# 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:

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

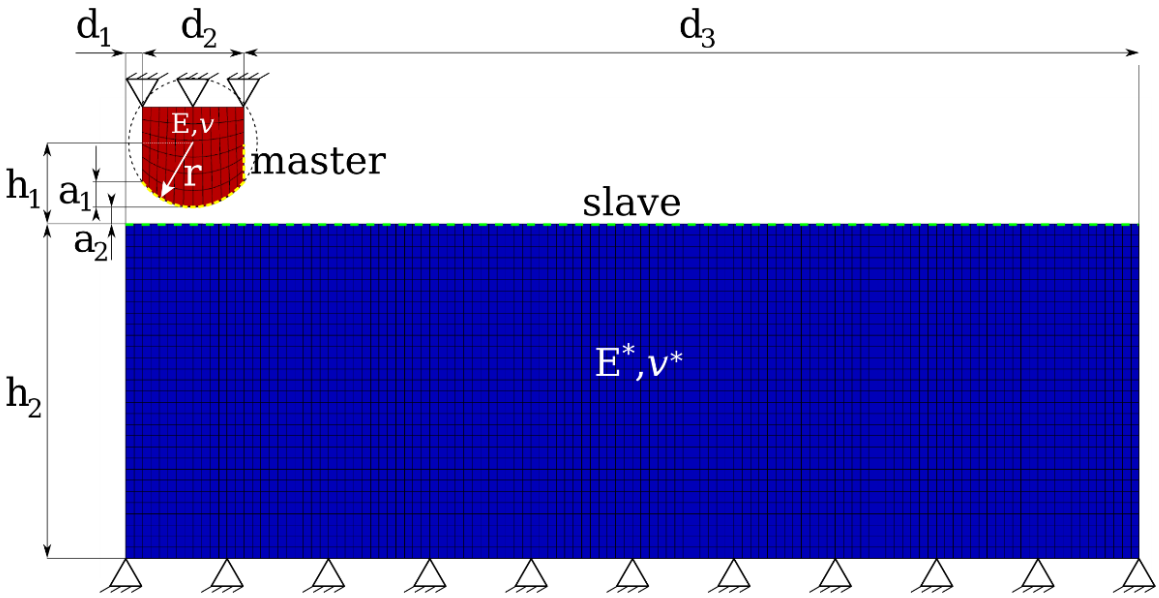


**Illustration 1: Geometry of the problem (image coming from [1])**

## 1.2 Properties of material

The 2 materials are elastic isotropic whose properties are:

- $E=68.96E8\ MPa \qquad \nu=0.32$
- $E^*=6.896E8\ MPa \qquad \nu^*=0.32$

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:

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

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

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 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' | -2.255709+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') | 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.

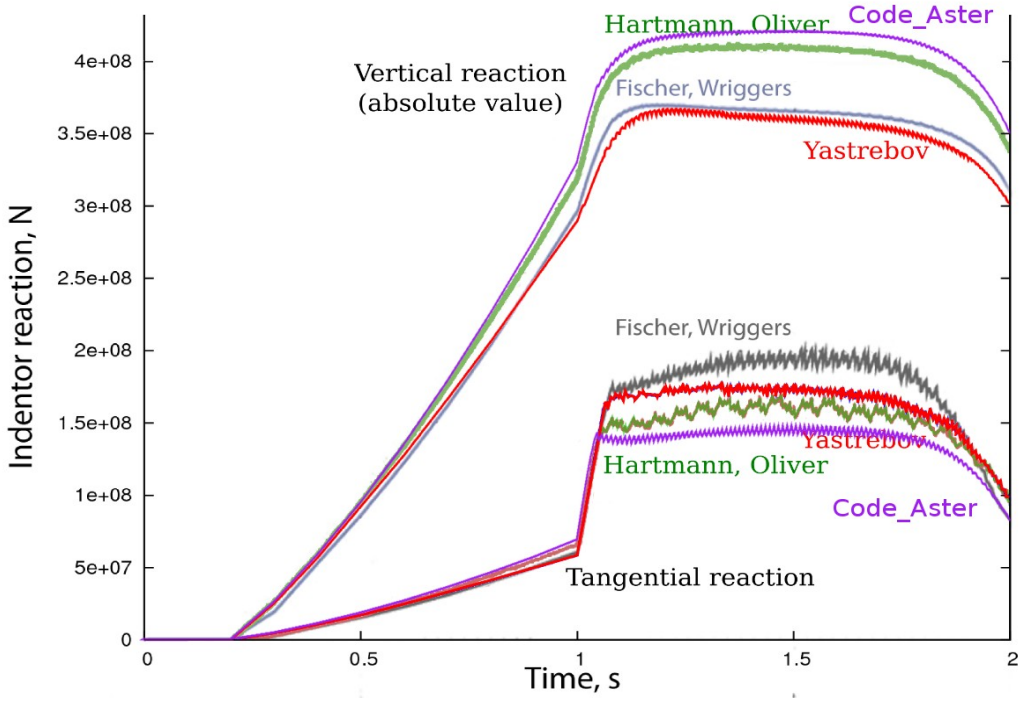


**Illustration 2: Comparison of the results of various teams (image coming initially from [1])**

# 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.*