SSNP154 – Benchmark NAFEMS of validation of the contact 1: *cylinder roller Summarized*

contact:

This problem constitutes the first benchmark of a benchmark NAFEMS of validation of contact-friction. The references of the benchmark are obtained with the codes Abaqus and MARC.
This test models a contact of Hertz with and without friction between a solid mass and a cylinder of different stiffness with a grid with different smoothnesses.
An analytical solution exists for the case without friction.

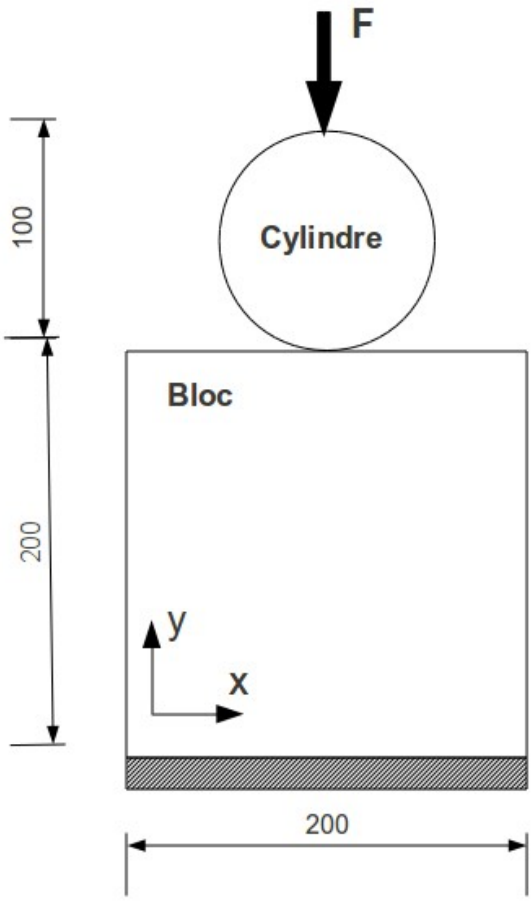
This test comprises 7 modelizations making it possible to test:

- linear and quadratic elements,
- formulations of processing of the contact without and with friction "DISCRETE" and "CONTINUE".

1 Problem of reference

1.1 Geometry

the structure is modelled in plane strains.



One notes B the point on the higher side of the block belonging to symmetry plane.

1.2 Properties of the materials

Block:

Poisson's ratio: $0,3$
Young modulus: $70000\,N.mm^{-2}$

Roll:

Poisson's ratio: $0,3$
Young modulus: $210000\,N.mm^{-2}$

The coefficient of kinetic friction between the block and the cylinder is worth $\mu=0,1$.

1.3 Boundary conditions and loadings

the structure symmetric and being subjected to a loading respecting symmetry, only a half is represented. One thus applies $DX=0$ as regards symmetry.

The block is embedded at its base:

- $DX=0$
- $DY=0$

The cylinder is subjected to a specific force on its top:

- $FY=35\,kN$, for $FY=17500\,N$ the half-structure Reference solution

2 Method of calculating

2.1

the reference solution is comes of results obtained with the codes Abaqus and MARC in a benchmark NAFEMS from validation of contact-friction [bib1].
For the modelizations without friction, a comparison with the analytical solution of Hertz is carried out.

2.2 Quantities and results of reference

vertical Displacement of the point B (according to y) (external reference).

Contact pressure at the point B (external reference). The contact pressure raised is that extrapolated starting from the stresses in volume.

2.3 Uncertainties on the Important

solution (average of codes).

2.4 Bibliographical reference

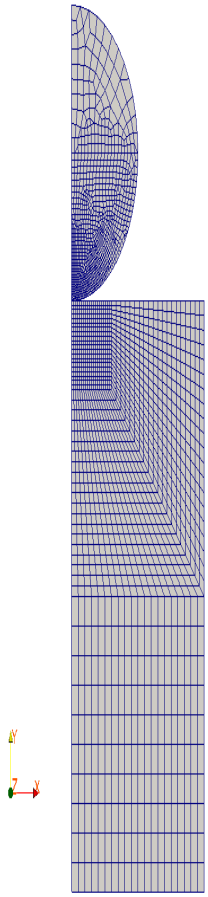
[1] A. KONTER. *"Advanced Finite Element Benchmarks Contact"*. NAFEMS, 2006.

3 Modelization A

3.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is CONTINUE, friction is disabled.

3.2 Characteristics of the mesh

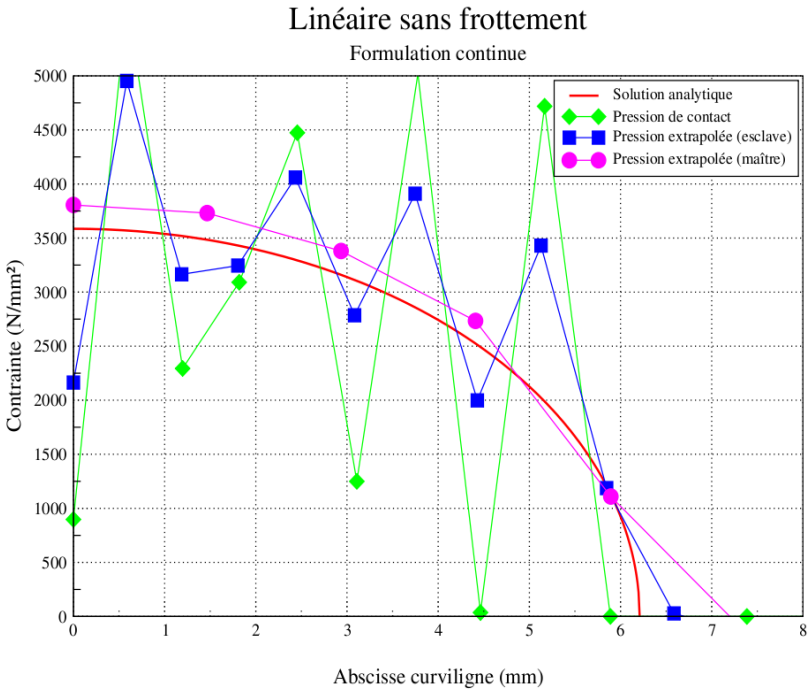


Many nodes: 2625
Number of meshes and types: 2467 QUAD4 and 53 TRIA3.

3.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY to point B	"SOURCE_EXTERNE"	-1,3069040401077	0,1%
$SIYY$ to point B	"SOURCE_EXTERNE"	-3800,4949548283	0,1%

3.4 Remarks



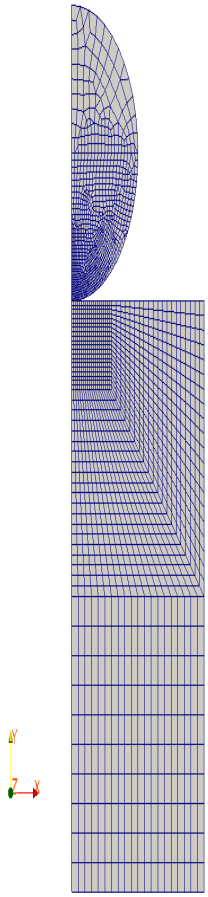
the results got into linear without friction with the formulation continue are in concord with the analytical solution when one records the contact pressure extrapolated on surface Master.
One will however note the strong oscillation of the contact pressure when it is raised starting from degree of freedom LAGS_C specific to the continuous formulation. The amplitude of the oscillations decreases when the mesh is refined.

4 Modelization B

4.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is CONTINUE, friction is disabled.

4.2 Characteristics of the mesh

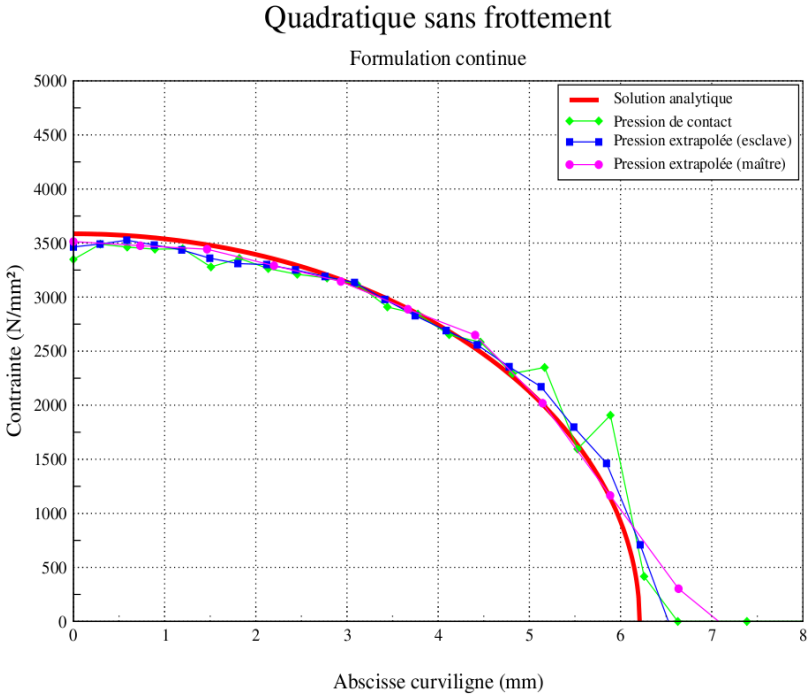


Many nodes: 7768
Number of meshes and types: 2467 QUAD8 and 53 TRIA6.

4.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY at the point B	"SOURCE_EXTERNE"	-1,3080192481252	0,1%
$SIYY$ at the point B	"SOURCE_EXTERNE"	-3513,3741602327	0,1%

4.4 Remarks



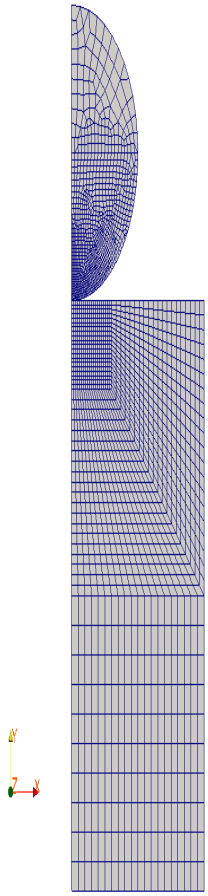
the results got into quadratic without friction with the formulation continues are in very good agreement with the analytical solution whatever the way in which the pressure is recorded.
It will be noted that the oscillations almost disappeared compared to the modelization A with linear elements. For that one used a numerical integration of the terms of contact of the type Gauss (`INTEGRATION=' GAUSS'`).

5 Modelization C

5.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is CONTINUE, friction is taken into account.

5.2 Characteristics of the mesh



Many nodes: 2625
Number of meshes and types: 2467 QUAD4 and 53 TRIA3.

5.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY at the point B	"SOURCE_EXTERNE"	-1,3010795638714	0,1%
$SIYY$ at the point B	"SOURCE_EXTERNE"	-3670,2561088662	0,1%

5.4 Remarks

the results got into linear with friction with the formulation continues are in concord with the analytical solution when one records the contact pressure extrapolated on surface Master.
One will however note the strong oscillation of the contact pressure when it is raised starting from degree of freedom LAGS_C specific to the continuous formulation. The amplitude of the oscillations decreases when the mesh is refined.

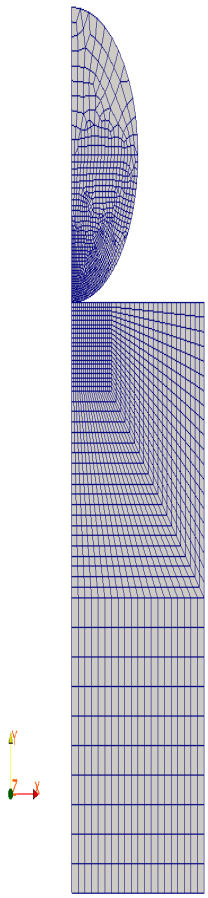
The results got by the commercial codes Abaqus and MARC in the benchmark have also oscillations for the case with friction.

6 Modelization D

6.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is CONTINUE, friction is taken into account.

6.2 Characteristics of the mesh

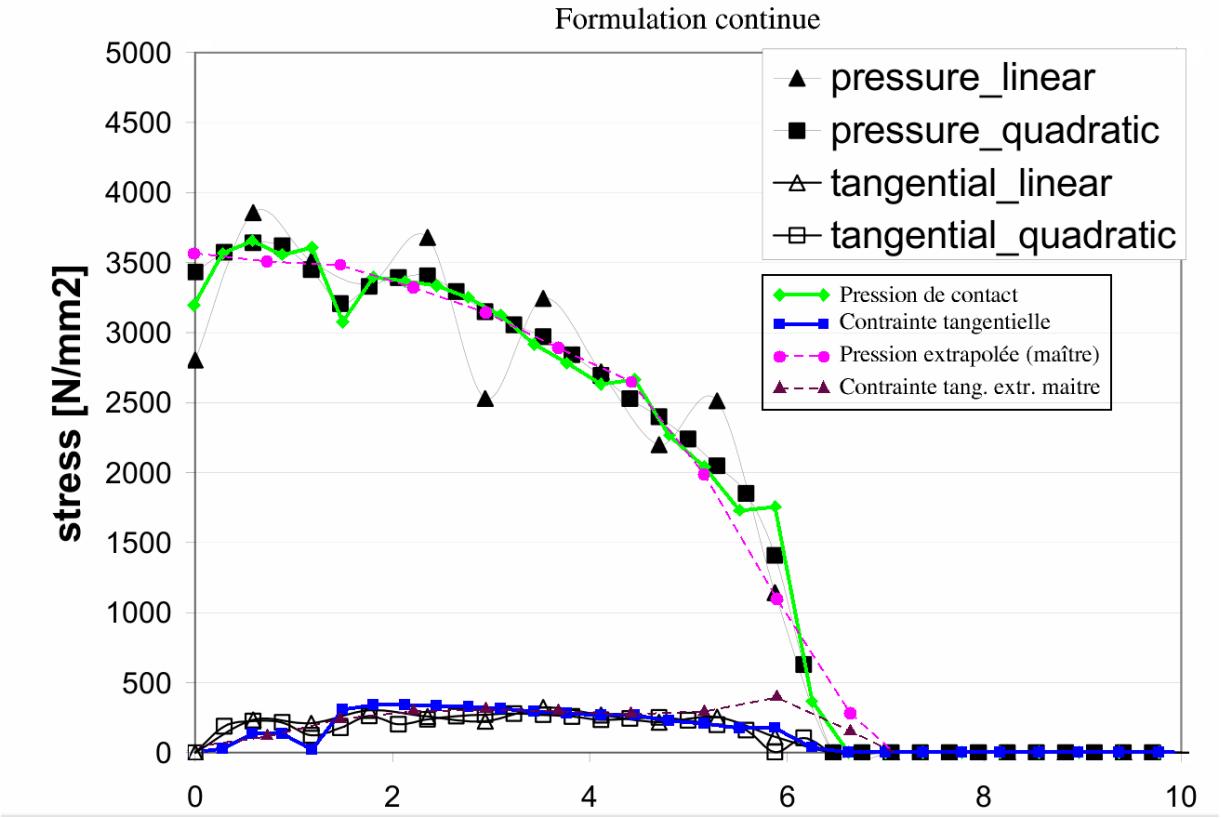


Many nodes: 7768
Number of meshes and types: 2467 QUAD8 and 53 TRIA6.

6.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY at the point B	"SOURCE_EXTERNE"	-1,3026356448389	0,1%
$SIYY$ at the point B	"SOURCE_EXTERNE"	-3542,6878770218	0,1%

6.4 Remarks



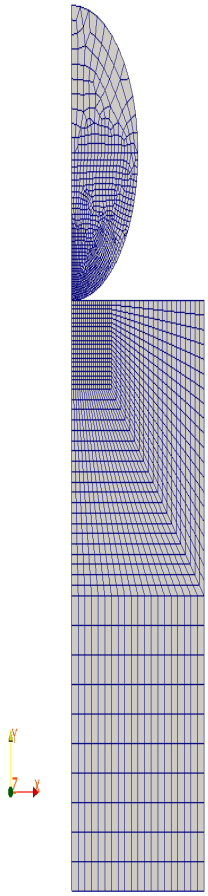
the results got into quadratic with friction with the formulation continues are in very good agreement with those obtained in the benchmark (here those of the code MARC).
It will be noted that the contact pressure as well as the shear stress raised starting from degrees of freedom LAGS_C and LAGS_F1 of the continuous formulation stick perfectly with the quantities calculated by MARC.
As it was the case without friction, the oscillations is much less important into quadratic, it is besides also the case for MARC.

7 Modelization E

7.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is DISCRETE, friction is disabled. The contact algorithm used is that by default.

7.2 Characteristics of the mesh



Many nodes: 2625
Number of meshes and types: 2467 QUAD4 and 53 TRIA3.

7.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY at the point B	"SOURCE_EXTERNE"	-1,3067596639633	0,1%
$SIYY$ at the point B	"SOURCE_EXTERNE"	-3814,1811065942	0,1%

7.4 Remarks

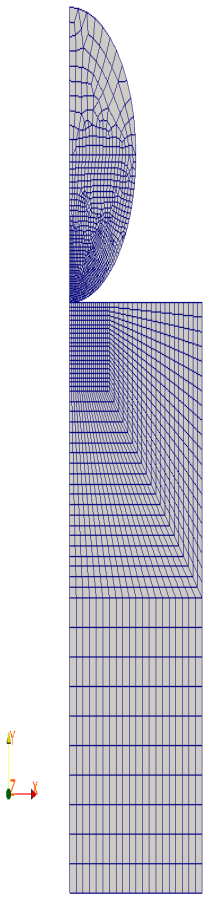
the results got into linear without friction with the discrete formulation are identical to those obtained in formulation continues (modelization A).
In discrete formulation one is obliged to bind the two nodes of the block and the cylinder in opposite initially preventing rigid body motion along the axis y.

8 Modelization F

8.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is DISCRETE, friction is disabled.
The contact algorithm used is that by default.

8.2 Characteristics of the mesh



Many nodes: 7768
Number of meshes and types: 2467 QUAD8 and 53 TRIA6.

8.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY to point B	"SOURCE_EXTERNE"	-1,3080923611548	0,1%
$SIYY$ to point B	"SOURCE_EXTERNE"	-3502,7937782466	0,1%

8.4 Remarks

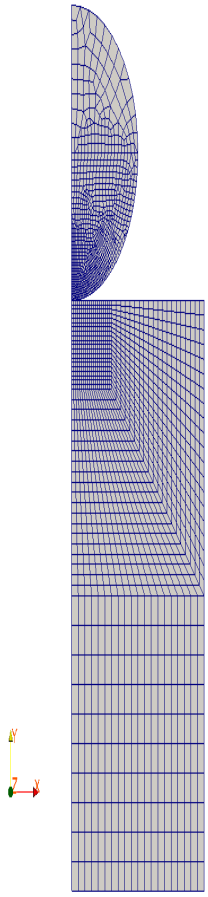
the results got into quadratic without friction with the discrete formulation are identical to those obtained in formulation continues (modelization B).
In discrete formulation one is obliged to bind the two nodes of the block and of the cylinder in opposite initially preventing rigid body motion along the axis y.

9 Modelization G

9.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is DISCRETE, friction is taken into account.
The algorithm for contact-friction is LAGRANGIAN

9.2 Characteristics of the mesh



Many nodes: 2625
Number of meshes and types: 2467 QUAD4 and 53 TRIA3.

9.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DY to point B	"SOURCE_EXTERNE"	-1,3010795793844	0,1%
$SIYY$ to point B	"SOURCE_EXTERNE"	-3670,2559152851	0,1%

9.4 Remarks

the results got into linear with friction with the discrete formulation are identical to those obtained in formulation continues (modelization C).

In discrete formulation one is obliged to bind the two nodes of the block and of the cylinder in opposite initially preventing rigid body motion along the axis y .

10 Summary of the results

This test makes it possible to validate contact-friction compared to an analytical solution but also compared to references given by commercial computer codes (Abaqus and MARC).
One observes a good agreement between the analytical results and those obtained by *Code_Aster* as well as a good agreement with the results of reference for computations with friction.

It will be noted that the formulations continues and discrete give identical results with however the following restrictions:

- computation in continuous formulation is easier to carry out because the blocking of vertical rigid body motion is carried out automatically
- computation with friction on a quadratic mesh could not be carried out in discrete formulation

Into quadratic, the contact pressure obtained starting from degree of freedom LAGS_C in continuous formulation has much less oscillations than into linear.