SSNV198 – Conditions of Dirichlet with X-FEM in 3D

Summary

The purpose of this test is to validate the imposition of conditions of Dirichlet (imposed displacements) on nodes nouveau riches by method X-FEM [bib1] on an academic case 3D.

This test brings into play a structure 3D comprising an emerging crack plane at right bottom. Boundary conditions are applied to a face of the structure, container of the nodes nouveau riches.

Several configurations of grid are tested and compared with the analytical solution.

1 Problem of reference

1.1 Geometry

The structure is a unit cube ($LX=1\,m$, $LY=1\,m$ and $LZ=1\,m$), comprising an emerging plane crack length $a=0,5\,m$, being located at middle height [Figure 1.1 -1.1-a]. One calls face from behind the face located in the plan $x=0$ and that of front the face located in the plan $x=LX$.

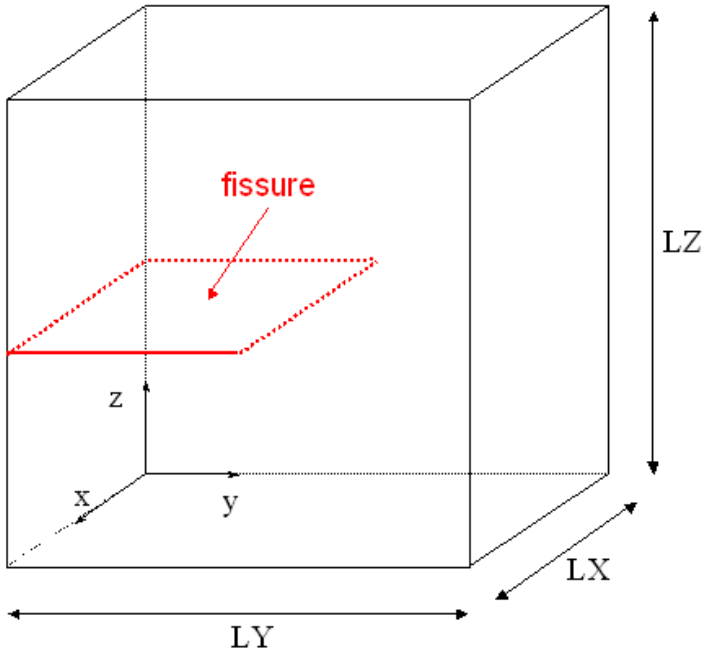

Figure 1.1 -1.1-a : geometry of the fissured cube

1.2 Properties of material

Young modulus: $E=100\,MPa$
Poisson's ratio: $\nu=0$.

1.3 Boundary conditions and loadings

The studied loading is a loading which requests the crack in mode III (out-plan), without creating discontinuity of displacement.

For that one imposes an embedding of the nodes of the face from behind: $DX=DY=DZ=0$ and a displacement of the nodes of the face of front following the normal direction (i.e along the axis x) $DNOR=10\ 6\,m$.

1.4 Bibliography

1. GENIAUT S., MASSIN P.: eXtended Finite Method Element, Handbook of reference of *Code_Aster*, [R7.02.12]

2 Modeling A

In this modeling, the crack is not with a grid, and the grid is selected so that the bottom of crack is in center of the elements containing the bottom.

2.1 Characteristics of the grid

The structure is modelled by a regular grid composed of $5\times5\times5$ HEXA8, respectively along the axes x, y, z [Figure 2.1 -2.1-a]. The bottom of crack is thus at the center of the elements containing the bottom of crack.

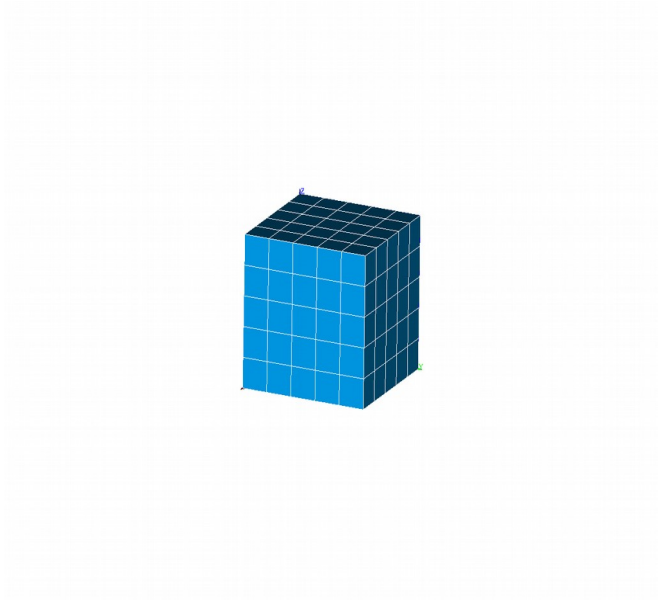

Figure 2.1 -2.1-a : grid such as the bottom is at the center of the elements

2.2 Features tested

One tests the application of conditions of Dirichlet via the order AFFE_CHAR_MECA on nodes nouveau riches (here, nodes nouveau riches by the Heaviside function and other nodes nouveau riches by the asymptotic functions). This imposition is done as for the classical nodes by the keyword DDL_IMPO or FACE_IMPO.

2.3 Sizes tested and results

One tests the values of displacements of the nodes to which the conditions were applied. The postprocessing of displacement with X-FEM requires a specific stage of reconstruction, which does not preserve the groups of nodes. It is thus necessary to recreate groups of nodes on the grid "fissured" post-treaty. Attention should be paid to keep only the old nodes, and to eliminate from the group the new nodes, i.e. those which coincide with the intersection of the crack and the edges of the healthy grid. This sorting is carried out thanks to the name of the nodes:

- $N\ldots$ for the classical nodes,
- $NX\ldots$ for nodes X-FEM which are not on the crack,
- $NM\ldots$ and $NP\ldots$ For the new nodes X-FEM which are on the lip "less" and the lip "more".

One thus eliminates the nodes whose name starts with NM and NP.

To test all the nodes of the group in only once, one tests the values minimum and maximum.

Identification	*Aster*	Reference	% difference

Face from behind: MAX (DX)	0.0	0.0	0.0
Face from behind: MIN (DX)	0.0	0.0	0.0
Face from behind: MAX (DY)	0.0	0.0	0.0
Face from behind: MIN (DY)	0.0	0.0	0.0
Face from behind: MAX (DZ)	0.0	0.0	0.0
Face from behind: MIN (DZ)	0.0	0.0	0.0
Face of front: MAX (DX)	10^{-6}	10^{-6}	0.0
Face of front: MIN (DX)	10^{-6}	10^{-6}	0.0

3 Modeling B

In this modeling, the crack is not with a grid, and the grid is selected so that the bottom of crack coincides with a node of the grid.

3.1 Characteristics of the grid

The structure is modelled by a regular grid composed of $6 \times 6 \times 6$ HEXA8, respectively along the axes x, y, z [Figure 3.1 -3.1-a]. The bottom of crack is thus at the center of the elements containing the bottom of crack. Moreover, the crack coincides with the edges of the elements.

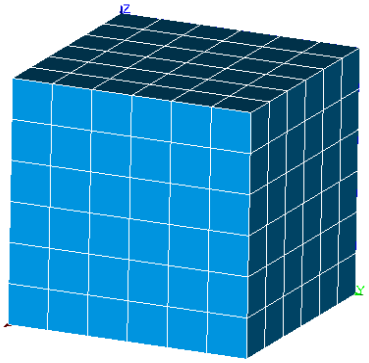

Figure 3.1 -3.1-a : grid such as the bottom coincides with a node

3.2 Features tested

One tests the application of conditions of Dirichlet via the order AFFE_CHAR_MECA on nodes nouveau riches (here, nodes nouveau riches doubly: by the Heaviside function and the asymptotic functions). This imposition is done as for the classical nodes by the keywords DDL_IMPO or FACE_IMPO.

3.3 Sizes tested and results

One tests the values of displacements of the nodes to which the conditions were applied.
As the crack passes by the nodes of the grid, the conditions were applied to the two lips of the crack.

It is thus not necessary to filter the nodes here. All the new nodes are tested.

To test all the nodes of the group in only once, one tests the values min and max.

Identification	*Aster*	Reference	% difference
Face from behind: MAX (DX)	0.0	0.0	0.0
Face from behind: MIN (DX)	0.0	0.0	0.0
Face from behind: MAX (DY)	0.0	0.0	0.0
Face from behind: MIN (DY)	0.0	0.0	0.0
Face from behind: MAX (DZ)	0.0	0.0	0.0
Face from behind: MIN (DZ)	0.0	0.0	0.0
Face of front: MAX (DX)	10^{-6}	10^{-6}	0.0
Face of front: MIN (DX)	10^{-6}	10^{-6}	0.0

4 Synthesis

This case test validates the imposition of conditions of Dirichlet on nodes X-FEM. The imposition is done by the keywords DDL_IMPO or FACE_IMPO order AFFE_CHAR_MECA.