \qquad \nu^*=0.32$

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

1.3 Boundary conditions and loadings

the lower edge of the solid mass is clamped.
The higher edge of the punch is subjected to an imposed displacement given by:

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

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

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 Quantities and results of reference

One tests the normal forces of contact and tangential 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, "*A contact domain method for broad strain frictional contact problems. Leaves 2: Numerical aspects* ", Methods Computer in Applied Mechanics and Engineering, vol. 198, pages 2607-2631, 2009

3 Modelization A

3.1 Characteristic of the modelization

One uses a modelization D_PLAN.

3.2 Characteristics of the mesh

The mesh contains:
-276 SEG2
-3672 QUAD4

3.3 Quantities tested and results

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

Normal forces:

Identification ("INST")	Standard 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"	-2.255709+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")	Standard 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 figure 2.

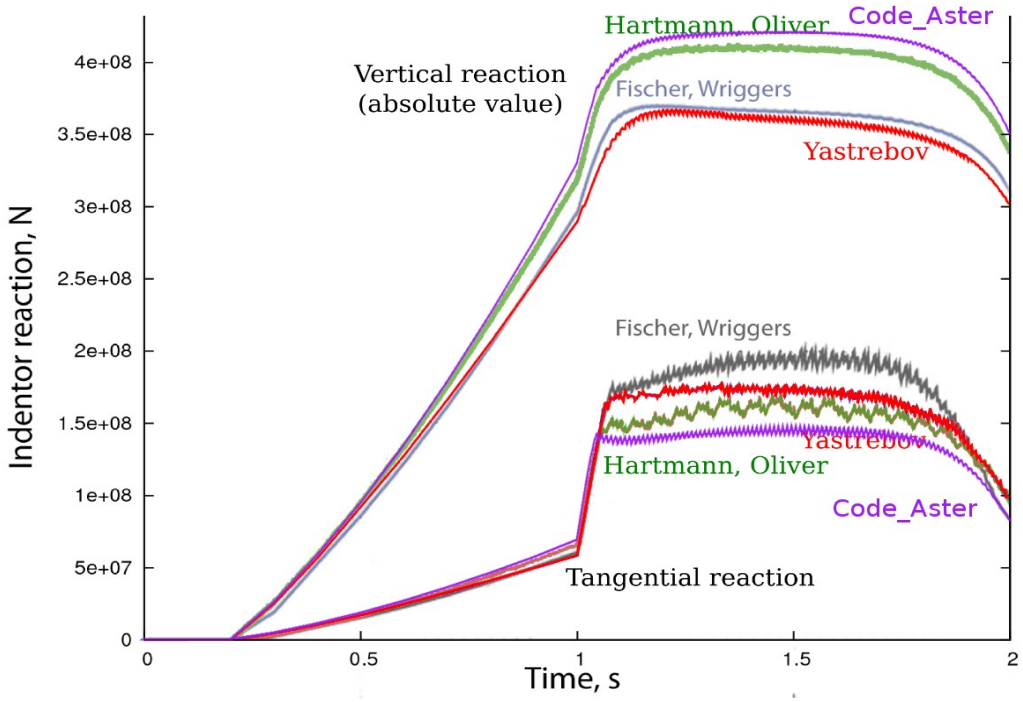

Illustration 2: Comparison of the results of various teams (image coming initially from [1])

4 Summary of the results

This test is regarded as very difficult in the international literature. Figure 2 shows 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 of Code_Aster fit *satisfactorily.*