SSNV128 - Plate with contact and friction on a rigid level

Summary:

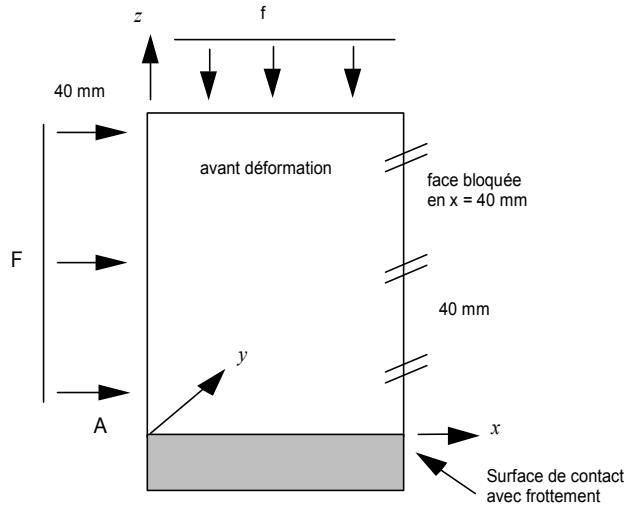
This problem corresponds to a quasi-static analysis of a problem of mechanics with contact and friction. A square plate is compressed on an indeformable level where it undergoes forces of contact and friction. This test is based on 2D results resulting from an average of codes.

This test comprises modelings making it possible to test:

- modelings 2D (QUAD4, QUAD8, TRIA3 and TRIA6) and modelings 3D (HEXA8, HEXA20, HEXA27, PENTA6, PENTA15, TETRA4 and TETRA10),
- algorithms of treatment of the contact with friction 'LAGRANGIAN', 'PENALIZATION' and 'CONTINUOUS',
- the geometrical reactualization of the contact
- various options of the algorithm of pairing
- various options specific to the case of friction

1 Problem of reference

1.1 Geometry



Side of the plate (square) $a=0,04\ m$.

Position of the points of reference under the surface of contact (m)

	x	y	z
A	0	0	0
B	0.00125	0	0
C	0.005	0	0
D	0.0075	0	0
E	0.01125	0	0
R	0.03875	0	0

1.2 Properties of materials

Plate :

Poisson's ratio: $0,2$
Young modulus: $1,3*10^{11}N.m^{-2}$

Frame (only if it is modelled by of the same elements dimension than the plate) :

Poisson's ratio: 0.2
Young modulus: $10^{16}N.m^{-2}$

The coefficient of friction under the rigid plan is $\mu=1$.

1.3 Boundary conditions and loadings

The frame, when it is of dimension $N-1$ compared to the dimension of the plate, is blocked:

- by a complete embedding.

The frame, when it is of the same dimension than the plate, is blocked:

- in the plan $x=40\ mm$ for displacements according to x (symmetry of the problem);
- by an embedding of its lower face.

The plate is blocked:

- in the plan $x=40\ mm$ for displacements according to x (symmetry of the problem);
- according to Y with the node located at the intersection of the symmetry plane, face of contact and plan $Z=0$ to prevent the movements of rigid body.

In 3D, to bring back itself to a problem 2D:

- following displacement Z is blocked for all the nodes.

The plate is subjected to two pressures distributed:

- a vertical acting on the face of the top: $f=-5*10^{7}N.mm^{-2}$;
- horizontal acting on the face initially in $x=0$, $F=15*10^{7}N.mm^{-2}$.

2 Reference solution

2.1 Method of calculating

The reference solution comes from results got by an average on other computer codes [bib1].

2.2 Sizes and results of reference

Tangential displacements (according to x) at the points $A\,B\,C\,D\,E$ surface of contact (external reference).

Statute of contact, game and reaction of contact at the point R for certain modelings (not-regression).

Contact pressures at the points $A\,B\,C\,D\,E$ surface of contact for modelings with wear (not-regression).

2.3 Uncertainties on the solution

Important (average of codes).

2.4 Bibliographical reference

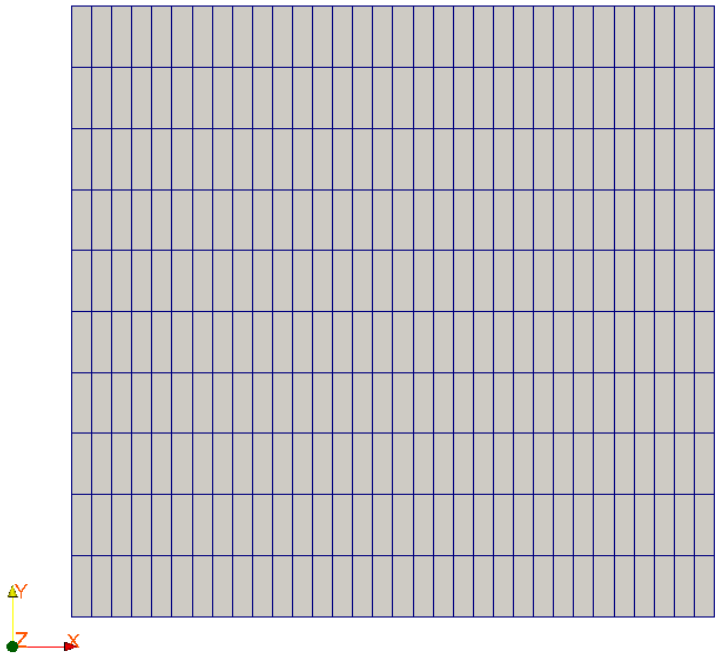
[1] R.A. FEIJOO H.J.C. BARBOSA and NR. ZOUAIN “Numerical formulations for contact problems with friction” Newspaper of Theorical and Applied Mechanics GAUTHIER-VILLARS.

3 Modeling A

3.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

3.2 Characteristics of the grid



Many nodes: 396
Many meshs and types: 320 QUAD4 for the plate and 32 SEG2 for the frame.

3.3 Sizes tested and results

The first calculation (algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment -2.0	'NON_REGRESSION'	1,138E-5	1,0E- 9%
JEU at the point R moment 1.0	'NON_REGRESSION'	0	1,0E-12
$CONT$ at the point R moment 1.0	'NON_REGRESSION'	1	1,0E- 5%
RN at the point R moment 1.0	'NON_REGRESSION'	1,049E+5	1,0E- 5%
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (master-slave normal, controlled geometrical reactualization, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (master-slave normal, controlled geometrical reactualization, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

One also tests projection by considering the penultimate node slave on the right.

Identification	Type of reference	Value of reference	Tolerance

PROJ_X of VALE_CONT moment 1.0	'ANALYTICAL'	3,88E-002	1,0E- 6%
PROJ_Y of VALE_CONT moment 1.0	'ANALYTICAL'	0,00E+000	1,0E- 6%

3.4 Remarks

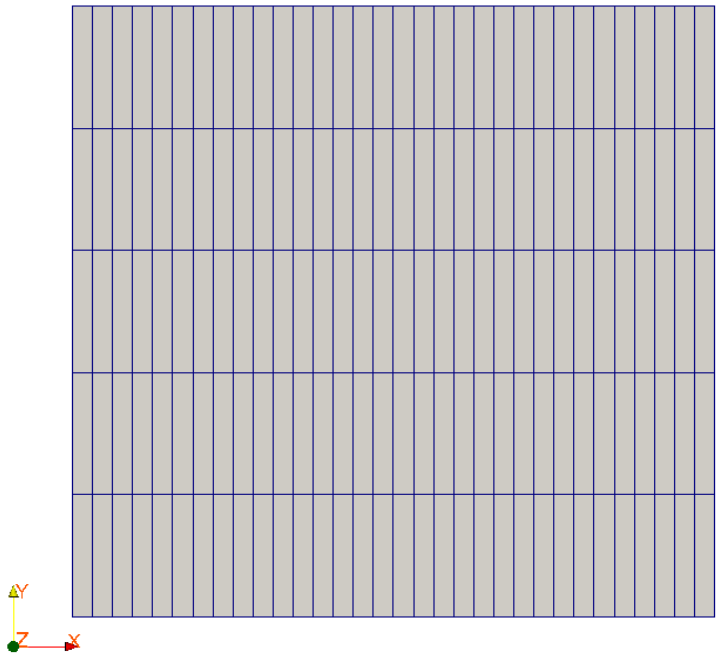
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
Results got in penalization (coefficient of penalization about $a*E$) are close to the results with dualisation of contact-friction.

4 Modeling B

4.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

4.2 Characteristics of the grid



Many nodes: 558
Many meshs and types: 160 QUAD8 for the plate and 1 SEG3 for the frame.

4.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (controlled reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (not of reactualization geometrical, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (not of reactualization geometrical, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

4.4 Remarks

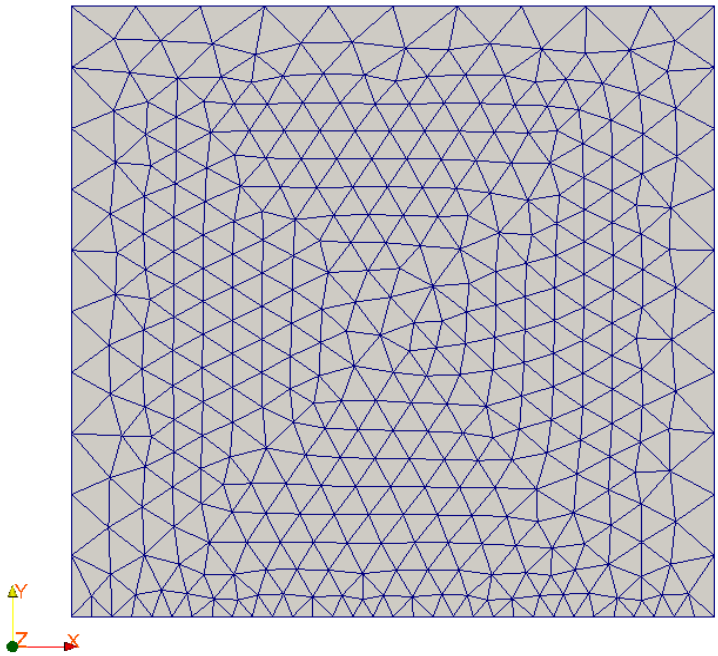
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
Results got in penalization (coefficient of penalization of friction about $a*E$) are close to the results with dualisation of contact-friction.
Calculation without geometrical reactualization validates here the assumption of small slips.

5 Modeling C

5.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

5.2 Characteristics of the grid



Many nodes: 431
Many meshs and types: 732 TRIA3 for the plate and 32 SEG2 for the frame.

5.3 Sizes tested and results

The first calculation (not of reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (not of reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

5.4 Remarks

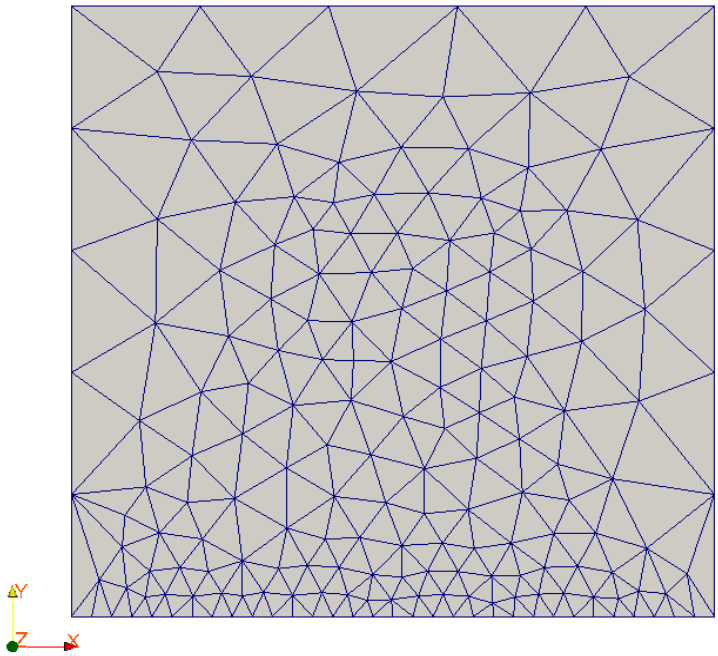
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
Results got in penalization (coefficient of penalization of friction about $a*E$) are close to the results with dualisation of contact-friction.
Calculation without geometrical reactualization validates here the assumption of small slips.

6 Modeling D

6.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

6.2 Characteristics of the grid



Many nodes: 763
Many meshs and types: 325 TRIA6 for the plate and 32 SEG3 for the frame.

6.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (controlled reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (nodal pairing, normal slave, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (nodal pairing, normal slave, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

6.4 Remarks

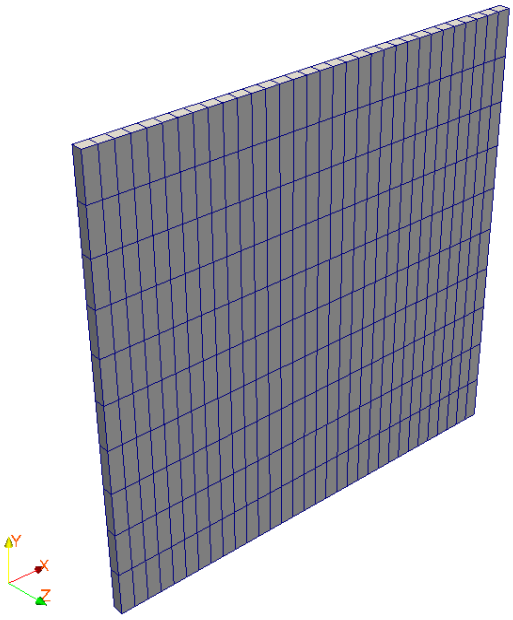
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
Results got in penalization (coefficient of penalization of friction about $a*E$) are close to the results with dualisation of contact-friction.

7 Modeling E

7.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

7.2 Characteristics of the grid



Many nodes: 792
Many meshs and types: 320 HEXA8 for the plate and 32 QUAD4 for the frame.

7.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, nodal pairing, normal slave, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (controlled reactualization geometrical, nodal pairing, normal slave, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (controlled reactualization geometrical, nodal pairing, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (controlled reactualization geometrical, nodal pairing, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

7.4 Remarks

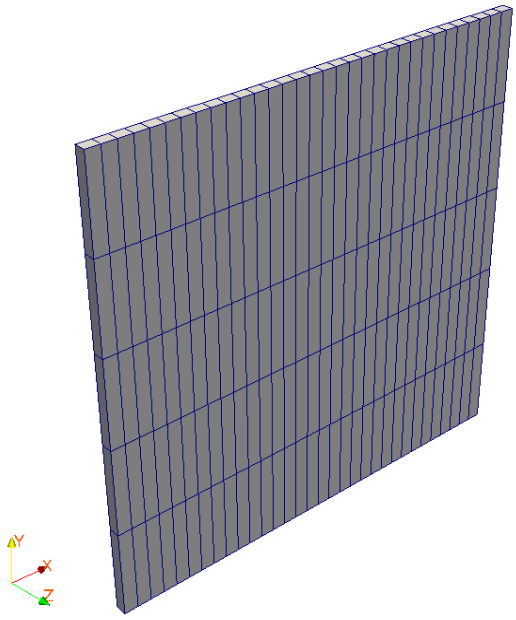
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
Results got in penalization (coefficient of penalization of friction about $a*E$) are close to the results with dualisation of contact-friction.
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

8 Modeling F

8.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

8.2 Characteristics of the grid



Many nodes: 1316
Many meshs and types: 160 HEXA20 for the plate and 1 QUAD8 for the frame.

8.3 Sizes tested and results

The first calculation (reactualization geometrical controlled, normal slave, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (reactualization geometrical controlled, normal slave, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

8.4 Remarks

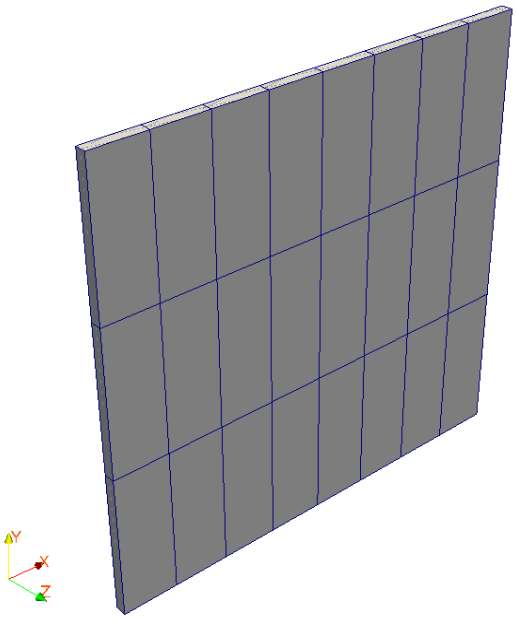
The results got in this modeling quadratic 3D are different from those obtained in preceding modelings while remaining in the tolerance of 5%. This difference is explained by the meshs of surfaces of contact of the type QUAD8 who are not adapted (what explains emitted alarm). The linear solvor does not affect the results.
The results got in penalization are very close to the results with dualisation of contact-friction. The difference with preceding modelings is a higher coefficient of penalization (coefficient of penalization of large friction in front $a*E$).
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

9 Modeling G

9.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

9.2 Characteristics of the grid



Many nodes: 408
Many meshs and types: 24 HEXA27 for the plate and 8 QUAD9 for the frame.

9.3 Sizes tested and results

The first calculation (algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

The second calculation (algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

The third calculation (controlled reactualization geometrical, nodal pairing, normal slave, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

The fourth calculation (controlled reactualization geometrical, nodal pairing, normal slave, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

9.4 Remarks

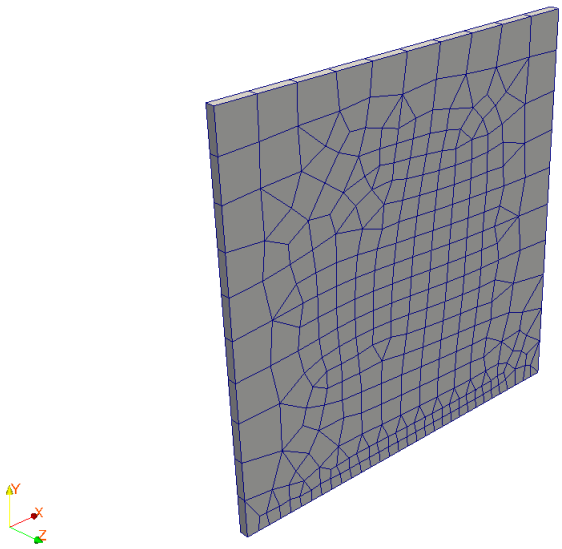
The results got in this modeling quadratic 3D are closer to the reference than preceding modeling in consequence of the use of meshs QUAD9 on the edge of contact.
The results got in penalization are very close to the results with dualisation of contact-friction. The difference with preceding modelings is a higher coefficient of penalization (coefficient of penalization of large friction in front $a*E$).
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

10 Modeling H

10.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

10.2 Characteristics of the grid



Many nodes: 670
Many meshs and types: 279 HEXA8 and 44 PENTA6 for the plate and 1 QUAD4 for the frame.

10.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (controlled reactualization geometrical, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance

DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

10.4 Remarks

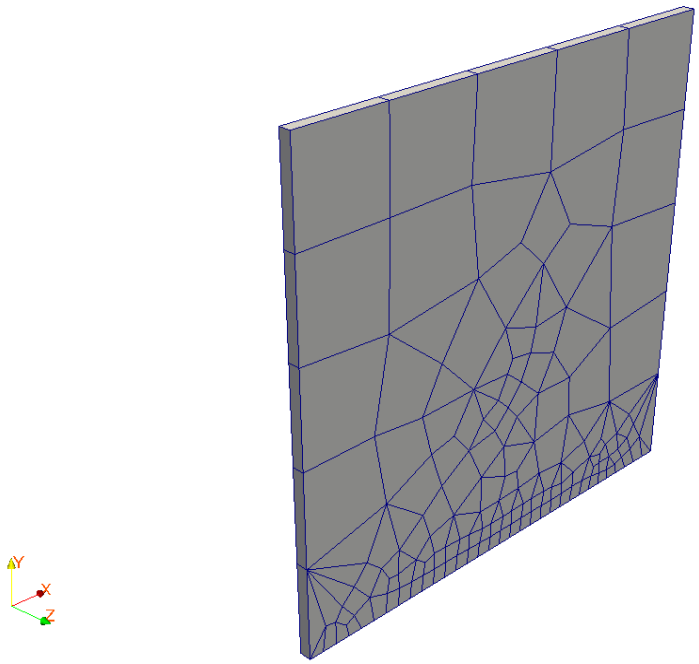
The results got in this modeling 3D with a mixed grid not structured are close to the reference.
The results got in penalization are very close to the results with dualisation of contact-friction. The difference with preceding modelings is a higher coefficient of penalization (coefficient of penalization of large friction in front $a*E$).
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

11 Modeling I

11.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

11.2 Characteristics of the grid



Many nodes: 1297
Many meshs and types: 121 HEXA20 and 37 PENTA15 for the plate and 32 QUAD8 for the frame.

11.3 Sizes tested and results

The first calculation (nodal pairing, normal slave, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (nodal pairing, normal slave, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance

DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (controlled reactualization geometrical, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (controlled reactualization geometrical, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

11.4 Remarks

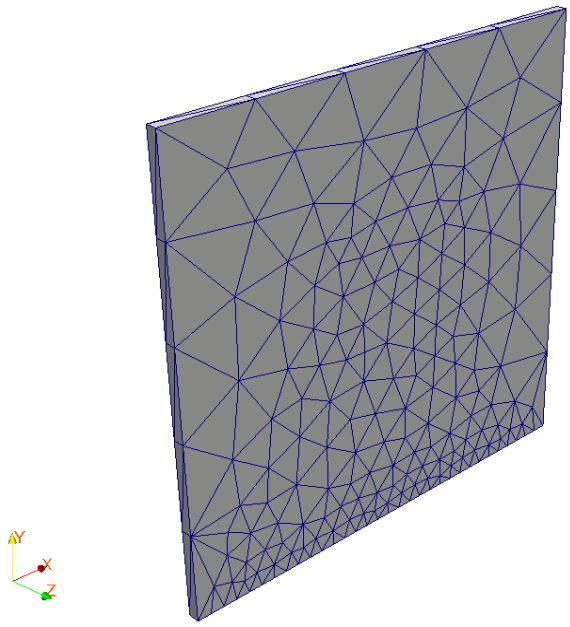
The results got in this modeling quadratic 3D are different from those obtained in preceding modelings while remaining in the tolerance of 5%. This difference is explained by the meshs of surfaces of contact of the type QUAD8 who are not adapted (what explains emitted alarm). The linear solvor does not affect the results.
The results got in penalization are very close to the results with dualisation of contact-friction. The difference with preceding modelings is a higher coefficient of penalization (coefficient of penalization of large friction in front $a*E$).
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

12 Modeling J

12.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

12.2 Characteristics of the grid



Many nodes: 441
Many meshs and types: 980 TETRA4 and 64 TRIA3 for the frame.

12.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, nodal pairing, normal slave, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (controlled reactualization geometrical, nodal pairing, normal slave, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The third calculation (algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The fourth calculation (algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

12.4 Remarks

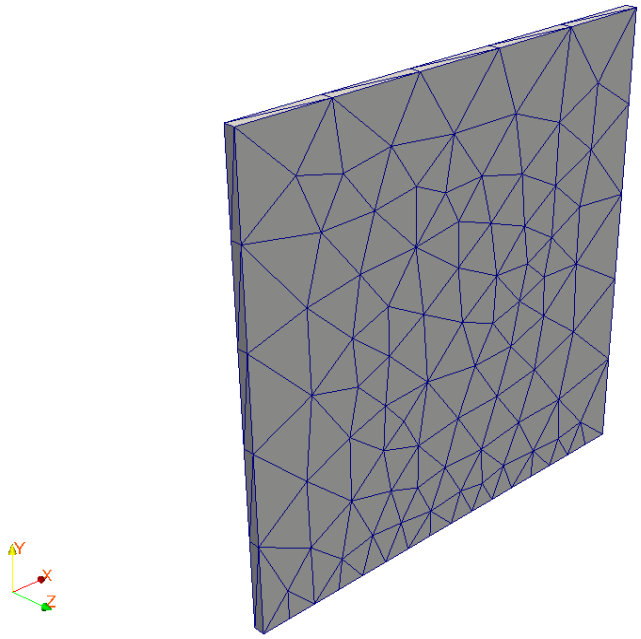
The results got in this modeling 3D with a grid not structured are less good than for preceding modelings but remain close to the reference. That can be explained by the grid the thickness which does not respect the symmetry of the problem (tetrahedrons).
The results got in penalization are very close to the results with dualisation of contact-friction. The difference with preceding modelings is a higher coefficient of penalization (coefficient of penalization of large friction in front $a*E$).
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

13 Modeling K

13.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Four calculations are carried out with options of pairing, algorithms of contact and linear solveurs different.

13.2 Characteristics of the grid



Many nodes: 1236
Many meshs and types: 526 TETRA10 for the plate and 32 TRIA6 for the frame.

13.3 Sizes tested and results

The first calculation (algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

The second calculation (algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

The third calculation (controlled reactualization geometrical, nodal pairing, algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

The fourth calculation (controlled reactualization geometrical, nodal pairing, algorithm 'PENALIZATION', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%

13.4 Remarks

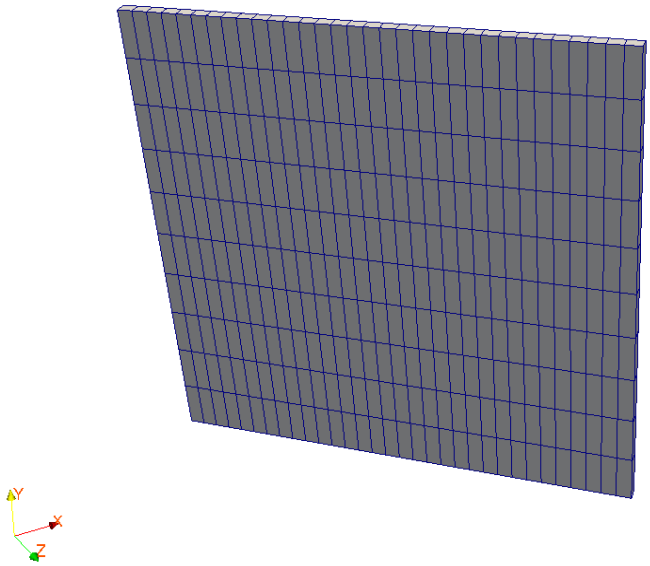
The results got in this modeling quadratic 3D not structured are close to the reference.
The results got in penalization are very close to the results with dualisation of contact-friction. The difference with preceding modelings is a higher coefficient of penalization (coefficient of penalization of large friction in front $a*E$).
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

14 Modeling L

14.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented. Two calculations are carried out with different linear solveurs. This modeling derives from modeling E, the only difference lies in the grid: it is turned of 45° around Oy .

14.2 Characteristics of the grid



Many nodes: 792
Many meshs and types: 320 HEXA8 for the plate and 32 QUAD4 for the frame.

14.3 Sizes tested and results

The first calculation (algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

14.4 Remarks

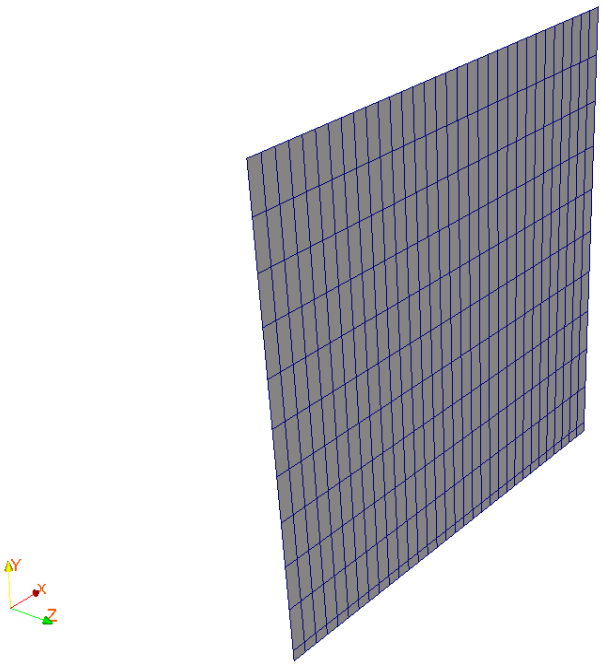
The got results are identical to those of modeling E and close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ . Moreover this test validates independence with the grid (after rotation).

15 Modeling M

15.1 Characteristics of modeling

Modeling is D_PLAN, the frame is represented by a quasi-rigid material solid. Two calculations are carried out with different linear solveurs.

15.2 Characteristics of the grid



Many nodes: 429
Many meshs and types: 320 QUAD4 for the plate and 32 QUAD4 for the frame.

15.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, formulation 'CONTINUES', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
JEU at the point R moment 1.0	'NON_REGRESSION'	0	1,0E-12
$CONT$ at the point R moment 1.0	'NON_REGRESSION'	1	1,0E- 5%
RN at the point R moment 1.0	'NON_REGRESSION'	1,049E+5	1,0E- 5%
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%

DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (controlled reactualization geometrical, formulation 'CONTINUES', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

15.4 Remarks

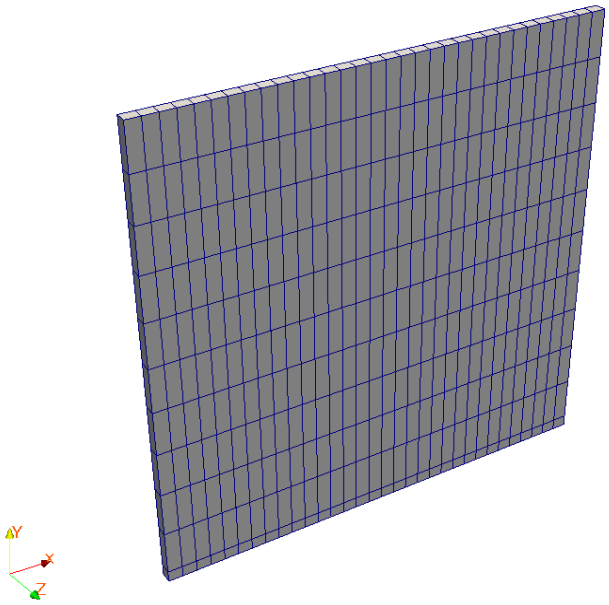
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
The formulation continues gives results identical to the discrete formulation.
The modeling of the frame by a very stiff material in front of material of the plate gives results equivalent to the case of the rigid frame whose only edge is represented.
The 3D problem gives many results identical to the 2D following the blocking of the degrees of freedom according to DZ .

16 Modeling NR

16.1 Characteristics of modeling

Modeling is 3D, the frame is represented by a quasi-rigid material solid.

16.2 Characteristics of the grid



Many nodes: 858
Many meshs and types: 320 HEXA8 for the plate and 32 HEXA8 for the frame.

16.3 Sizes tested and results

The first calculation (controlled reactualization geometrical, formulation 'CONTINUES', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

16.4 Remarks

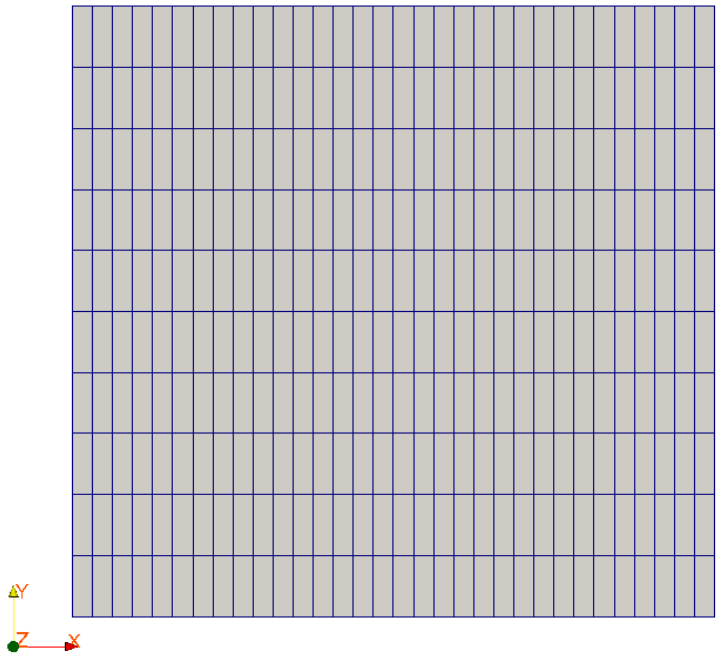
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
The formulation continues gives results identical to the discrete formulation.
The modeling of the frame by a very stiff material in front of material of the plate gives results equivalent to the case of the rigid frame whose only edge is represented.

17 Modeling O

17.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented. Two calculations are carried out with different linear solveurs.

17.2 Characteristics of the grid



Many nodes: 396
Many meshs and types: 320 QUAD4 for the plate and 32 SEG2 for the frame.

17.3 Sizes tested and results

The first calculation (initial geometry, algorithm 'LAGRANGIAN', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

The second calculation (initial geometry, algorithm 'LAGRANGIAN', solvor 'LDLT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

17.4 Remarks

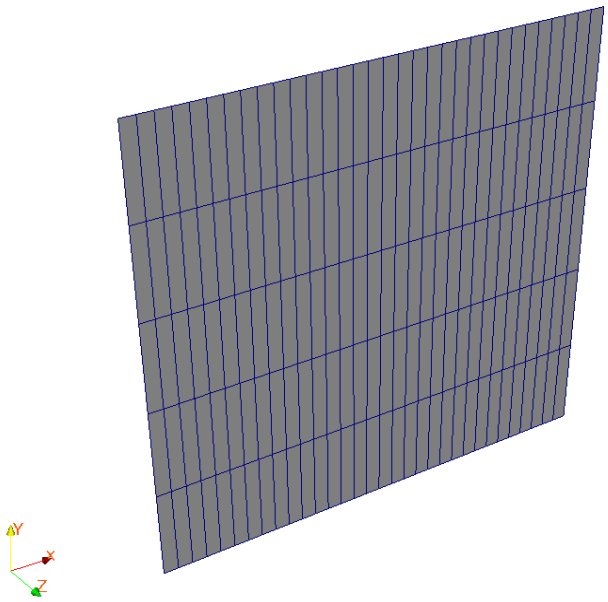
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
This modeling solved in initial geometry validates also the assumption of small slips of this test.

18 Modeling P

18.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented.

18.2 Characteristics of the grid



Many nodes: 620
Many meshs and types: 160 QUAD8 for the plate and 32 SEG3 for the frame.

18.3 Sizes tested and results

The first calculation (formulation 'CONTINUES', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

One also tests projection by considering the last node slave on the right.

Identification	Type of reference	Value of reference	Tolerance

PROJ_X of VALE_CONT moment 1.0	'ANALYTICAL'	4.00 E-002	1,0E- 6%
PROJ_Y of VALE_CONT moment 1.0	'ANALYTICAL'	0,00E+000	1,0E- 6%

18.4 Remarks

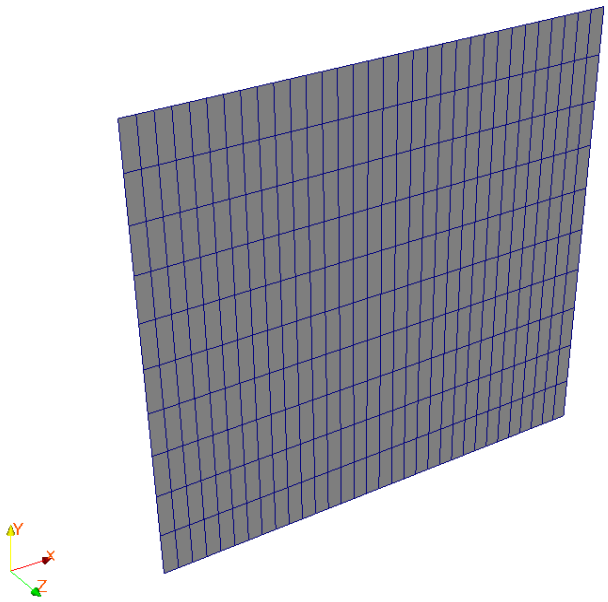
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.
The formulation continues gives results identical to the discrete formulation.

19 Modeling Q

19.1 Characteristics of modeling

Modeling is D_PLAN, only the edge of the frame is represented.

19.2 Characteristics of the grid



Many nodes: 396
Many meshs and types: 320 QUAD4 for the plate and 32 SEG2 for the frame.

19.3 Sizes tested and results

The first calculation (formulation 'CONTINUES', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

19.4 Remarks

The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.

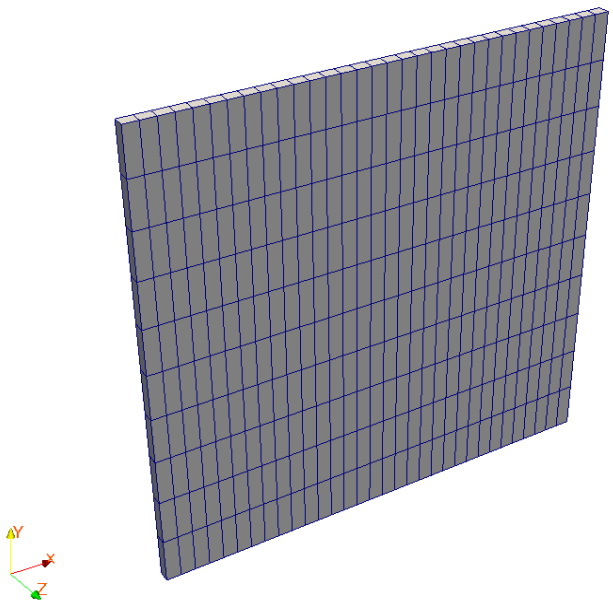
This modeling validates the exclusion of nodes only of the resolution of friction in continuous formulation.

20 Modeling R

20.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented.

20.2 Characteristics of the grid



Many nodes: 792
Many meshs and types: 320 HEXA8 for the plate and 32 QUAD4 for the frame.

20.3 Sizes tested and results

The first calculation (formulation 'CONTINUES', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

20.4 Remarks

The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.

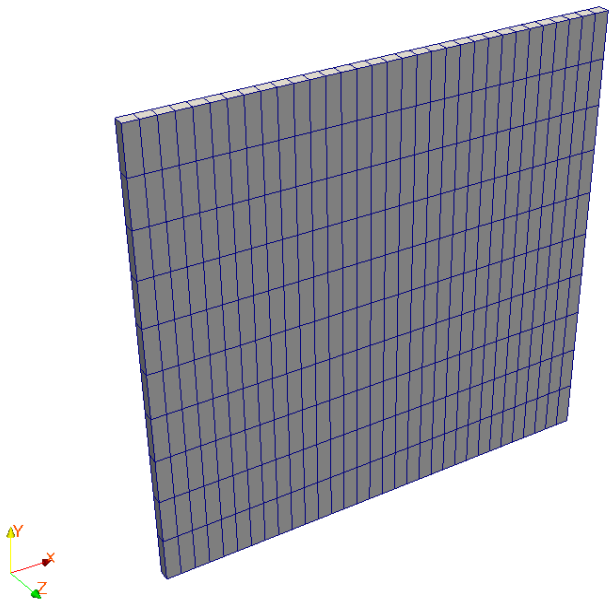
This modeling validates in 3D the exclusion of nodes only of the resolution of friction in continuous formulation.

21 Modeling W

21.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented.

21.2 Characteristics of the grid



Many nodes: 792
Many meshs and types: 320 HEXA8 for the plate and 32 QUAD4 for the frame.

21.3 Sizes tested and results

The first calculation (formulation 'CONTINUES', algorithm 'PENALIZATION', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

21.4 Remarks

The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.

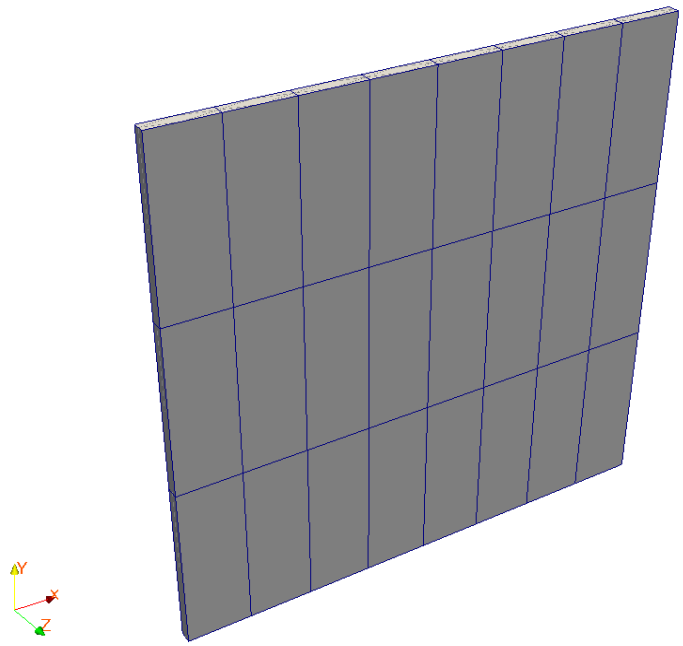
This modeling validates the penalized formulation of the continuous contact. The coefficients of penalization are selected so as to find same the results as in classical formulation.

22 Modeling X

22.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented.

22.2 Characteristics of the grid



Many nodes: 408
Many meshs and types: 24 HEXA27 for the plate and 8 QUAD9 for the frame.

22.3 Sizes tested and results

The first calculation (formulation 'CONTINUES', solvor 'MULT_FRONT')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

22.4 Remarks

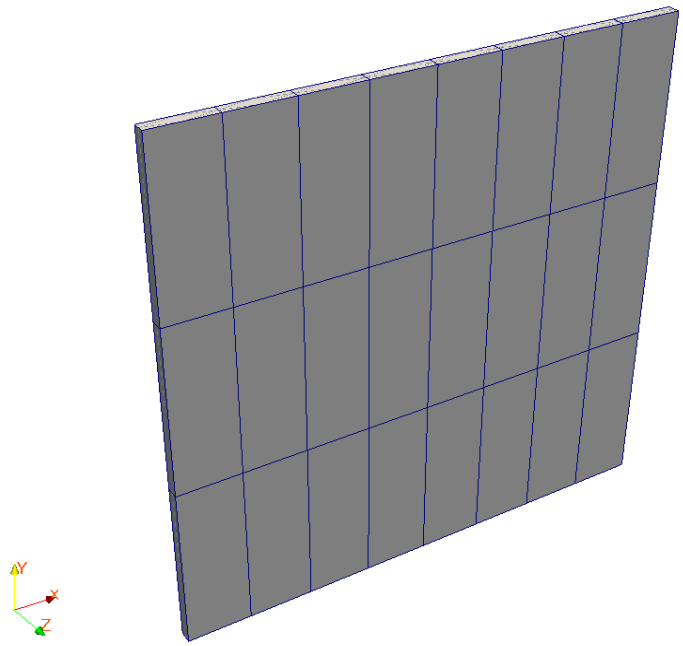
The got results are close to the external source with 5% close (average of codes). The linear solvor does not affect the results.

23 Modeling Y

23.1 Characteristics of modeling

Modeling is 3D, only the edge of the frame is represented.

23.2 Characteristics of the grid



Many nodes: 792
Many meshs and types: 320 HEXA8 for the plate and 32 QUAD4 for the frame.

23.3 Sizes tested and results

The first calculation (formulation 'CONTINUES', solvor 'MULT_FRONT', algorithm 'PENALIZATION')

Identification	Type of reference	Value of reference	Tolerance
DX at the point A moment 1.0	'SOURCE_EXTERNE'	2,86E-5	5,0%
DX at the point B moment 1.0	'SOURCE_EXTERNE'	2,72E-5	5,0%
DX at the point C moment 1.0	'SOURCE_EXTERNE'	2,28E-5	5,0%
DX at the point D moment 1.0	'SOURCE_EXTERNE'	1,98E-5	5,0%
DX at the point E moment 1.0	'SOURCE_EXTERNE'	1,5E-5	5,0%

23.4 Remarks

The got results are close to the external source with 5% close (average of codes). The choice of the good coefficient of penalization is essential to have a good quality of solution.

24 Summary of the results

The results got on the whole of modelings of this case test are satisfactory, as well in 2D as in 3D. On the points A, B, C and D, one obtains an error relative lower than 1% compared to the results of the GRECO. On the other hand, for the point E, the relative error, about 2,5%, remains acceptable.

From a time point of view computing, one notes that the method by penalization is in general faster than the Lagrangian method. One notes, on the other hand, an ease of use of the Lagrangian method (cf Doc. [U2.04.04]) compared to the penalized method, since the convergence and the quality of the results got by this last method are conditioned by the coefficient of penalization.

From a qualitative point of view:

- in 2D, one notes a positive effect on the results of the quadratic grid compared to the linear grid (cf modelings A and B),
- in 3D, it is noted that calculations with quadratic grid does not improve the results. This is explained by the fact why one decreased by 50% the number of meshs compared to the linear grid to have an equivalent number of nodes. In all the cases only the use of meshs TETRA10 or HEXA27 is recommended in discrete formulation, meshs HEXA20 needing to be linearized (they thus lose their interest).

As regards modeling L, inclined plate, one notes a good convergence and satisfactory results.

Lastly, for the method continues (modelings M, NR, P, Q, R, V, W and X), one gets in 3D results with relative errors slightly more important than those obtained by the methods Lagrangian and penalized. These errors come from blocking following the direction `DZ` who is not complete in continuous formulation in modelings which do not use the functionality `SANS_GROUP_NO_FR` of exclusion of the nodes of friction.