SSNP156 – Benchmark NAFEMS of validation of the contact 4: *loaded Summarized*

pine:

This problem constitutes the fourth 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 with friction between a pin and a boring with a grid with different smoothnesses and thus not compatibles. The computation with *Code_Aster* the use of compatible meshes requires however.

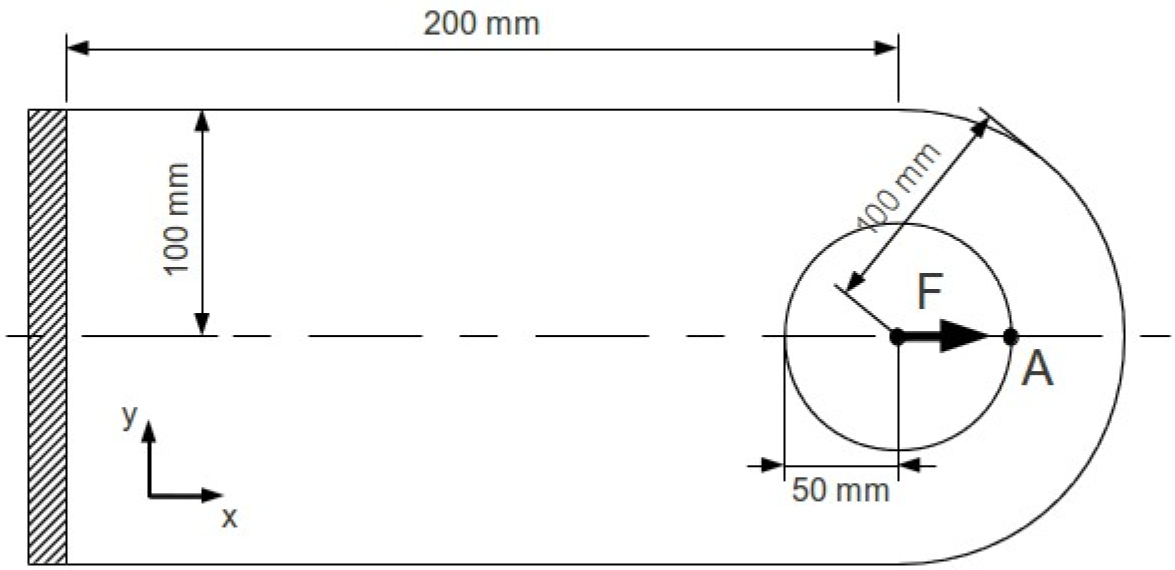
This test comprises 4 modelizations making it possible to test:

- the linear and quadratic elements,
- the formulations of processing of the contact with friction "DISCRETE" and "CONTINUE"
- contact pressures and the tangential stresses of friction

1 Problem of reference

1.1 Geometry

the structure is modelled in plane strains. Only a half is with a grid for reason of symmetry.



One notes F the center of the pin, A the point pertaining to the cantilever and located as regards symmetry.

1.2 Properties of the materials

Comforts:

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

Pin:

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 $DY=0$ as regards symmetry.

The cantilever is embedded on its left side:

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

The pin is subjected to a specific force in its center F :

- $FX=20000\,kN$, for $FX=10000\,N$ 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].

2.2 Quantities and results of reference

horizontal Displacement of the point A (according to x) (external reference).

Contact pressure at the point A (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).
It will be noted that the mesh used is different from that of *the benchmark*. The reason is given in conclusion of the document.

2.4 Bibliographical reference

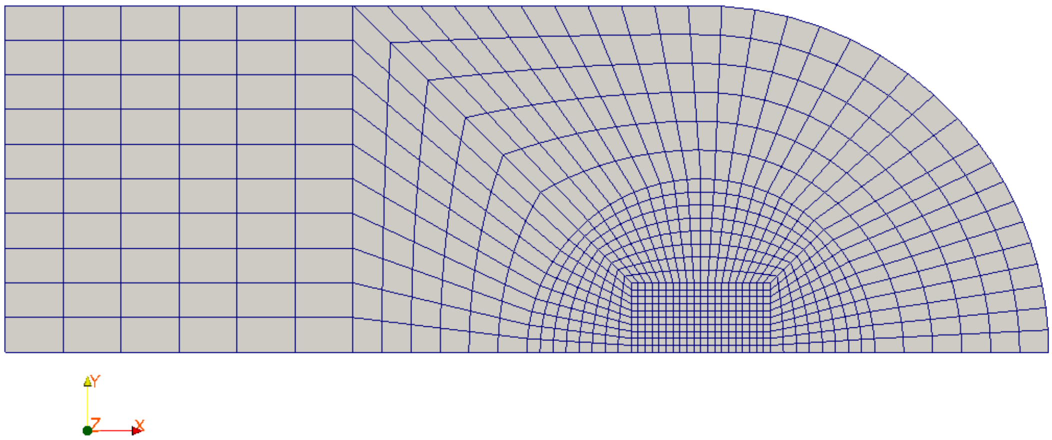
[1] A. KONTER. *"Advanced Finite Element Benchmarks Contact"*. NAFEMS, 2006.

3 Modelization A

3.1 Characteristic of the modelization

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

3.2 Characteristics of the mesh



Many nodes: 912
Number of meshes and types: 820 QUAD4.

3.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DX to point A	"SOURCE_EXTERNE"	0,71798956398122	0,1%
$SIXX$ to point A	"SOURCE_EXTERNE"	-136,67272217658	0,1%

3.4 Remarks

the results got into linear by the formulation continue with friction are very close to the results to MARC and Abaqus. It will be noted that the horizontal displacement of the nodes of the pin does not coincide with the results of reference.
This difference undoubtedly comes from the setting in data of this *benchmark* in particular with respect to the plane strains, made difficult by contradictory information in document NAFEMS (the thickness is taken into account in the commercial codes even in plane strains).
Although different from the references Abaqus and MARC, the got results are nevertheless identical to those obtained by CAST3M on this same computation.

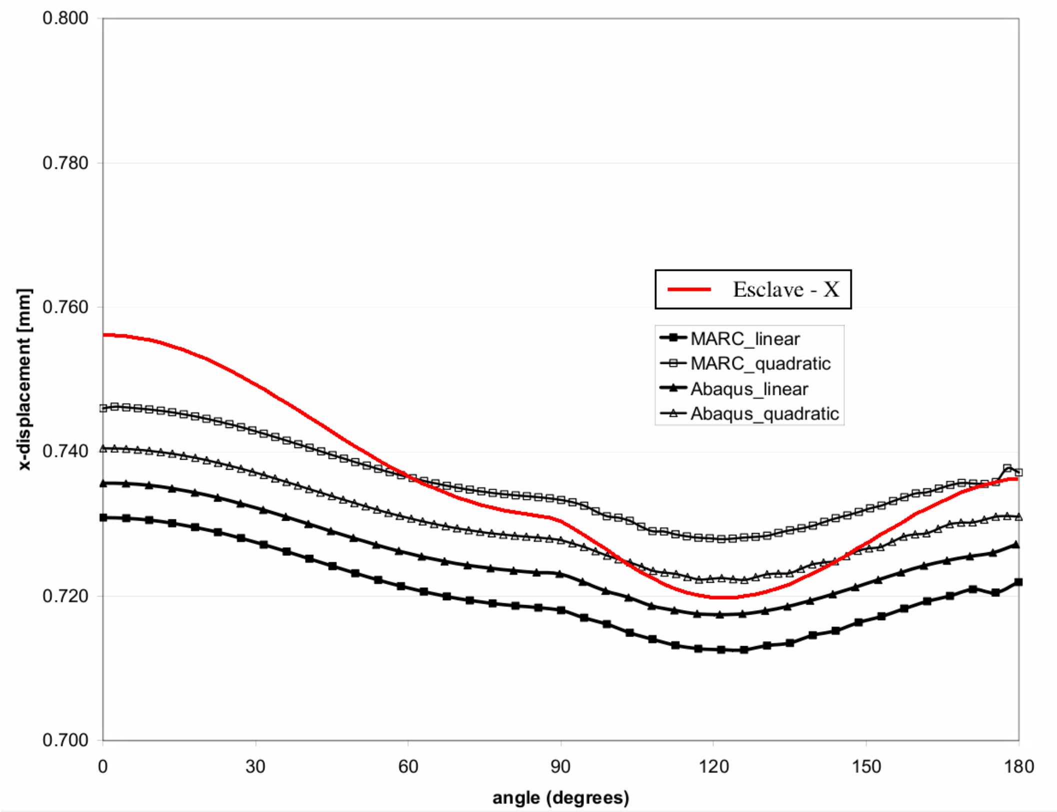


Illustration 1: comparison of the results between Abaqus, MARC and Code_Aster (following displacement x of the punch)

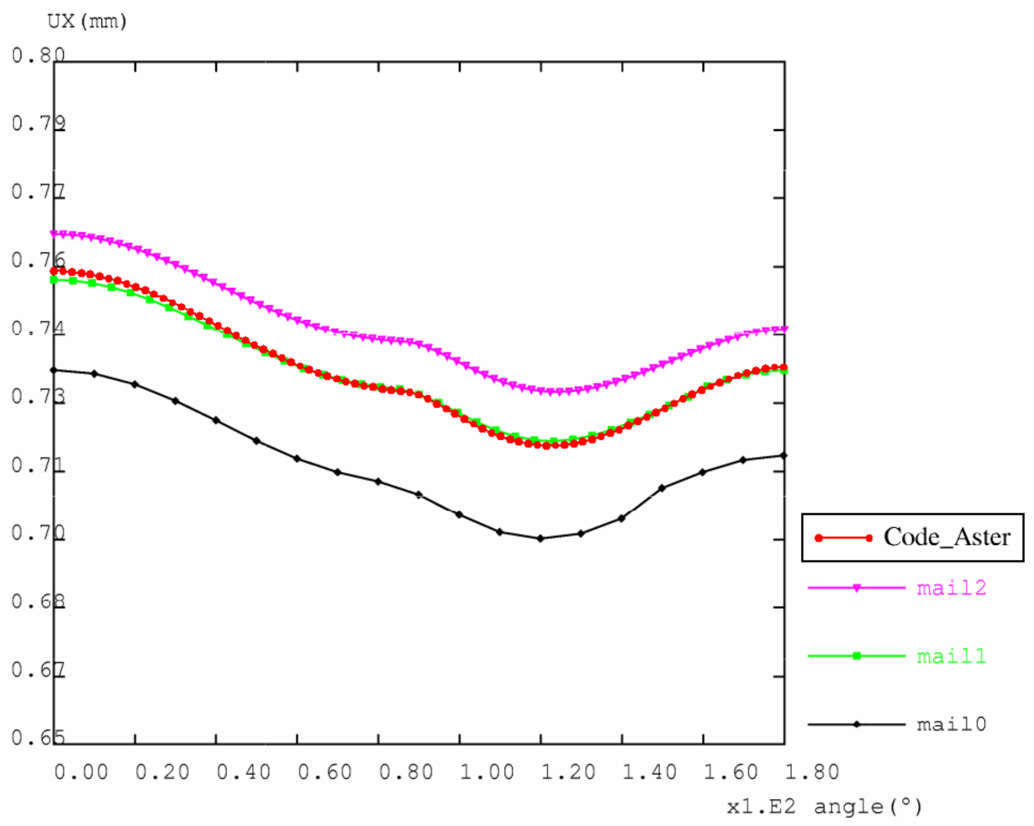


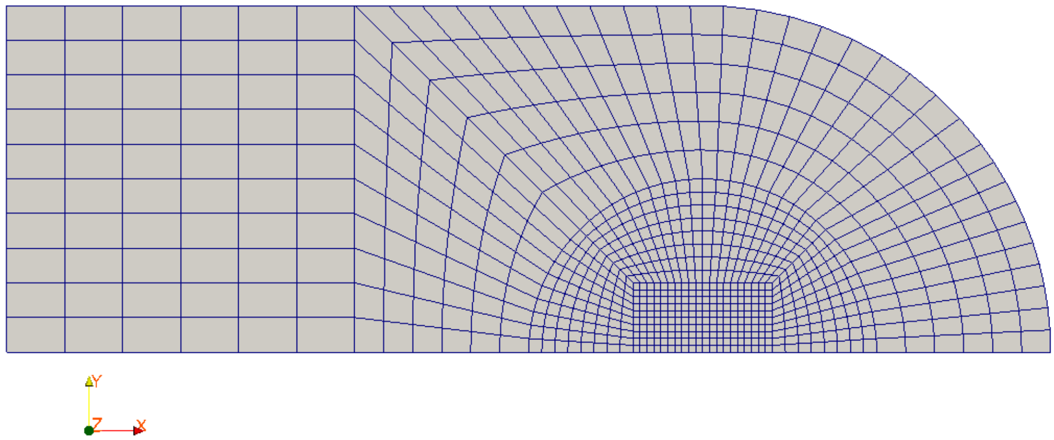
Illustration 2: comparison of the results between CAST3M and Code_Aster (following displacement x of the punch)

4 Modelization B

4.1 Characteristic of the modelization

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

4.2 Characteristics of the mesh



Many nodes: 2642
Number of meshes and types: 820 QUAD8.

4.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
DX to point A	"SOURCE_EXTERNE"	0,73616515310581	0,1%
$SIXX$ to point A	"SOURCE_EXTERNE"	-160,40053222751	0,1%

4.4 Remarks

the results got into quadratic by the formulation continue with friction are close to the results of reference that it is in displacement or pressure. They are almost identical to those obtained by the modelization A (linear mesh).
The contact pressure raised on edge of the pin that it is via degree of freedom LAGS_C of the continuous formulation or by extrapolation starting from the stresses stick perfectly to the reference.
Degree of freedom LAGS_C has oscillations: their amplitude decreases when one uses a diagram of integration of the type "GAUSS" and that one increases the number of points of squaring.

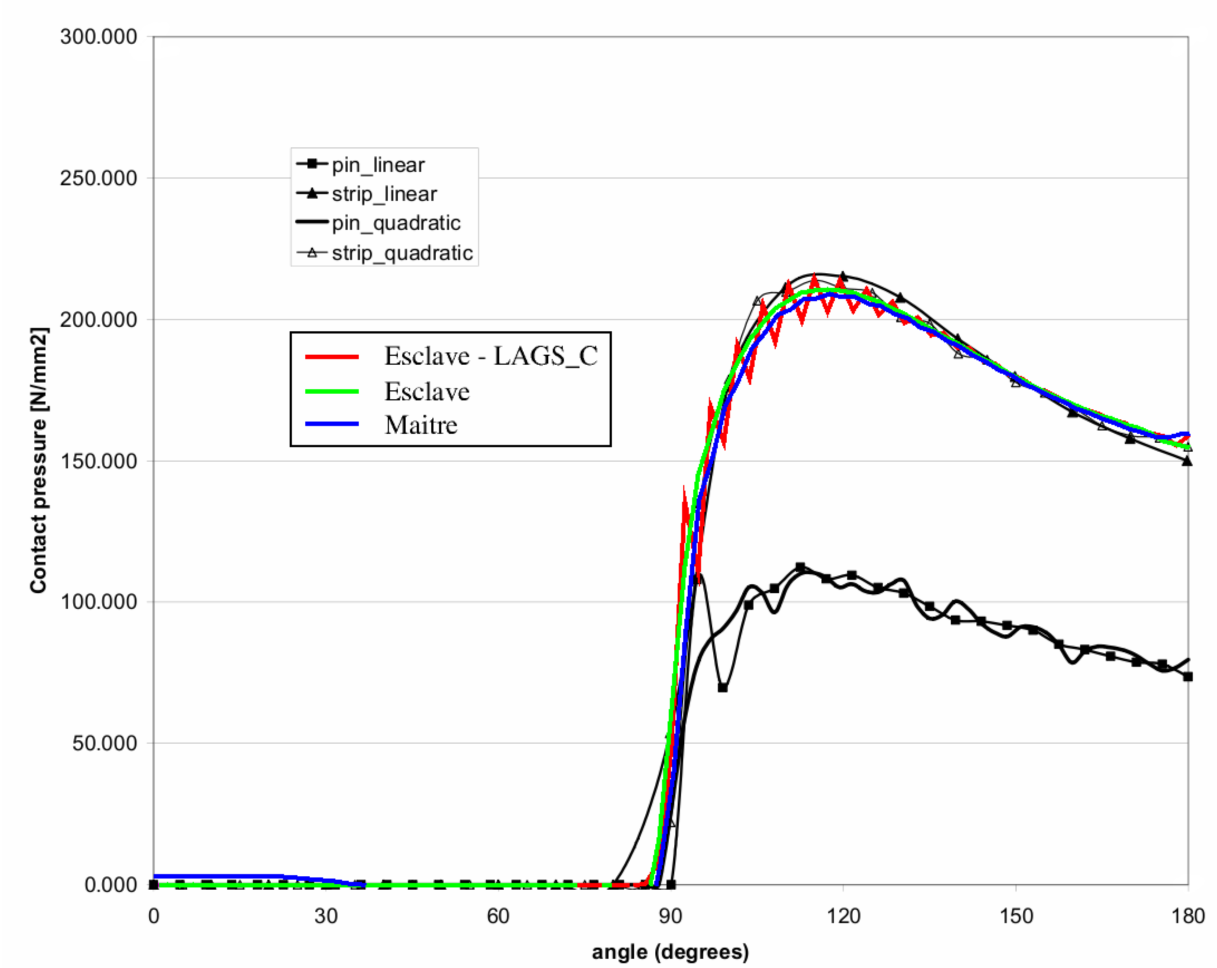


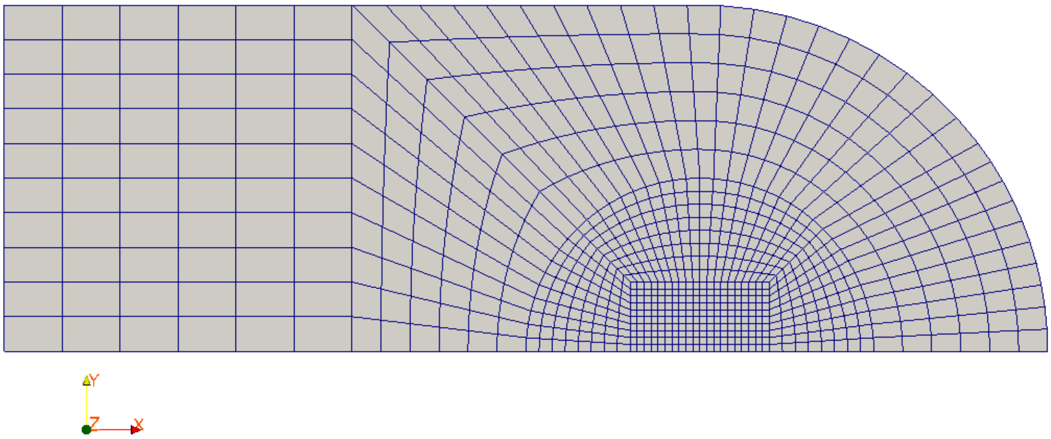
Illustration 3: comparison between MARC and *Code_Aster* (contact pressure on the punch)

5 Modelization C

5.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is DISCRETE.

5.2 Characteristics of the mesh



Many nodes: 912
Number of meshes and types: 820 QUAD4.

5.3 Quantities tested and Algorithm

results of contact-friction used: LAGRANGIAN

Standard	Identification of reference	Value of reference	Tolerance
DX to point A	"SOURCE_EXTERNE"	0,71798990369944	0,1%
$SIXX$ to point A	"SOURCE_EXTERNE"	-136,67278394277	0,1%

5.4 Remarks

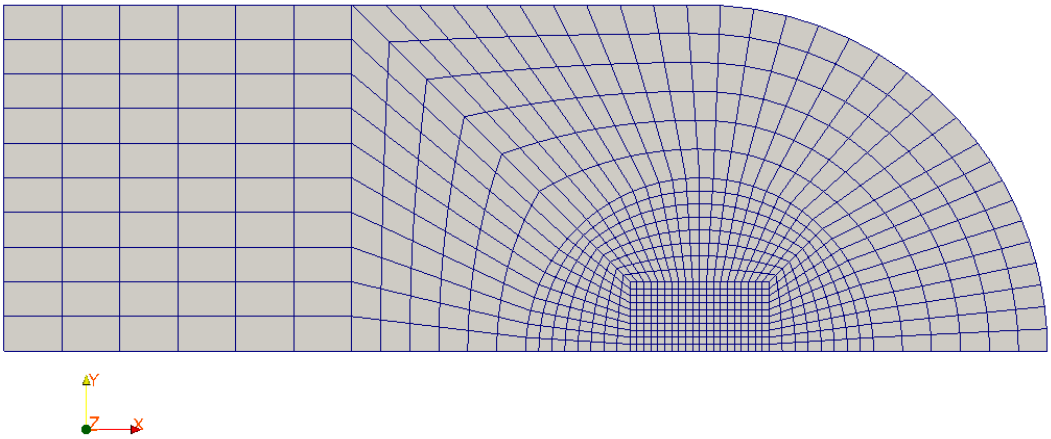
the results got into linear by the discrete formulation with friction are identical to those obtained in the modelization A (continuous formulation).

6 Modelization D

6.1 Characteristic of the modelization

The modelization is D_PLAN, the formulation of the contact is DISCRETE.

6.2 Characteristics of the mesh



Many nodes: 2642
Number of meshes and types: 820 QUAD8.

6.3 Quantities tested and Algorithm

results of contact-friction used: LAGRANGIAN

Standard	Identification of reference	Value of reference	Tolerance
DX to point A	"SOURCE_EXTERNE"	0,73618956486592	0,1%
$SIXX$ to point A	"SOURCE_EXTERNE"	-160,47115198705	0,1%

6.4 Remarks

the results got into quadratic by the discrete formulation are identical to those obtained in modelization B (continuous formulation). For example, the displacement following y of the punch to the interface is in very good agreement with the commercial codes.

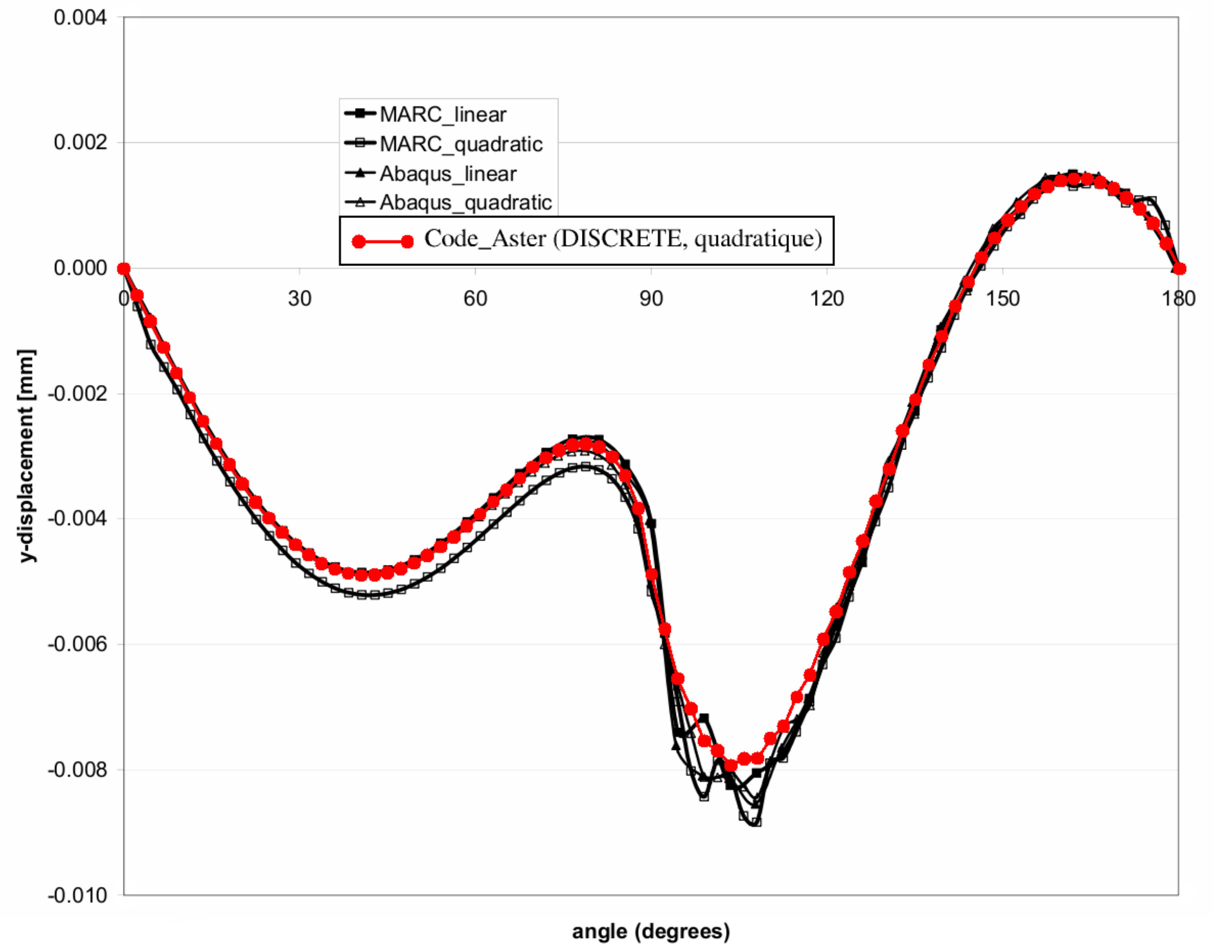


Illustration 4: comparison between MARC, Abaqus and *Code_Aster* (following displacement y of the punch)

7 Summary of the results

This test makes it possible to validate contact-friction compared to references given by commercial computer codes (Abaqus and MARC).
One observes a good agreement with the results of reference. However it is important to note that the meshes used by Aster computations are different from the meshes of *the benchmark* : the latter had the effect of not being compatible (for a cylindrical contact that means either initial interpenetration or an initial non-zero clearance). However in the presence of curved contact, this kind of meshes leads to strong oscillations (for example on the pressure because of an alternation of contacting points and not contacting) which can be avoided only by the use of advanced features (*splines*, repositioning of nodes). These features are not available at present in *Code_Aster*.

Into quadratic, the contact pressure obtained starting from degree of freedom `LAGS_C` in continuous formulation has less oscillations when one increases the number of points of the diagram of integration.