SSNV203 – The purpose of application of a pressure on the lips of a crack with X-FEM

Summarized

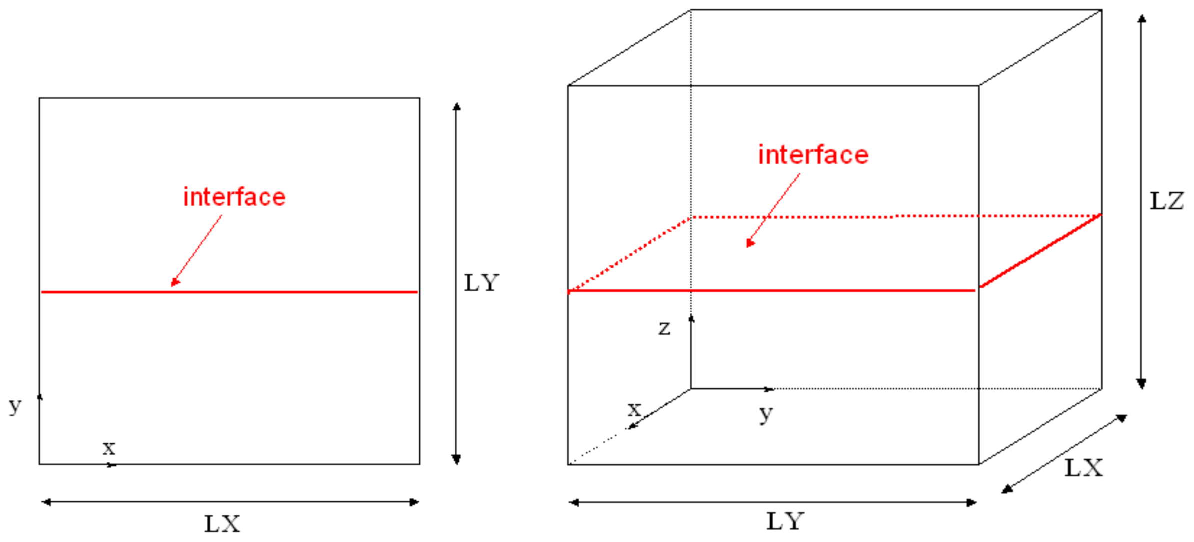
This test is validating the imposition of conditions of Neumann (flux conditions) on lips of a crack by the method X-FEM [bib1] on an academic case 2D/3D. In fact, one considers only the case of an interface, the case of a crack is considered in the cases tests `ssnv185a` and `ssnv185c`.

This test brings into play a structure 2D then 3D comprising a plane interface. Boundary conditions in pressure are applied to this interface.

1 Problem of reference

1.1 Geometry

the structure 2D is a unit square ($LX=1\,m$, $LY=1\,m$), cut into two by a right interface located at middle height. [Appear 1.1-a on the left]. The structure 3D is a unit cube ($LX=1\,m$, $LY=1\,m$ and $LZ=1\,m$), cut into two by a straight lines interface located in the plane $z=LZ/2$ [Appear 1.1-a on the right].



Appear 1.1-a : geometries of the square (on the left), the cube (on the right)

1.2 Properties of the material

Modulus Young: $E=10000\ MPa$
Poisson's ratio: $\nu=0$

1.3 Boundary conditions and loadings

a loading in pressure constant $p=10000\ Pa$ is applied to the interface (of the two with dimensions ones of the interface).
Displacements of the nodes of the sides higher and lower are blocked according to all the directions.

1.4 Analytical solutions

For the loading with constant pressure, all occurs as if there were two plates on both sides of the interface in uniform compression. The solution is thus analytical.

Displacement right with the top of the level set is worth $v^{+}=+\frac{p}{E}\frac{LY}{2}$ in 2D and $v^{+}=+\frac{p}{E}\frac{LZ}{2}$ 3D.

Displacement right below the level set is worth $v^{-}=-\frac{p}{E}\frac{LY}{2}$ in 2D and $v^{+}=-\frac{p}{E}\frac{LZ}{2}$ 3D.

2 Modelization a: in dimension 2

In this modelization, one considers structure in 2d.

2.1 Characteristics of the mesh

the structure is modelled by a regular mesh composed of 5×5 QUAD4, respectively along the axes x, y [Figure 2.1 -2.1-a]. The interface passes in the middle of the elements.

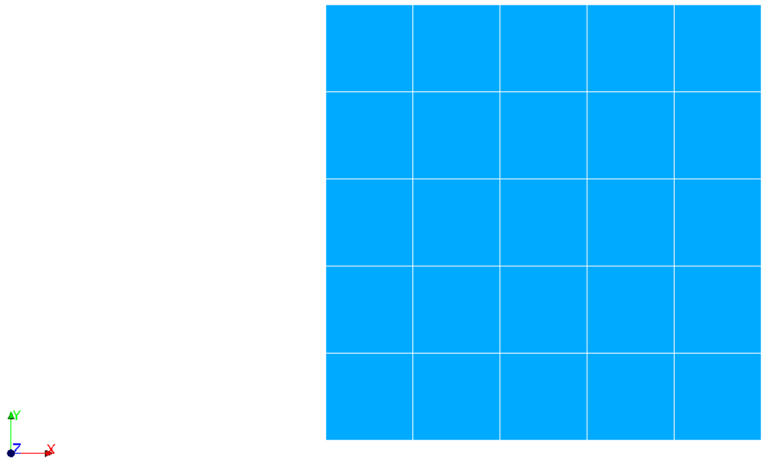


Figure 2.1 -2.1-a : mesh 2d

2.2 Fonctionnalités tested

One tests the application of conditions of Neumann via commands AFFE_CHAR_MECA and AFFE_CHAR_MECA_F on an interface nonwith a grid with X-FEM.

This imposition is made the key word by means of FISSURES operand PRES_REP, because the interface is not a mesh group of edge.

One tests the application of a constant pressure using a reality then using a function of space such as $p=y\times20000\,Pa$ (the crack is in $y=0.5$ what amounts applying a constant load).

2.3 Quantities tested and results

One tests the values of displacement after convergence of the iterations of operator STAT_NON_LINE.

Identification	Reference
DX for all the nodes right below interface	0.00
DY for all the nodes right below the interface	-5,00E-7
DX for all the nodes right to the top of interface	0.00
DY for all the nodes right to the top of the interface	5,00E-7

to test all the nodes in only once, one tests the minimum and the maximum of column.

3 Modelization b: in dimension 3

In this modelization, one considers structure in 3D.

3.1 Characteristics of the mesh

the structure is modelled by a regular mesh composed of $2 \times 5 \times 5$ HEXA8, respectively along the axes x, y, z [Figure 3.1 -3.1-a]. The interface passes in the middle of the elements.

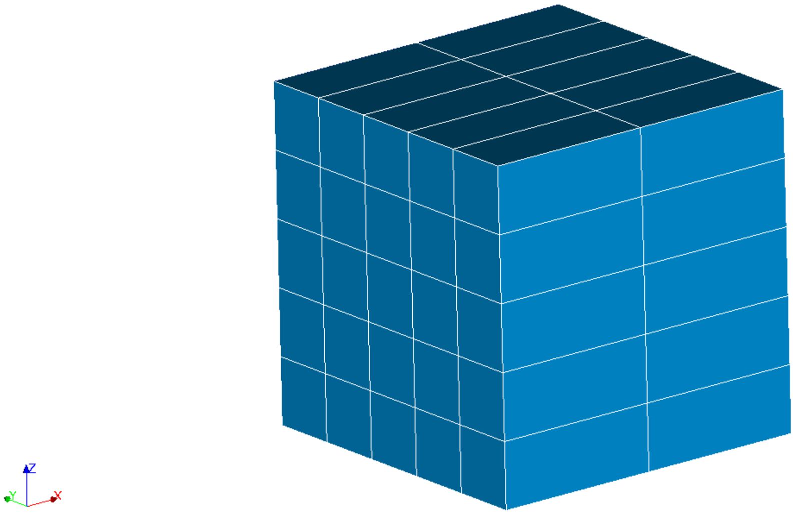


Figure 3.1 -3.1-a : mesh 3D

3.2 Features tested

One tests the application of conditions of Neumann via commands AFFE_CHAR_MECA and AFFE_CHAR_MECA_F on an interface nonwith a grid with X-FEM.

This imposition is made the key word by means of FISSURES operand PRES_REP, because the interface is not a mesh group of edge.

One tests the application of a constant pressure using a reality then using a function of space such as $p = y \times 20000\, Pa$ (the crack is in $y = 0.5$ what amounts applying a constant load).

3.3 Quantities tested and results

One tests the values of displacement after convergence of the iterations of operator STAT_NON_LINE.

Identification	Reference
DZ for all the nodes right below the interface	-5,00E-7
DZ for all the nodes right to the top of the interface	5,00E-7

to test all the nodes in only once, one tests the minimum and the maximum of column.

4 Modelization C: in dimension 2

In this modelization, one considers structure in 2d with a grid with quadratic elements.

4.1 Characteristics of the mesh

the structure is modelled by a regular mesh composed of 5×5 QUAD8, respectively along the axes x, y [Figure 2.1 -2.1-a]. The interface passes in the middle of the elements.

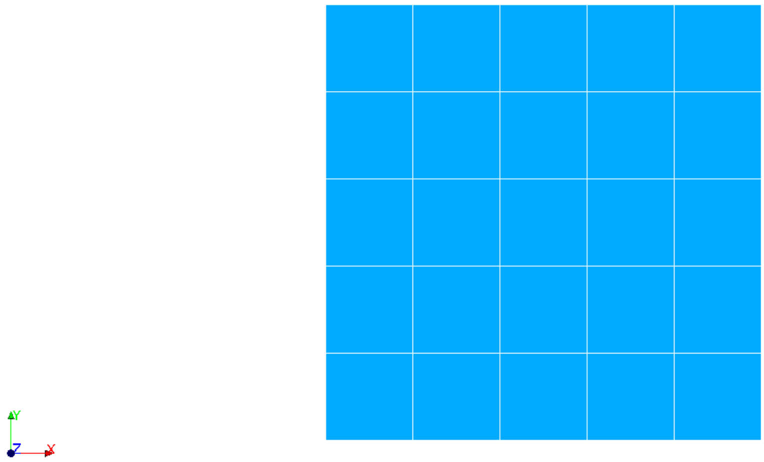


Figure 2.1 -4.1-a : mesh 2d

4.2 Fonctionnalités tested

One tests the application of conditions of Neumann via commands AFFE_CHAR_MECA and AFFE_CHAR_MECA_F on an interface nonwith a grid with X-FEM.

This imposition is made the key word by means of FISSURES operand PRES_REP, because the interface is not a mesh group of edge.

One tests the application of a constant pressure using a reality then using a function of space such as $p=y\times20000\,Pa$ (the crack is in $y=0.5$ what amounts applying a constant load).

4.3 Quantities tested and results

One tests the values of displacement after convergence of the iterations of operator STAT_NON_LINE.

Identification	Reference
DX for all the nodes right below interface	0.00
DY for all the nodes right below the interface	-5,00E-7
DX for all the nodes right to the top of interface	0.00
DY for all the nodes right to the top of the interface	5,00E-7

to test all the nodes in only once, one tests the minimum and the maximum of column.

5 Modelization D: in dimension 3

In this modelization, one considers structure in 3D with a grid with quadratic elements.

5.1 Characteristics of the mesh

the structure is modelled by a regular mesh composed of $2\times5\times5$ HEXA20, respectively along the axes x, y, z [Figure 3.1 -3.1-a]. The interface passes in the middle of the elements.

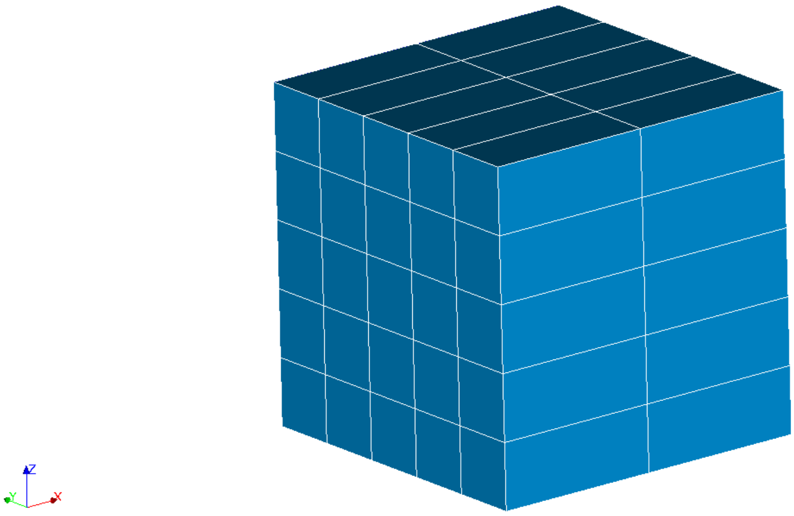


Figure 3.1 -5.1-a : mesh 3D

5.2 Features tested

One tests the application of conditions of Neumann via commands AFFE_CHAR_MECA and AFFE_CHAR_MECA_F on an interface nonwith a grid with X-FEM.

This imposition is made the key word by means of FISSURES operand PRES_REP, because the interface is not a mesh group of edge.

One tests the application of a constant pressure using a reality then using a function of space such as $p=y\times20000\,Pa$ (the crack is in $y=0.5$ what amounts applying a constant load).

5.3 Quantities tested and results

One tests the values of displacement after convergence of the iterations of operator STAT_NON_LINE.

Identification	Reference
DZ for all the nodes right below the interface	-5,00E-7
DZ for all the nodes right to the top of the interface	5,00E-7

to test all the nodes in only once, one tests the minimum and the maximum of column.

6 Conclusion

This test validates the imposition of a pressure on the lips of a crack in the frame X-FEM. The pressure can be constant or function of space and time and structure can be with a grid with linear or quadratic elements.

This test does not validate the taking into account of the narrower term of pressure for postprocessing in fracture mechanics (computation of rate of energy restitution). A case test makes it possible to validate this functionality (`ssnv185c`).