SSNP156 – Benchmark NAFEMS of validation of contact 4: *loaded pine*

Summary:

This problem constitutes the fourth CAS-test 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 and thus noncompatible smoothnesses. Calculation with *Code_Aster* require the use of compatible grids however.

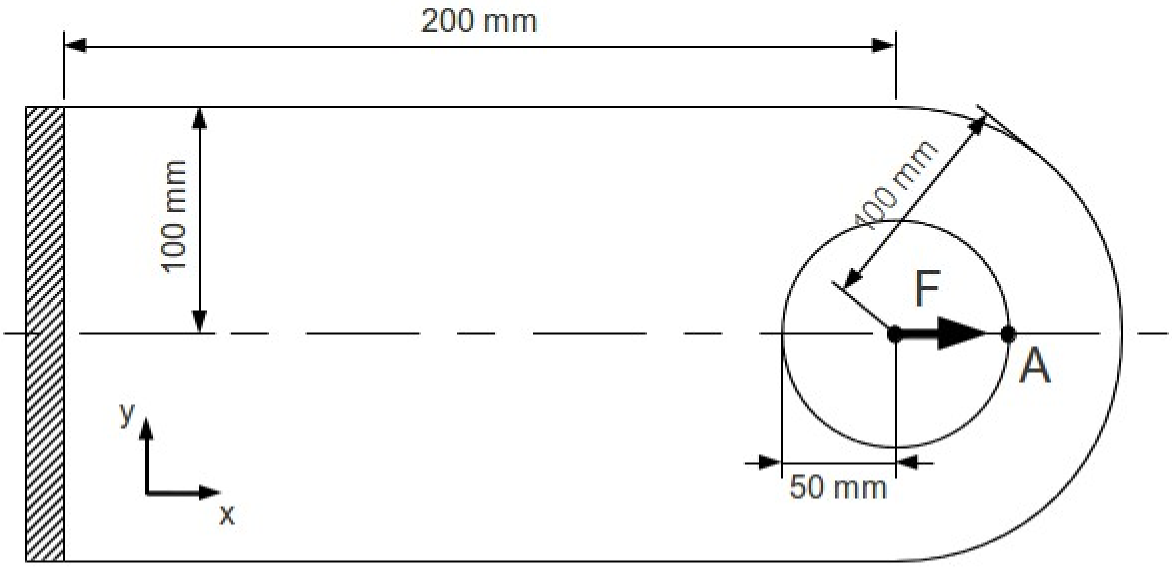
This test comprises 4 modelings making it possible to test:

- linear and quadratic elements,
- formulations of treatment of the contact with friction `'DISCRETE'` and `'CONTINUOUS'`
- contact pressures and tangential stresses of friction

1 Problem of reference

1.1 Geometry

The structure is modelled in plane deformations. 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 console and located as regards symmetry.

1.2 Properties of materials

Console :

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 friction between the block and the cylinder is worth $\mu=0{,}1$.

1.3 Boundary conditions and loadings

The structure symmetrical and being subjected to a loading respecting symmetry, only a half is represented. One thus applies $DY=0$ as regards symmetry.

The console is embedded on its left side:

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

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

- $FX=20000\,kN$, that is to say $FX=10000\,N$ for the half-structure

2 Reference solution

2.1 Method of calculating

The reference solution comes from results got with the codes Abaqus and MARC in a benchmark NAFEMS of validation of contact-friction [bib1].

2.2 Sizes 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 constraints in volume.

2.3 Uncertainties on the solution

Important (average of codes).
It will be noted that the grid used is different from that from *benchmark*. The reason is given in conclusion of the document.

2.4 Bibliographical reference

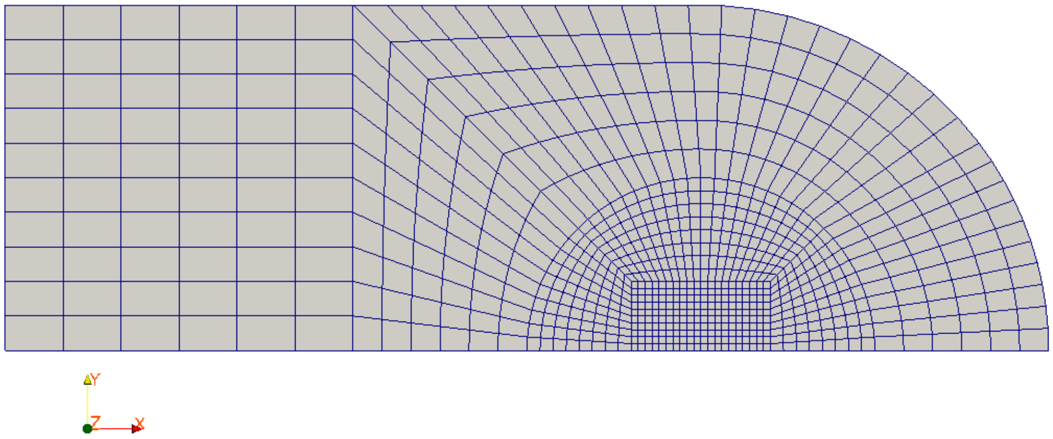
[1] A. KONTER. *“Advanced Finite Element Benchmarks Contact”*. NAFEMS, 2006.

3 Modeling A

3.1 Characteristics of modeling

Modeling is D_PLAN, the formulation of the contact is CONTINUOUS.

3.2 Characteristics of the grid



Many nodes: 912
Many meshs and types: 820 QUAD4.

3.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
DX at the point A	'SOURCE_EXTERNE'	0.71798956398122	0.1%
$SIXX$ at the point A	'SOURCE_EXTERNE'	-136.67272217658	0.1%

3.4 Remarks

The results got into linear by the formulation continues 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 it *benchmark* in particular with respect to the plane deformations, made difficult by contradictory information in document NAFEMS (the thickness is taken into account in the commercial codes even in plane deformations).
Although different from the references Abaqus and MARC, the got results are nevertheless identical to those obtained by CAST3M on this same calculation.

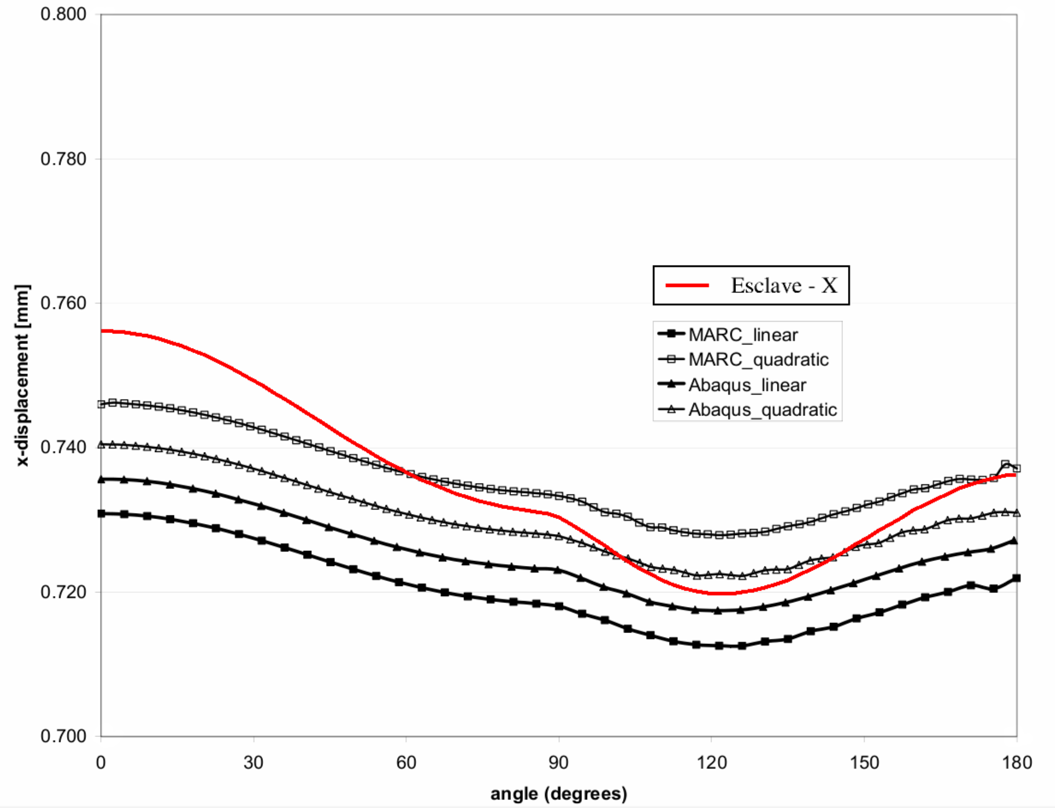


Illustration 1: comparison of the results between Abaqus, MARC and Code_Aster (following displacement x punch)

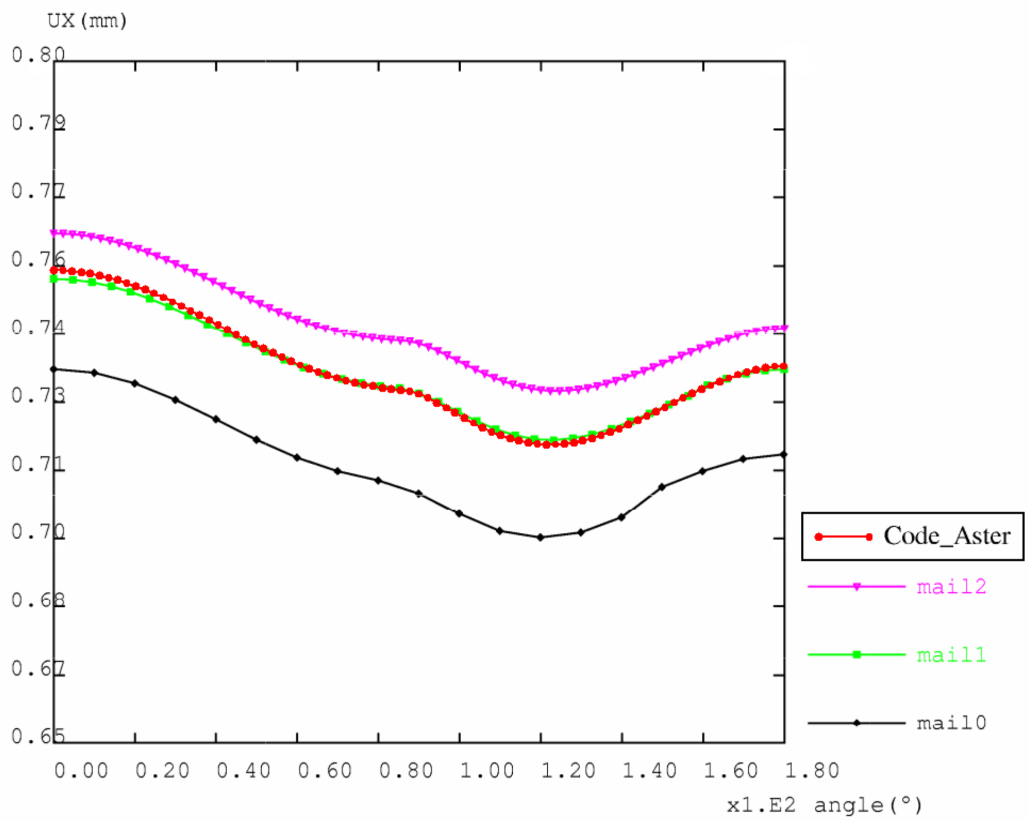


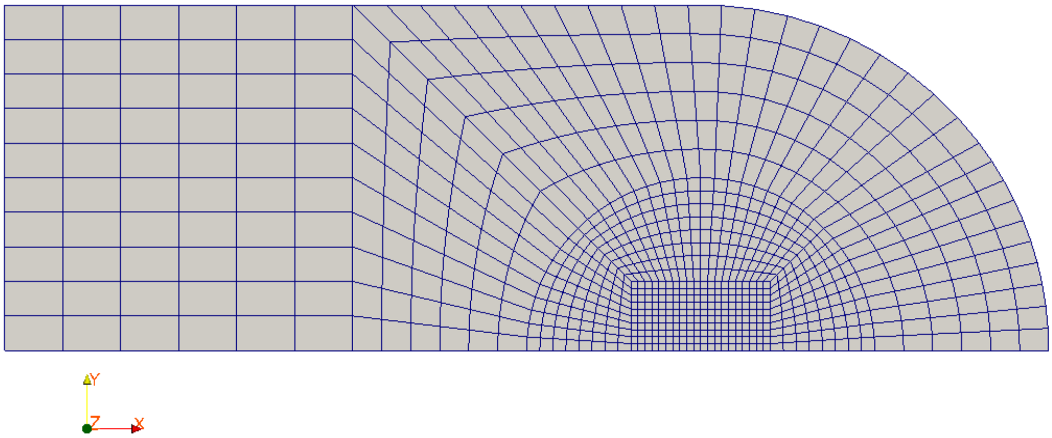
Illustration 2: comparison of the results between CAST3M and Code_Aster (following displacement x punch)

4 Modeling B

4.1 Characteristics of modeling

Modeling is D_PLAN, the formulation of the contact is CONTINUOUS.

4.2 Characteristics of the grid



Many nodes: 2642
Many meshs and types: 820 QUAD8.

4.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
DX at the point A	'SOURCE_EXTERNE'	0.73616515310581	0.1%
$SIXX$ at the point A	'SOURCE_EXTERNE'	-160.40053222751	0.1%

4.4 Remarks

The results got into quadratic by the formulation continues with friction are close to the results of reference that it is in displacement or pressure. They are almost identical to those obtained by modeling A (linear grid).
The contact pressure raised on the edge of the pin that it is via the degree of freedom LAGS_C formulation continues or by extrapolation starting from the constraints stick perfectly to the reference.
The degree of freedom LAGS_C have 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.

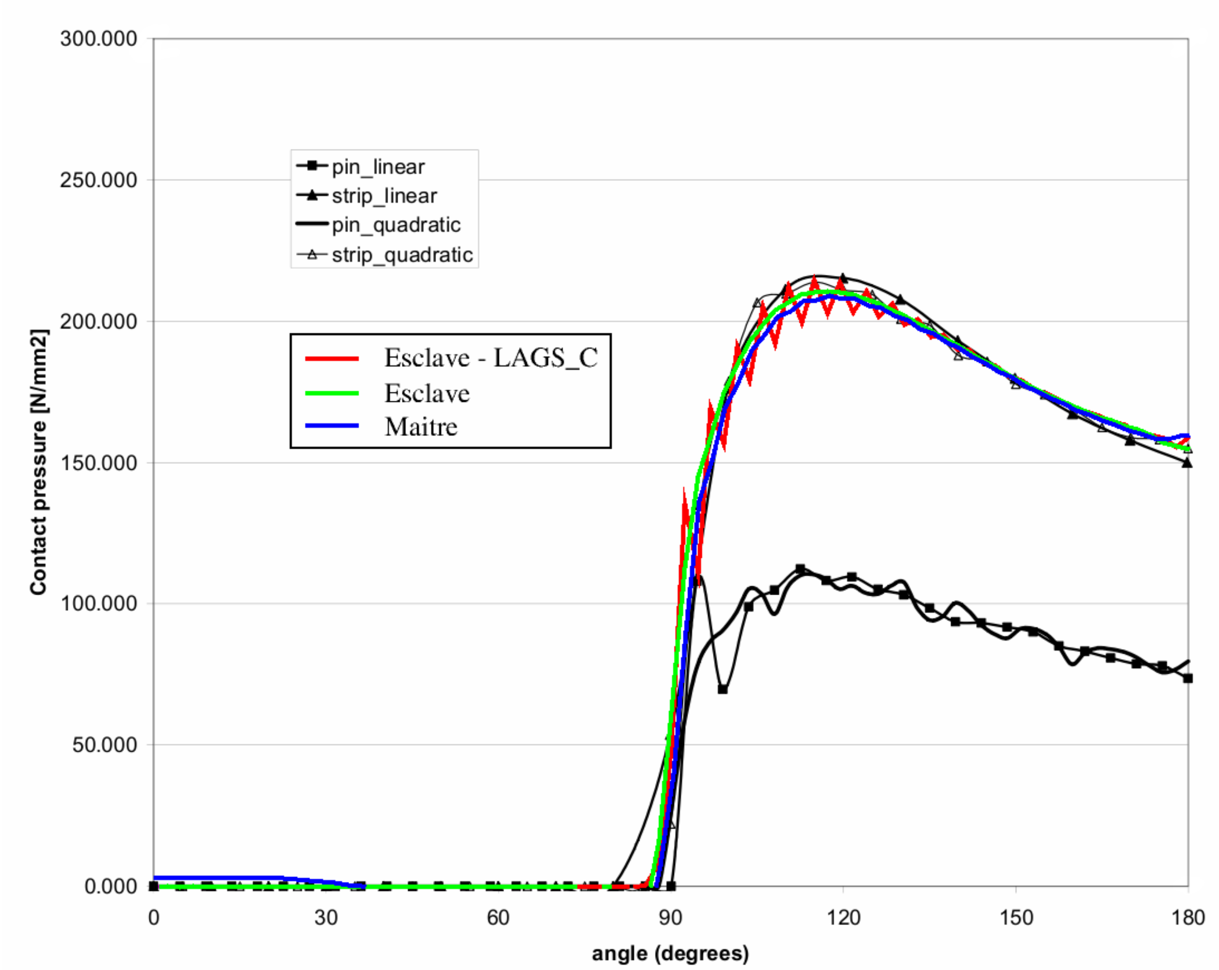


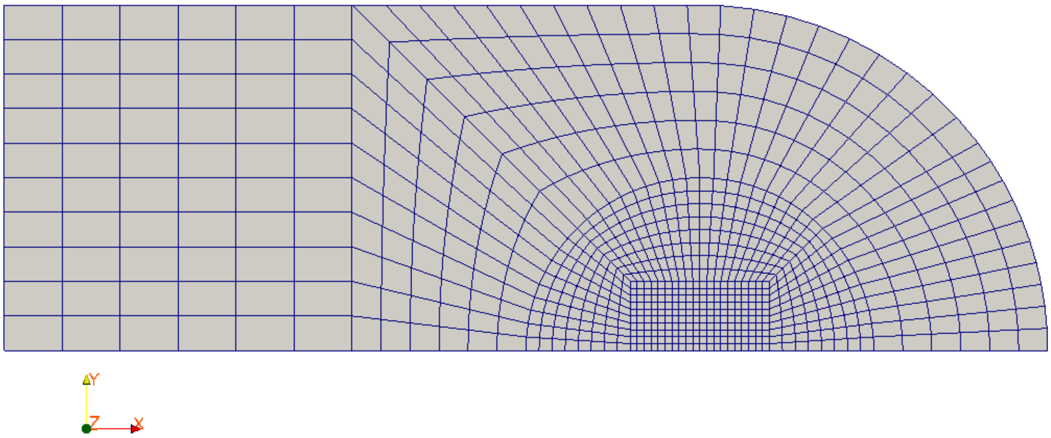
Illustration 3: comparison between MARC and *Code_Aster* (contact pressure on the punch)

5 Modeling C

5.1 Characteristics of modeling

Modeling is D_PLAN, the formulation of the contact is DISCRETE.

5.2 Characteristics of the grid



Many nodes: 912
Many meshs and types: 820 QUAD4.

5.3 Sizes tested and results

Algorithm of contact-friction used: LAGRANGIAN

Identification	Type of reference	Value of reference	Tolerance
DX at the point A	'SOURCE_EXTERNE'	0.71798990369944	0.1%
$SIXX$ at the point A	'SOURCE_EXTERNE'	-136.67278394277	0.1%

5.4 Remarks

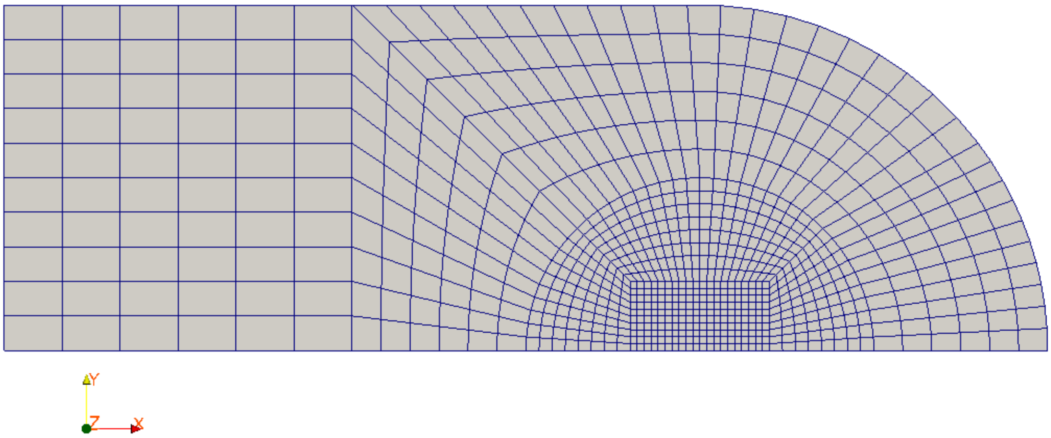
The results got into linear by the discrete formulation with friction are identical to those obtained in modeling A (continuous formulation).

6 Modeling D

6.1 Characteristics of modeling

Modeling is D_PLAN, the formulation of the contact is DISCRETE.

6.2 Characteristics of the grid



Many nodes: 2642
Many meshs and types: 820 QUAD8.

6.3 Sizes tested and results

Algorithm of contact-friction used: LAGRANGIAN

Identification	Type of reference	Value of reference	Tolerance
DX at the point A	'SOURCE_EXTERNE'	0.73618956486592	0.1%
$SIXX$ at the 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 modeling B (continuous formulation). For example, following displacement y punch with the interface is in very good agreement with the commercial codes.

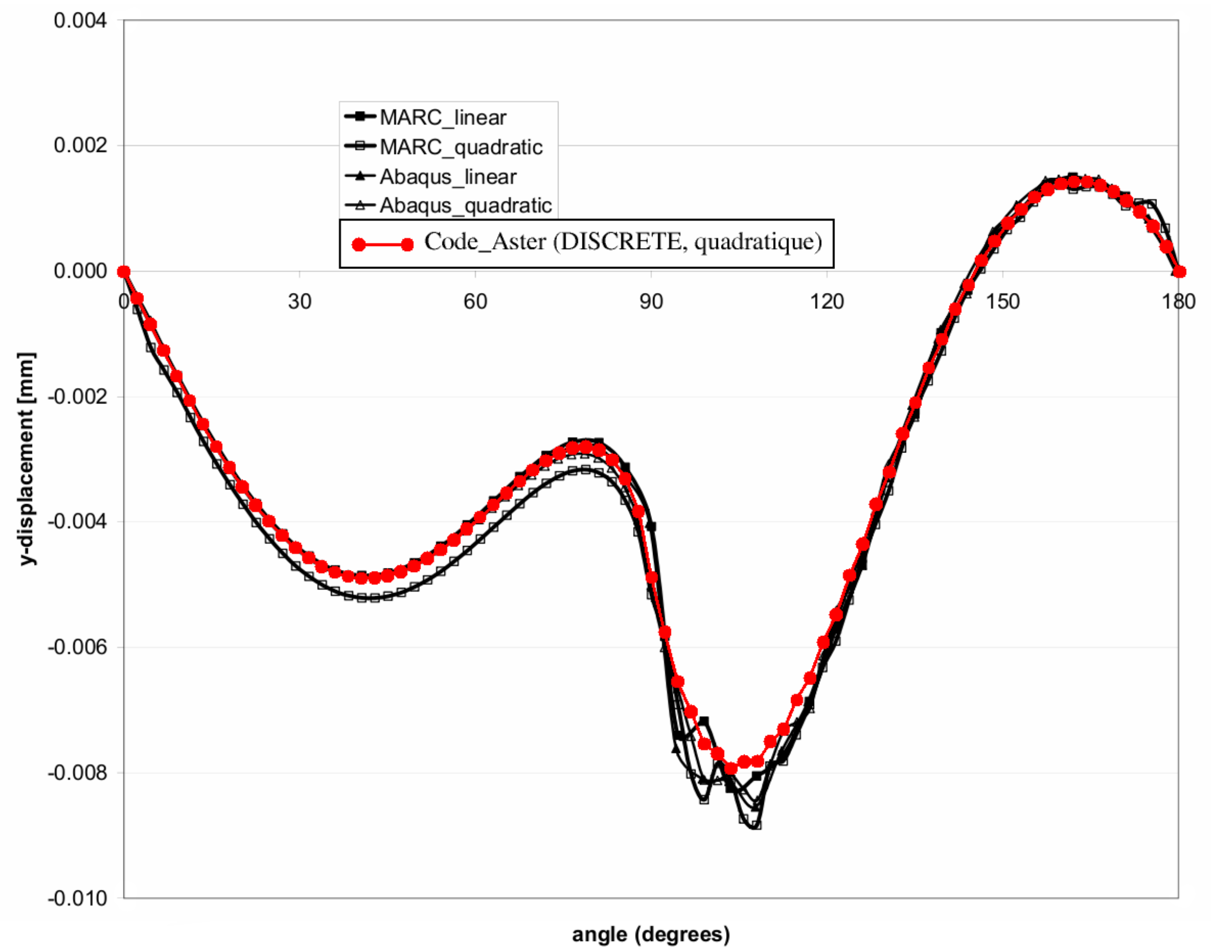


Illustration 4: comparison between MARC, Abaqus and *Code_Aster* (following displacement y punch)

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 grids used by calculations Aster are different from the grids from *benchmark* : the latter had the effect of not being compatible (for a cylindrical contact that means either initial interpenetration or a game not no initial). However in the presence of curved contact, this kind of grids 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 the degree of freedom `LAGS_C` in continuous formulation has less oscillations when one increases the number of points of the diagram of integration.