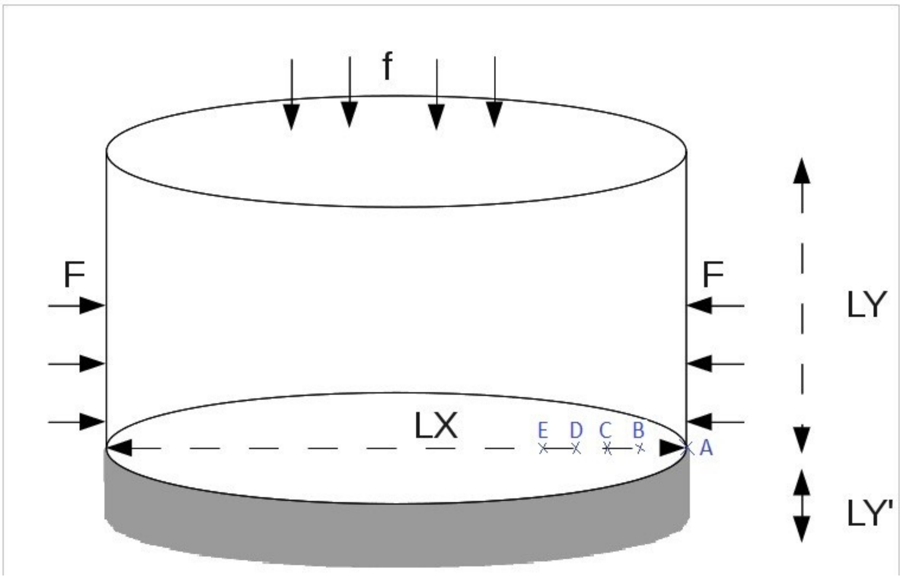
The second geometry is obtained by a revolution around the axis y geometry of the problem $2D$, the structure is then a cylinder.
Dimensions of the lower parts and higher are:

$LX = 80\text{mm}$, $LY = 40\,mm$ and $LY' = 10\,mm$



Taking into account the adopted grid, the positions of the points of reference are (in mm):

	x	y	z
A	40.0	0	0
B	35.0	0	0
C	30.0	0	0
D	25.0	0	0
E	20.0	0	0

1 Modeling I

1.1 Characteristics of modeling

Modeling: $3D$ FEM to test the operand Keyword FORMULATION 'CONTINUES' in the operator DEFI_CONTACT for elements TETRA4.

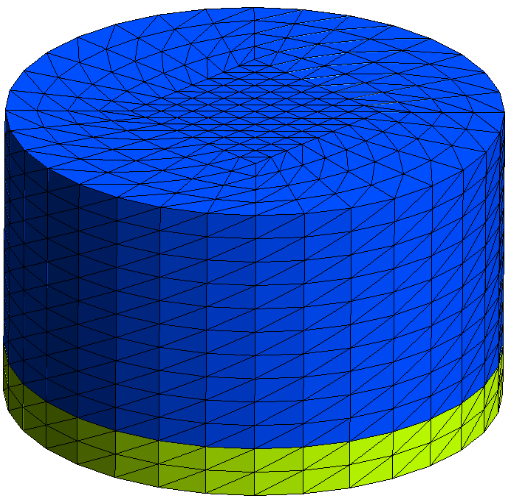
The geometry, the boundary conditions and the loadings are those of the problem of reference $3D$ cylinder describes paragraph §9 'Problem of reference in $3D$ '.

The plate and the frame are with a grid with elements TETRA4.

This case is used as reference for the cases $3D$ XFEM of modelings J and P.

1.2 Characteristics of the grid

Many nodes: 2926
Many meshs and types: 13824 TETRA4 for the plate and the frame.
1792 TRIA3 for the elements of edge.



1.3 Sizes tested and results

Identification	Aster
DX at the point A	-2,37E-005
DX at the point B	-1,84E-005
DX at the point C	-1,30E-005
DX at the point D	-8,09569E-06
DX at the point E	-3,90803E-06

1.4 Notice

These results are used as references for modelings J and P.

2 Modeling J

2.1 Characteristics of modeling

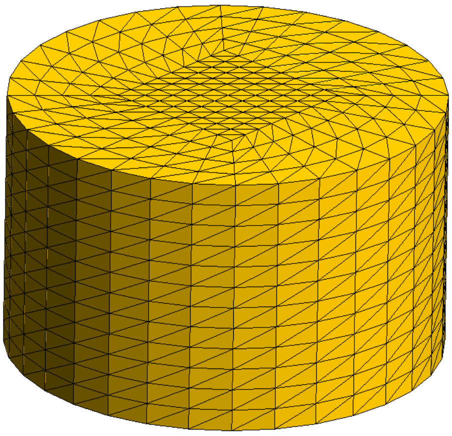
Modeling: $3D$ cylinder to test the operand 'XFEM' keyword FORMULATION in the operator DEFI_CONTACT for elements TETRA4 .

The geometry, the boundary conditions and the loadings are those of the problem of reference $3D$ cylinder describes paragraph §9 'Problem of reference in $3D$ '.

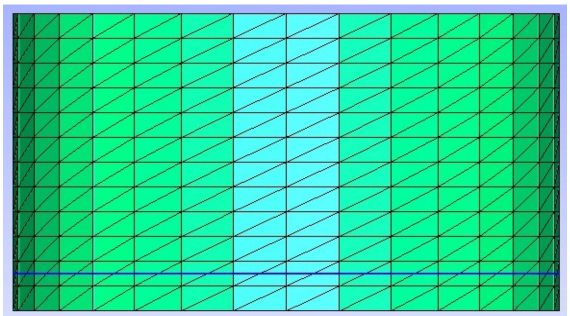
The plate and the frame are with a grid with elements TETRA4.

2.2 Characteristics of the grid

Many nodes: 2717
Many meshs and types: 13824 TETRA4 for the plate and the frame.
1536 TRIA3 for the elements of edge.



The crack (milked blue) coincides with the Z=0 plan and is located at 40 mm below the higher face



2.3 Sizes tested and results

Identification	Reference	Tolérence (%)
DX at the point A	-2,37083E-05	1.0
DX at the point B	-1,83709E-05	1.0
DX at the point C	-1,29919E-05	1.0
DX at the point D	-8,09569E-06	1.0
DX at the point E	-3,90803E-06	1.0

3

4
5

6 Modeling P

6.1 Characteristics of modeling

It is the same modeling as modeling J, but with a penalized formulation this time. One uses a formulation with Nœuds.

6.2 Characteristics of the grid

It is the same grid as that of modeling J.

6.3 Sizes tested and results

The values of reference and the tolerances are identical to modeling J.

Identification	***Reference***	***Tolérence (%)***
DX at the point A	-2,37083E-05	1.0
DX at the point B	-1,83709E-05	1.0
DX at the point C	-1,29919E-05	1.0
DX at the point D	-8,09569E-06	1.0
DX at the point E	-3,90803E-06	1.0

7

SSNV209 – Interface in contact rubbing with X-FEM

Summary:

This problem corresponds to a quasi-static analysis of a problem of mechanics with contact and friction. A rectangular plate is subjected to horizontal and vertical compressive forces and is compressed on a plan where it undergoes forces of contact and friction.

It is about a case equivalent to the CAS-test ssnv128 [V6.04.128], but solved with method XFEM.

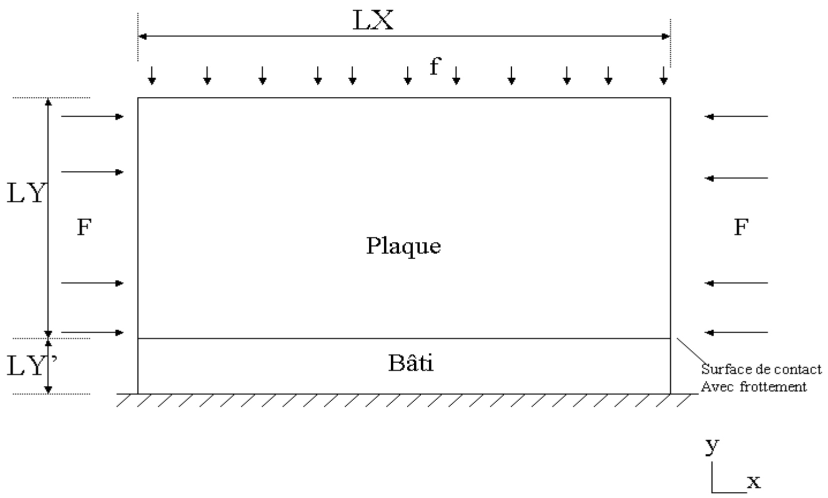
This test brings into play various grids, in $2D$ and $3D$, within the framework of calculations X-FEM [R7.02.12]

It comprises 14 modelings and makes it possible to test:

- modelings $2D$ (QUAD4, TRIA3, QUAD8, TRIA6) and $3D$ (HEXA8, TETRA4),
- a position of crack to the interface or in the middle of the elements,
- the operand XFEM keyword CONTACT
- integration by subelements (resulting from XFEM) of a size depending on a variable of order
- various diagrams of integration for the terms of contact (NODE, SIMPSON, NCOTES)
- formulations with lagranges on the edges and those with lagranges on the nodes (of the initial grid)
- parameters of the generalized formulation (coefficients of regularization and stabilization for the contact and friction),
- the simultaneous calculation of the separated zones, in slipping contact, and adherent contact
- postprocessing, in particular the calculation of the normal reaction RN,
- the algorithm of satisfaction of the condition LBB with the transitions taken off/contact and slipping/adherent,
- method of Lagrangian increased and method penalized for the treatment of contact-friction.

8 Problem of reference in 2D

8.1 Geometry



The structure is a rectangle made up of two of the same plates material, separated by an interface.

Dimensions of the plate, to which the pressures are applied, are:
$LX=80\text{mm}$, $LY=40\,mm$

The second plate, comparable to a frame, has following dimensions:
$LX=80\text{mm}$, $LY'=10\,mm$

The position of the points of reference under the surface of contact (mm) is:

	x	y
A	0	0
B	1.25	0
C	5.	0
D	7.5	0
E	11.25	0

8.2 Material properties

Plate and built:

Poisson's ratio: 0.2
Young modulus: $1.3\,10^{11}\,N/m^2$

The coefficient of friction under the plan is $\mu=1.0$.

8.3 Boundary conditions and loadings

Let us recall that displacement under X-FEM is the sum of a continuous displacement and a discontinuous displacement. In the case of an interface, bottomless of crack in the following way, the approximation of displacement is written:

$$u^h(x)=\sum_{i\in N_n(x)} a_i\Phi_i(x)-\sum_{i\in\Omega^+(x)\cap K} b_i\Phi_i(x)2\chi_-(x)+\sum_{i\in\Omega^-(x)\cap K} b_i\Phi_i(x)2\chi_+(x)$$

Where:

a_i and b_i are the degrees of freedom of displacement to the node i
Φ_i functions of form associated with the node i .
$\chi_\pm(x)$ functions characteristic on the sides + and – crack,
$\Omega^\pm(x)$ half spaces + and – determined by the crack,
$N_n(x)$ is the whole of the nodes whose support contains the point x ,
K is the whole of the nodes whose support is entirely cut by the crack

For more details, to refer to the reference material X-FEM [R7.02.12].

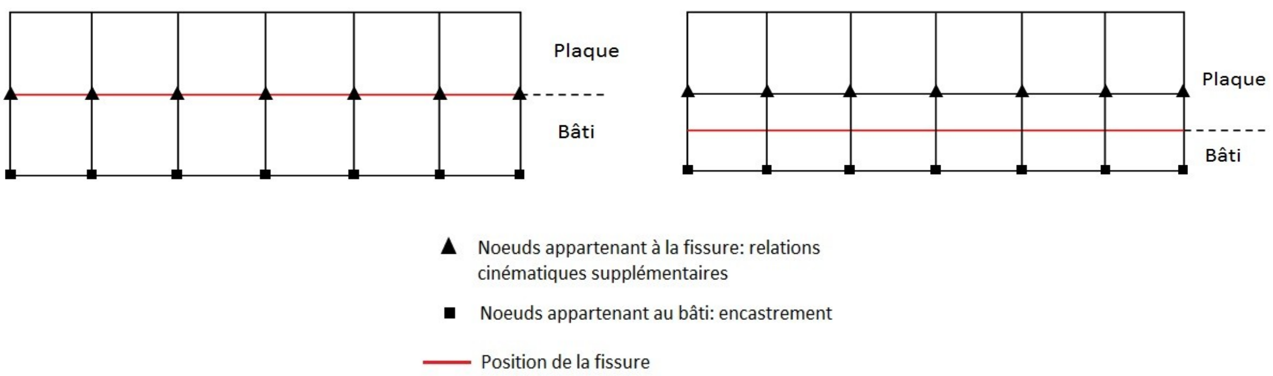
The rigid frame, of the same width than the plate, is blocked entirely by an embedding. DDL of displacement of nodes frame according to X and Y are put at 0:

$$DX_{NBATI}=0 \text{ and } DY_{NBATI}=0$$

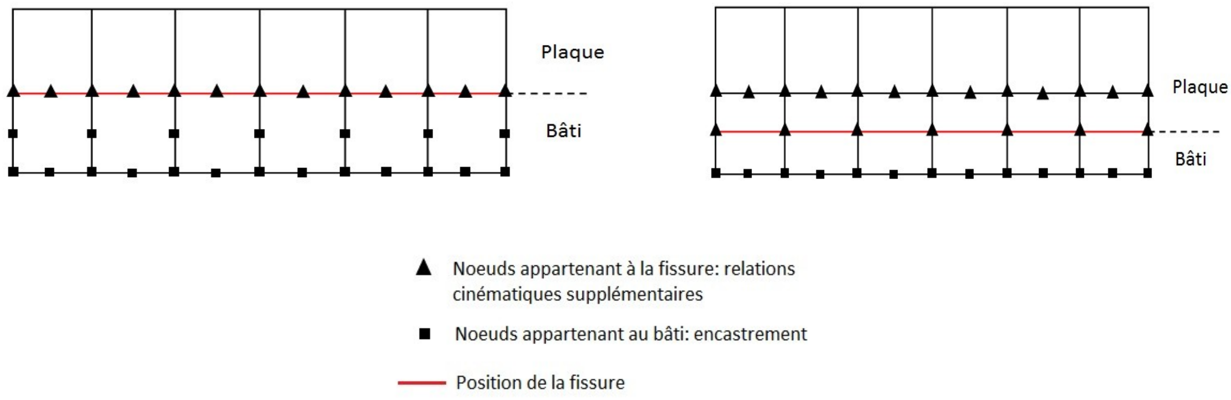
Additional equations are written on the DDL of the nodes of the elements cut by the crack, so that displacement is null everywhere on the lower part of these elements corresponding to the frame. Very concretely the relations kinematics which impose that in any point built under the interface displacement is quite null are the following ones:

$$DX_{NPLAQUE}-2HX_{NPLAQUE}=0 \qquad DY_{NPLAQUE}-2HY_{NPLAQUE}=0$$

The following figure shows the nodes which carry these relations kinematics according to the type of grid: conform (left) and not conforms (right)



For a grid **quadratic** here strategy to be followed: grid in conformity (left) and not conforms (right, with crack in the middle of the elements)



nodes medium belong to the upper part of the interface when the interface passes by the latter. If any point of the frame has a null displacement it results from it that with nodes medium one has also the following relation:

$$DX_{NMILIEU} - 2\,HX_{NMILIEU} = 0 \qquad DY_{NMILIEU} - 2\,HY_{NMILIEU} = 0$$

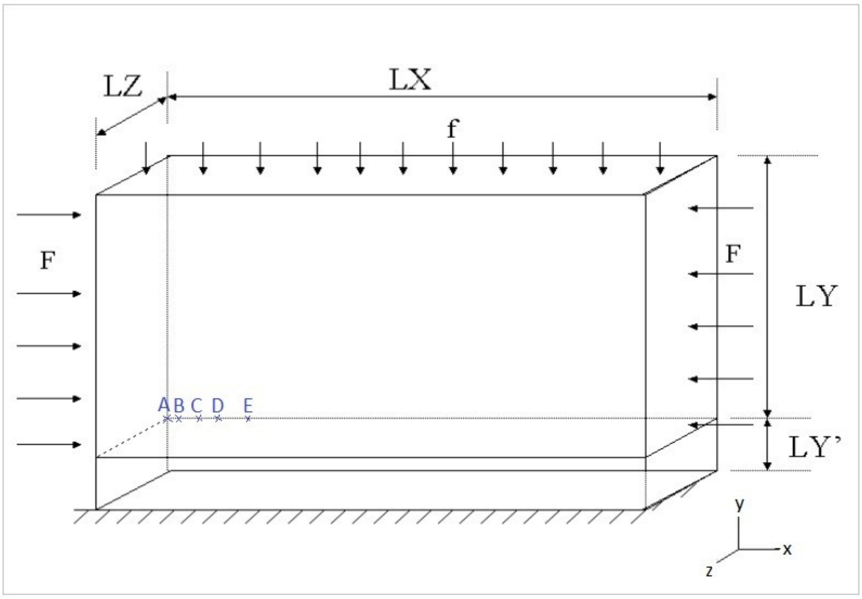
The plate is subjected to two pressures distributed:

- a vertical pressure acting on the face of the top: $f = -5\ daN/mm^2$,
- a horizontal pressure acting on the side faces, for $y > 0$, $F = \pm 15\,daN/mm^2$ (according to the principle of compression)

9 Problem of reference in 3D

9.1 Geometry

One takes into account two geometries:
The first is obtained by extrusion of the geometry of the problem $2D$: the structure is then one right-angled parallelepiped.



Dimensions of the upper part to which the pressures are applied, are fixed:
$LX = 80\text{mm}$, $LY = 40\,mm$ and $LZ = 1\text{mm}$

The comparable lower part with a frame, has following dimensions:
$LX = 80\text{mm}$, $LY' = 10\,mm$ and $LZ = 1\text{mm}$

The position of the points of reference under the surface of contact (mm) is:

	x	y	z
A	0	0	0
B	1.25	0	0
C	5.	0	0
D	7.5	0	0
E	11.25	0	0

9.2 Material properties

Plate and built:

Poisson's ratio: 0.2
Young modulus: $1.3\,10^{11}\,N/m^2$

The coefficient of friction under the plan is $\mu = 1.0$.

9.3 Boundary conditions and loadings

The rigid frame, of the same width than the plate, is blocked entirely by an embedding. DDL of displacement of nodes frame according to X and Y are put at 0:

$$DX_{NBATI}=0 \text{ , } DY_{NBATI}=0 \text{ and } DZ_{NBATI}=0$$

Additional equations are written on the DDL of the nodes of the elements cut by the crack, so that displacement is null everywhere on the lower part of these elements corresponding to the frame. Very concretely the relations kinematics which impose that in any point built under the interface displacement is quite null are the following ones:

$$DX_{NPLAQUE}-2HX_{NPLAQUE}=0 \text{ , } DY_{NPLAQUE}-2HY_{NPLAQUE}=0 \text{ and } DZ_{NPLAQUE}-2HZ_{NPLAQUE}=0$$

Groups of nodes who carry additional equations (nodes medium for example) are identical to those of the case 2D explained in §1.3.

The plate is subjected to two pressures distributed:

- a vertical pressure acting on the face of the top: $f=-5\ daN/mm^2$,
- horizontal acting on the side faces, for $y>0$, $F=\pm 15\,daN/mm^2$ (according to the principle of compression).

10 Reference solution

10.1 Method of calculating used for the reference solution

The reference solution comes from the results got by modeling A ($2D$) and F ($3D$), namely a modeling D_PLAN in $2D$ and 3D in $3D$ under the keyword FORMULATION= ' CONTINUE' of the operator DEFI_CONTACT.

10.2 Results of reference

Tangential displacements (according to X) at the points $A\,B\,C\,D\,E$ surface of contact.
Normal reaction at the point medium.

11 Modeling A

11.1 Characteristics of modeling

Modeling: D_PLAN to test the operand 'CONTINUES' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG2 .

The plate and the frame are with a grid with elements QUAD4.

11.2 Characteristics of the grid

Many nodes: 975
Many meshs and types: 832 QUAD4 for the plate and the frame.

11.3 Sizes tested and results

Identification	***Aster***
RN at the point medium	1.04864 E+5
DX at the point A	2.84595 E-5
DX at the point B	2.70793 E-5
DX at the point C	2.27403 E-5
DX at the point D	1.97271 E-5
DX at the point E	1.53641 E-5

11.4 Notice

These results are used as reference for four modelings which follow.

12 Modeling B

12.1 Characteristics of modeling

Modeling: D_PLAN to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG2 .

The structure is a healthy rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\,mm$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located at the interface of the elements.

The plate and the frame are with a grid with elements QUAD4 64×25 .

Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\,mm$
Frame:
$LX=80\,mm$ and $LY'=10\,mm$

12.2 Characteristics of the grid

Many nodes: 1690
Many meshs and types: 1600 QUAD4 for the plate and the frame and 178 SEG2 for the edges.

12.3 Sizes tested and results

Identification	Reference	Tolerance (%)
RN at the point medium	1.04864 E+5	0.1
DX at the point A	2.84595 E-5	2.0
DX at the point B	2.70793 E-5	2.0
DX at the point C	2.27403 E-5	2.0
DX at the point D	1.97271 E-5	2.0
DX at the point E	1.53641 E-5	2.0

13 Modeling C

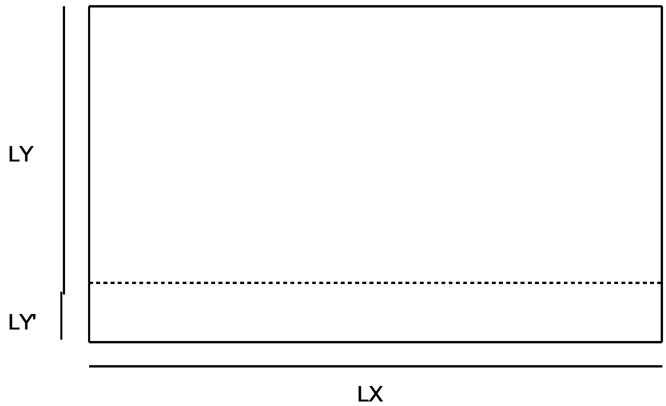
13.1 Characteristics of modeling

Modeling: D_PLAN to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG2 .

The structure is a healthy rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\,mm$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located in the middle of the elements.

The rigid condition of frame is introduced in a definite way in the paragraph §1.3.



Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\,mm$
Frame:
$LX=80\,mm$ and $LY'=\frac{3}{325}mm$

13.2 Characteristics of the grid

Many nodes: 1625
Many meshs and types: 1536 QUAD4 for the plate and the frame and 176 SEG2 for the edges.

13.3 Sizes tested and results

Identification	Reference	Tolerance (%)
DX at the point A	2.84595 E-5	2.0
DX at the point B	2.70793 E-5	2.0
DX at the point C	2.27403 E-5	2.0
DX at the point D	1.97271 E-5	2.0
DX at the point E	1.53641 E-5	2.0

14 Modeling D

14.1 Characteristics of modeling

Modeling: D_PLAN to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG2 .

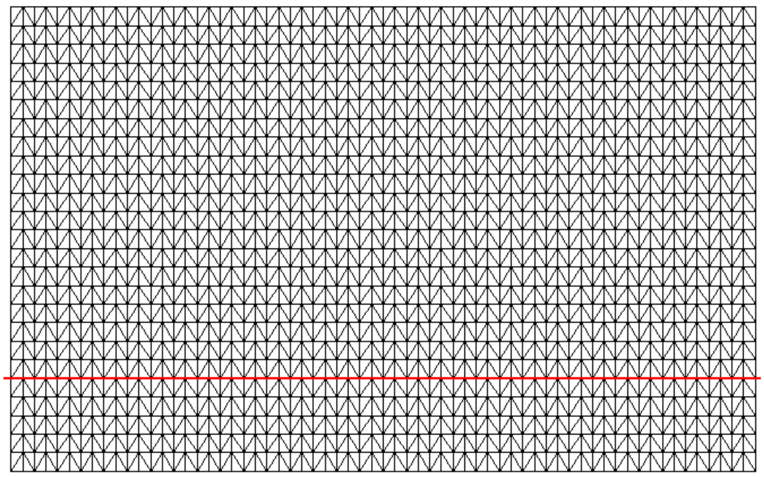
The structure is a rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\mathrm{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located at the interface of the elements.

Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\mathrm{mm}$
Frame:
$LX=80\,mm$ and $LY'=10\mathrm{mm}$

14.2 Characteristics of the grid

Many nodes: 1690
Many meshs and types: 3200 TRIA3 for the plate and the frame and 178 SEG2 for the edges.



14.3 Sizes tested and results

Identification	Reference	Tolerance (%)
RN at the point medium	1.04864 E+5	10.0
DX at the point A	2.84595 E-5	1.0
DX at the point B	2.70793 E-5	1.0
DX at the point C	2.27403 E-5	1.0
DX at the point D	1.97271 E-5	1.0
DX at the point E	1.53641 E-5	1.0

14.4 Remarks

In this case of the oscillations of the coefficient of Lagrange for the pressure appear. The point on which reaction RN is compared with the reference is a “low” point in the oscillation. The close points have an error of approximately $+8\%$.
Let us note that one can check by decreasing the step of the grid that the condition LBB is respected: the oscillations decrease in amplitude.

15 Modeling E

15.1 Characteristics of modeling

Modeling: D_PLAN to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG2 .

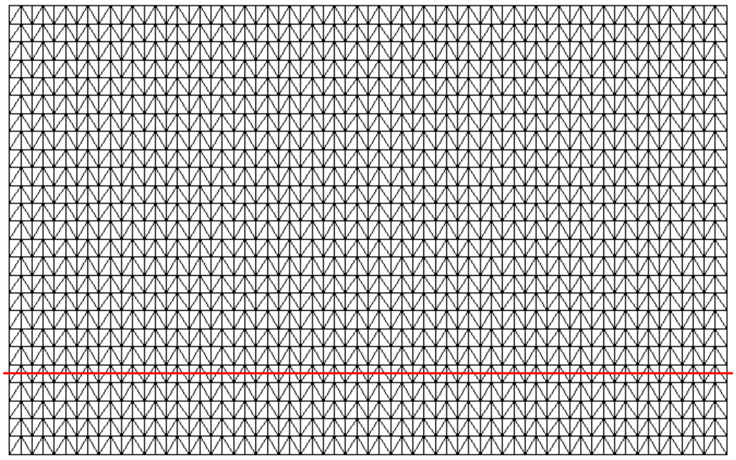
The structure is a healthy rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\text{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located in the middle of the elements.

Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\text{mm}$
Frame:
$LX=80\,mm$ and $LY'=\frac{3}{325}mm$

15.2 Characteristics of the grid

Many nodes: 1625
Many meshs and types: 3072 TRIA3 for the plate and the frame and 176 SEG2 for the edges.



15.3 Sizes tested and results

In this test, the contact is validated XFEM for a crack non-coïncidente with the grid.

Identification	Reference	Tolerance (%)
RN at the point medium	1.04864 E+5	5.0
DX at the point A	2.84595 E-5	1.0
DX at the point B	2.70793 E-5	1.0
DX at the point C	2.27403 E-5	1.0
DX at the point D	1.97271 E-5	1.0
DX at the point E	1.53641 E-5	1.0

16 Modeling F

16.1 Characteristics of modeling

Modeling: 3D to test the operand 'CONTINUES' keyword FORMULATION under the operator DEFI_CONTACT for elements HEXA8 .

The geometry, the boundary conditions and the loadings are those of the problem of reference $3D$ described paragraph §9 'Problem of reference in $3D$ '.

The plate and the frame are with a grid with elements HEXA8.

The blocking of the movements of rigid body is done by blocking displacement along the axis Z, that is to say DZ for the 4 nodes with the corners of the higher face. It is necessary to block these modes for the first iteration of contact, during which friction is not activated. Then, friction prevents these movements.

This case is used as reference for the cases $3D$ Following XFEM.

16.2 Characteristics of the grid

Many nodes: 1950
Many meshs and types: 832 HEXA8 for the plate and the frame.
1108 QUAD4 for the elements of edge.

16.3 Sizes tested and results

Identification	Aster
DX at the point A	3.06970 E-5
DX at the point B	2.92588 E-5
DX at the point C	2.47360 E-5
DX at the point D	2.15871 E-5
DX at the point E	1.70045 E-5

16.4 Remarks

For calculations in $3D$, boundary conditions $DZ=0$ (to bring back itself to a problem $2D$) are not respected to avoid a too important memory allocation. One imposes a minimum of it to block the movements of rigid body.

These results are used as references for two following modelings.

17 Modeling G

17.1 Characteristics of modeling

Modeling: `3D` to test the operand `'XFEM'` keyword `FORMULATION` under the operator `DEFI_CONTACT` for elements `HEXA8` .

The geometry, the boundary conditions and the loadings are those of the problem of reference $3D$ described paragraph §9 'Problem of reference in $3D$ '.

17.2 Geometry

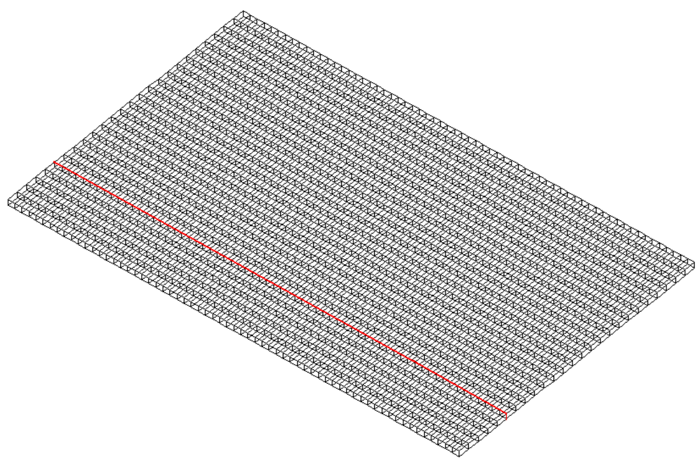
The structure is a healthy parallelepiped, into which a crack will be introduced directly into card-indexing it of order using the operator `DEFI_FISS_XFEM` [U4.82.08]. The crack is present at a distance $LY=40\text{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located at the interface of the elements.

Dimensions are the following ones:
Plate:
$LX=80\text{mm}$, $LY=40\text{mm}$ and $LZ=1\text{mm}$
Frame:
$LX=80\text{mm}$, $LY'=10\text{mm}$ and $LZ=1\text{mm}$

17.3 Characteristics of the grid

Many nodes: 3380
Many meshs and types: 1600 `HEXA8` for the plate and the frame and
1778 `QUAD4` for the faces of edges .



17.4 Sizes tested and results

In this test, the contact is validated `XFEM` for a crack coïncidente with the grid in $3D$.

Identification	Reference	Tolerance (%)

DX at the point A	3.06970 E-5	1.0
DX at the point B	2.92588 E-5	1.0
DX at the point C	2.47360 E-5	1.0
DX at the point D	2.15872 E-5	1.0
DX at the point E	1.70046 E-5	1.0

18 Modeling H

18.1 Characteristics of modeling

Modeling: `3D` to test the operand `'XFEM'` keyword `FORMULATION` under the operator `DEFI_CONTACT` for elements `HEXA8` .

The geometry, the boundary conditions and the loadings are those of the problem of reference $3D$ described paragraph §11 'Problem of reference in $3D$ '.

18.2 Geometry

The structure is a healthy parallelepiped, into which a crack will be introduced directly into card-indexing it of order using the operator `DEFI_FISS_XFEM` [U4.82.08]. The crack is present at a distance $LY=40\text{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located in the middle of the elements.

Dimensions are the following ones:
Plate:
$LX=80\text{mm}$, $LY=40\text{mm}$ and $LZ=1\text{mm}$
Frame:
$LX=80\text{mm}$, $LY'=\frac{3}{325}mm$ and $LZ=1\text{mm}$

18.3 Characteristics of the grid

For this case, the grid was reduced in order to limit the computing time. Consequently, the nodes B and E are not any more in the grid and displacements in these points are not calculated.

Many nodes: 858
Many meshs and types: 384 `HEXA8` for the plate and the frame
472 `QUAD4` for the faces of edges

18.4 Sizes tested and results

Identification	Reference	Tolerance (%)
DX at the point A	3.06970 E-5	1.0
DX at the point C	2.47360 E-5	1.0
DX at the point D	2.15872 E-5	1.0

19 Modeling K

19.1 Characteristics of modeling

Modeling: D_PLAN_XFEM_CONT to test the operand 'XFEM' keyword FORMULATION of the operator DEFI_CONTACT for elements SEG2 .

The structure is a healthy rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\text{mm}$ higher edge of the plate.

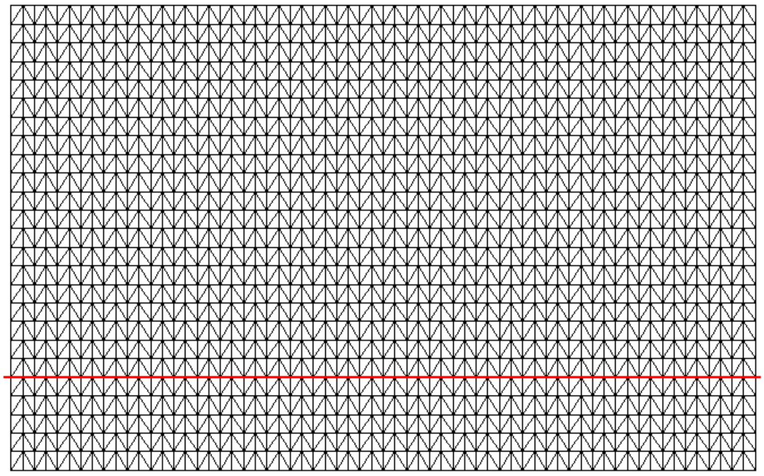
The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located at the interface of the elements.

The penalized method is used for the treatment of contact-friction.

Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\text{mm}$
Frame:
$LX=80\,mm$ and $LY=10\text{mm}$

19.2 Characteristics of the grid

Many nodes: 1690
Many meshs and types: 3200 TRIA3 for the plate and the frame and 178 SEG2 for the edges.



19.3 Sizes tested and results

Identification	Reference	Tolerance (%)
RN at the point medium	1.04864 E+5	10.0
DX at the point A	2.84595 E-5	1.0
DX at the point B	2.70793 E-5	1.0
DX at the point C	2.27403 E-5	1.0
DX at the point D	1.97271 E-5	1.0
DX at the point E	1.53641 E-5	1.0

20 Modeling L

20.1 Characteristics of modeling

Modeling: 3D to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements HEXA8 .

The geometry, the boundary conditions and the loadings are those of the problem of reference $3D$ described paragraph §9 'Problem of reference in $3D$ '.

The penalized method is used for the treatment of contact-friction.

20.2 Geometry

The structure is a healthy parallelepiped, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\mathrm{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located in the middle of the elements.

Dimensions are the following ones:
Plate:
$LX=80mm$, $LY=40mm$ and $LZ=1mm$
Frame:
$LX=80mm$, $LY'=\frac{1}{19}LY$ and $LZ=1mm$

20.3 Characteristics of the grid

For this case, the grid was reduced in order to limit the computing time. Consequently, nodes B and E are not any more in the grid and displacements in these points are not calculated.

Many nodes: 858
Many meshs and types: 384 HEXA8 for the plate and the frame
472 QUAD4 for the faces of edges

20.4 Sizes tested and results

Identification	Reference	Tolerance (%)
DX at the point A	3.06970 E-5	1.0
DX at the point C	2.47360 E-5	1.0
DX at the point D	2.15872 E-5	1.0

21 Modeling M

21.1 Characteristics of modeling

Modeling: D_PLAN_XFEM_CONT to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG3 .

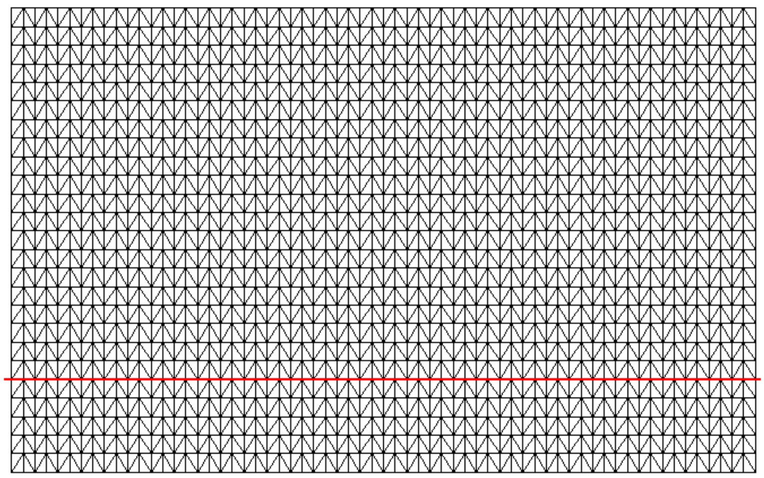
The structure is a healthy rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\text{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located at the interface of the elements.

Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\text{mm}$
Frame:
$LX=80\,mm$ and $LY'=10\text{mm}$

21.2 Characteristics of the grid

Many nodes: 1690
Many meshs and types: 3200 TRIA6 for the plate and the frame and 178 SEG3 for the edges.



21.3 Sizes tested and results

Identification	Reference	Tolerance (%)
DX at the point A	2.8617 E-5	1.0
DX at the point B	2.7229 E-5	1.0
DX at the point C	2.2855 E-5	1.0
DX at the point D	1.9805 E-5	1.0
DX at the point E	1.5411 E-5	1.0

The values of reference result from modeling A (FEM).

22 Modeling NR

22.1 Characteristics of modeling

Modeling: D_PLAN_XFEM_CONT to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT for elements SEG3. It is also used to validate the keyword 'CAR'for ALGO_LAGR in DEFI_CONTACT.

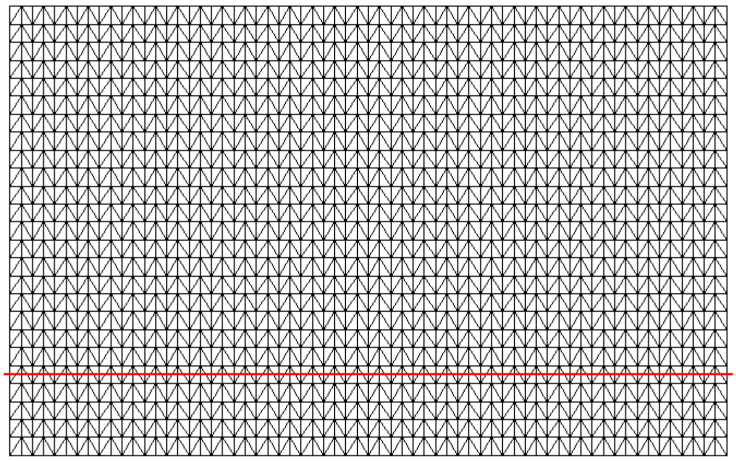
The structure is a healthy rectangle, into which a crack will be introduced directly into card-indexing it of order using the operator DEFI_FISS_XFEM [U4.82.08]. The crack is present at a distance $LY=40\text{mm}$ higher edge of the plate.

The bottom of crack is located apart from the structure, which allows a total separation. This modeling is such as the crack is located in the middle of the elements.

Dimensions are the following ones:
Plate:
$LX=80\,mm$ and $LY=40\text{mm}$
Frame:
$LX=80\,mm$ and $LY'=\frac{3}{325}mm$

22.2 Characteristics of the grid

Many nodes: 1625
Many meshs and types: 3072 TRIA6 for the plate and the frame and 176 SEG3 for the edges.



22.3 Sizes tested and results

Identification	Reference	Tolerance (%)
DX at the point A	2.8617 E-5	1.0
DX at the point B	2.7229 E-5	1.0
DX at the point C	2.2855 E-5	1.0
DX at the point D	1.9805 E-5	1.0
DX at the point E	1.5411 E-5	1.0

The values of reference result from modeling A (FEM).

23 Modeling R

23.1 Characteristics of modeling

We take again characteristics identical to modeling H, put except for the grid which is quadratic. The objective is thus to test the operand ' XFEM ' keyword FORMULATION under the operator DEFI_CONTACT , with friction (FROTTEMENT=' COULOMB') for a modeling 3D, but with a discretization P2P1 (CONTACT=' P2P1' informed in MODI_MODELE_XFEM), which differentiates this modeling from modeling H.
For recall, the geometry, the boundary conditions and the loadings are those definite paragraph §2.1, corresponding to the problem of reference 3D described paragraph §2 'Problem of reference in 3D '.

23.2 Characteristics of the grid

The grid is that of the modeling H which one made quadratic. As for modeling H, Nœuds B and E are not any more in the grid and displacements in these points are not calculated.

23.3 Sizes tested and results

One tests the results with the references of modeling F. the error is of a few percent (1% max) taking into account the difference in interpolation of the displacement, which is quadratic for this modeling and linear for the reference.

Identification	Reference	Tolerance (%)
DX at the point A	-2.3713E-05	1.0
DX at the point C	-1.8445E-05	1.0
DX at the point D	-1.568E-05	1.0

24 Modeling S

24.1 Characteristics of modeling

We take again characteristics identical to modeling R, but by dealing with the problem in great slips. To recapitulate, the objective is thus to test the operand 'XFEM' keyword FORMULATION under the operator DEFI_CONTACT, with friction (FROTTEMENT=' COULOMB') for a modeling 3D, with a discretization P2P1 (CONTACT=' P2P1'well informed in MODI_MODELE_XFEM), but in great slips (REAC_GEOM=' CONTRÔLE' informed in DEFI_CONTACT) what differentiates this modeling from modeling R.
For recall, the geometry, the boundary conditions and the loadings are those definite paragraph §2.1, corresponding to the problem of reference 3D described paragraph §2 'Problem of reference in 3D'.

24.2 Characteristics of the grid

The grid is that of the modeling H which one made quadratic. As for modeling H, Nœuds B and E are not any more in the grid and displacements in these points are not calculated.

24.3 Sizes tested and results

One tests the results with the references of modeling F. the error is of a few percent (3% max) taking into account the difference in interpolation of the displacement, which is quadratic for this modeling and linear for the reference.

Identification	Reference	Tolerance (%)
DX at the point A	-2.3713E-05	2.0
DX at the point C	-1.8445E-05	3.0
DX at the point D	-1.568E-05	3.0

25 Summary of the results

The case test ssnv209 makes it possible to observe the three states of the conditions of contact, namely separation, the slipping contact and the adhering contact. It puts also concerned modelings $2D$ and $3D$ with elements of various natures (quadrangles, triangles, parallelepipeds) within the framework of X-FEM.

This case test makes it possible to highlight satisfactory results for modelings $2D$ and $3D$, in particular the satisfaction of the condition LBB for the modeling of contact-rubbing with X-FEM.

The goals of this test are achieved:

1) with a relative error compared to the reference solution of less 1% for displacements,
2) whether the crack is in the middle of an element or with the interface,
3) that modeling is in $2D$ or in $3D$,
4) that the formulation places the unknown factors of contact at the edges of the elements or the nodes,
5) with several diagram of integration for the terms of contact `(NODE, SIMPSON, NCOTES)`,
6) by using the coefficients (friction and pressure) of the generalized formulation `(COEF_REGU_CONT, COEF_STAB_CONT, COEF_REGU_FROT, COEF_STAB_FROT)`,
7) by using the methods of Lagrangian increased and penalization for the treatment of contact-friction.