SSNV203 – Application of a pressure on the lips of a crack with X-FEM

Summary

The purpose of this test is to validate the imposition of conditions of Neumann (conditions of flow) on lips of a crack by 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 ($LX=1\,m$, $LY=1\,m$), crossed into two by a right interface located at middle height. [Figure 1.1-a on the left]. The structure 3D is a unit cube ($LX=1\,m$, $LY=1\,m$ and $LZ=1\,m$), crossed into two by a right interface located in the plan $z=LZ/2$ [Figure 1.1-a on the right].

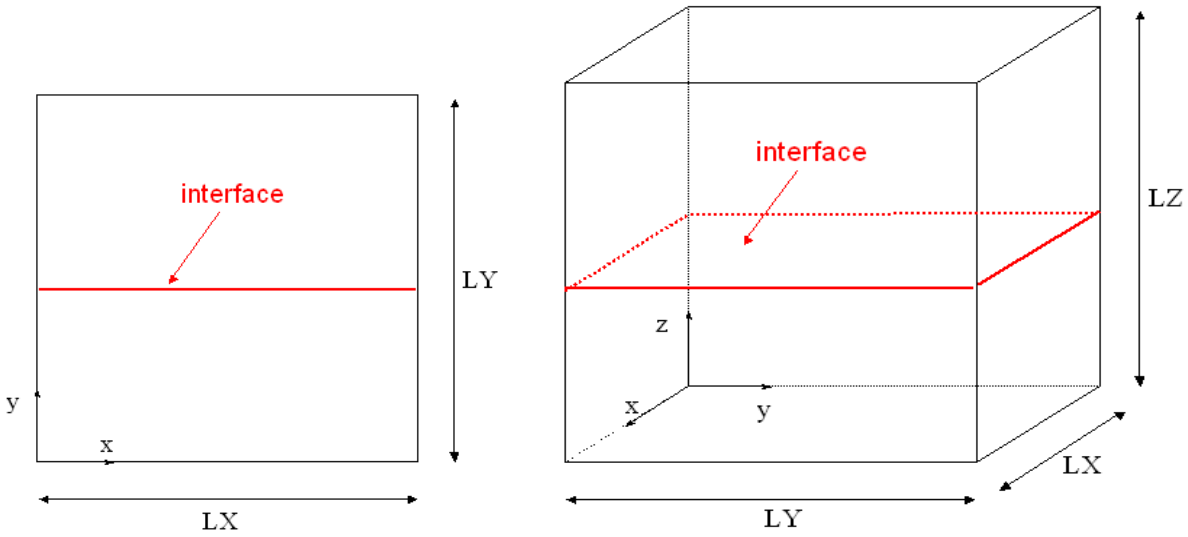

Figure 1.1-a : geometries of the square (on the left), the cube (on the right)

1.2 Properties of material

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

1.3 Boundary conditions and loadings

A loading in constant pressure $p=10000\,Pa$ is applied to the interface (of the two with dimensions ones of the interface).
Displacements of the nodes of the faces 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 $v^{+}=+\frac{p}{E}\frac{LZ}{2}$ in 3D.

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

2 Modeling a: in dimension 2

In this modeling, the structure in 2d is considered.

2.1 Characteristics of the grid

The structure is modelled by a regular grid 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.

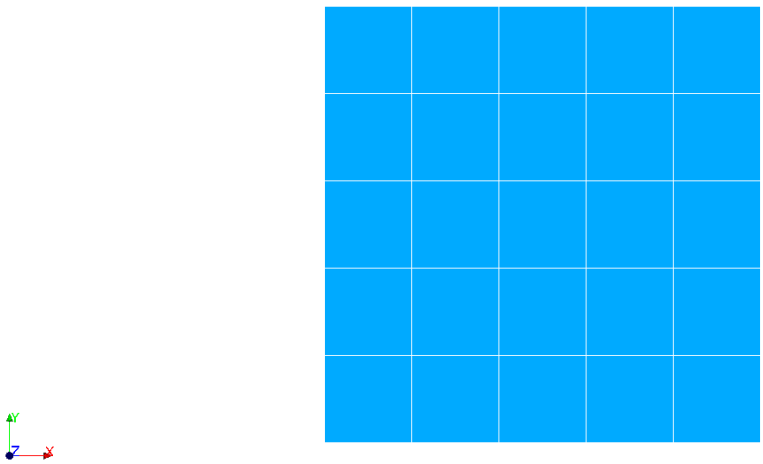

Figure 2.1 -2.1-a : grid 2d

2.2 Features tested

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

This imposition is done by using the keyword CRACK operand PRES_REP, because the interface is not a group of meshs 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).

2.3 Sizes tested and results

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

Identification	Reference
DX for all the nodes just below the interface	0.00
DY for all the nodes just below the interface	-5,00E-7
DX for all the nodes just with the top of the interface	0.00
DY for all the nodes just with 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 Modeling b: in dimension 3

In this modeling, the structure in 3D is considered.

3.1 Characteristics of the grid

The structure is modelled by a regular grid composed of $2\times5\times5$ HEXA8, respectively along the axes x, y, z [Figure 3.1 -3.1-a]. The interface passes in the middle of the elements.

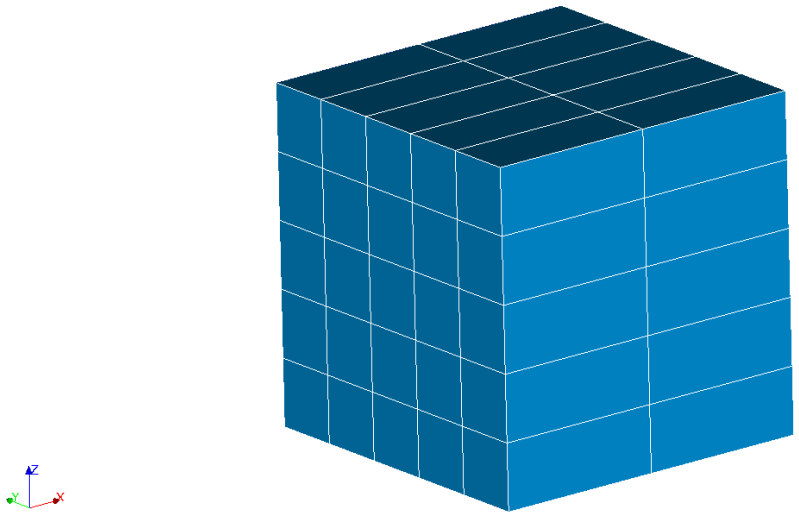

Figure 3.1 -3.1-a : grid 3D

3.2 Features tested

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

This imposition is done by using the keyword CRACK operand PRES_REP, because the interface is not a group of meshs 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).

3.3 Sizes tested and results

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

Identification	Reference
DZ for all the nodes just below the interface	-5,00E-7
DZ for all the nodes just with 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 Modeling C: in dimension 2

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

4.1 Characteristics of the grid

The structure is modelled by a regular grid 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.

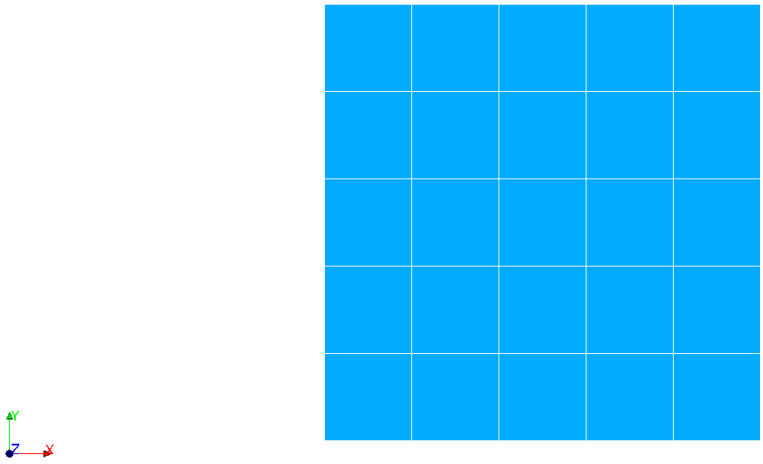

Figure 2.1 -4.1-a : grid 2d

4.2 Features tested

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

This imposition is done by using the keyword CRACK operand PRES_REP, because the interface is not a group of meshs 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 Sizes tested and results

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

Identification	Reference
DX for all the nodes just below the interface	0.00
DY for all the nodes just below the interface	-5,00E-7
DX for all the nodes just with the top of the interface	0.00
DY for all the nodes just with 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 Modeling D: in dimension 3

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

5.1 Characteristics of the grid

The structure is modelled by a regular grid 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.

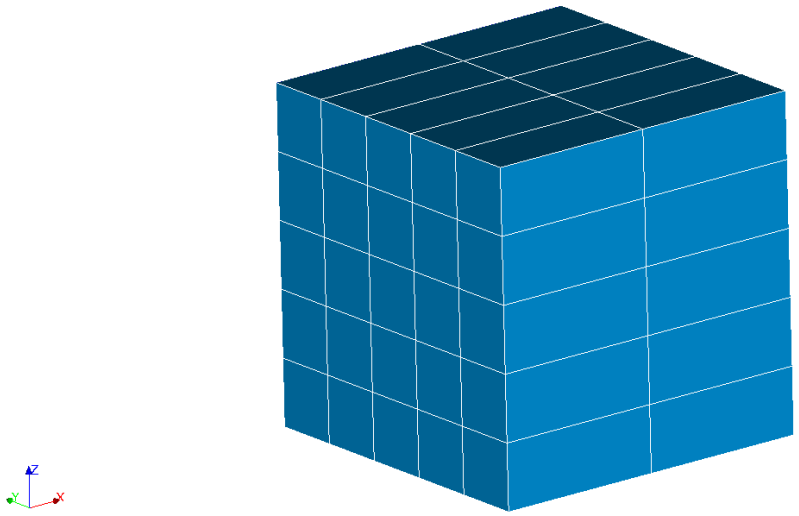

Figure 3.1 -5.1-a : grid 3D

5.2 Features tested

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

This imposition is done by using the keyword CRACK operand PRES_REP, because the interface is not a group of meshs 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 Sizes tested and results

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

Identification	Reference
DZ for all the nodes just below the interface	-5,00E-7
DZ for all the nodes just with 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 within framework X-FEM. The pressure can be constant or function of space and time and the 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 breaking process (calculation of the rate of refund of energy). A case test makes it possible to validate this functionality (ssnv185c).