ZZZZ346 – Junction of a right interface XFEM with quadratic elements 2D

Summary

The purpose of this test is to validate the algorithm of under-cutting XFEM, with quadratic elements 2D. The algorithm general of under-cutting is described in the reference material [R7.02.12]. In addition under-cutting intervenes primarily at the time of the call to the operator MODI_MODELE_XFEM [U4.41.11].

In this test, one is interested in a situation of particular cutting: the junction of an interface along an edge, within an element. According to the position of the point of junction on the edge, there are two configurations of cutting [R7.02.12]. These configurations correspond to two regularizations of the form of the level-set.

4 modelings are considered:

1. modeling A : X-FEM 2D with elements TRIA6, the interface forks before the point medium on the edge of junction. Figure 1.1-2
2. modeling B : X-FEM 2D with elements QUAD8, the interface forks before the point medium on the edge of junction. Figure 1.1-2
3. modeling C : X-FEM 2D with elements TRIA6, the interface forks after the point medium on the edge of junction. Figure 1.1-3
4. modeling D : X-FEM 2D with elements QUAD8, the interface forks after the point medium on the edge of junction. Figure 1.1-3

1 Problem of reference

1.1 Geometry

The structure $2D$ is a unit square plate ($LX=0{,}1$, $LY=0{,}1$). A “right” interface cuts the field in 2 under-fields.

The interface forks in the vicinity of the center of the square $(0,0.5)$ with an angle $\theta=67{,}5°$ compared to the horizontal one.

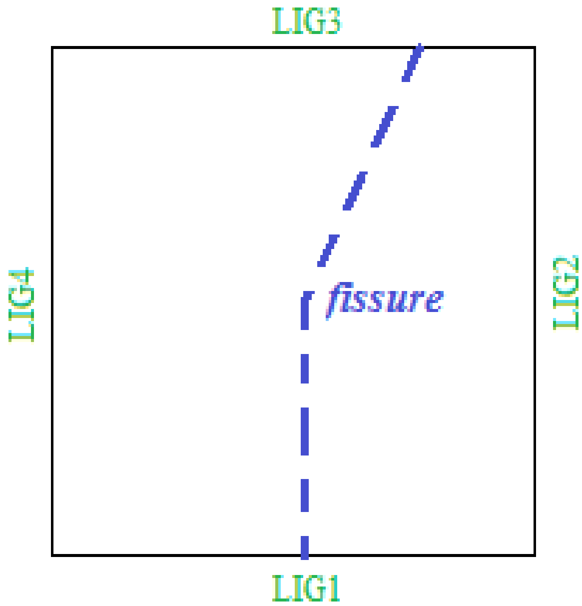

Figure 1.1-1: Geometry of the fissured plate

The interface is analytically defined by the union of 2 segments of right-hand side, whose respective equations are:

- $X=0$ for the vertical segment.
- $Y=2x+0.55$ for the segment obliques.

The point of intersection of the 2 segments of right-hand side is calculated to be located on the edge where the interface forks:

- $(0,0.55)$ for modelings A and B, even Figure 1.1-2
- $(0,0.6)$ for modelings C and D, even Figure 1.1-3

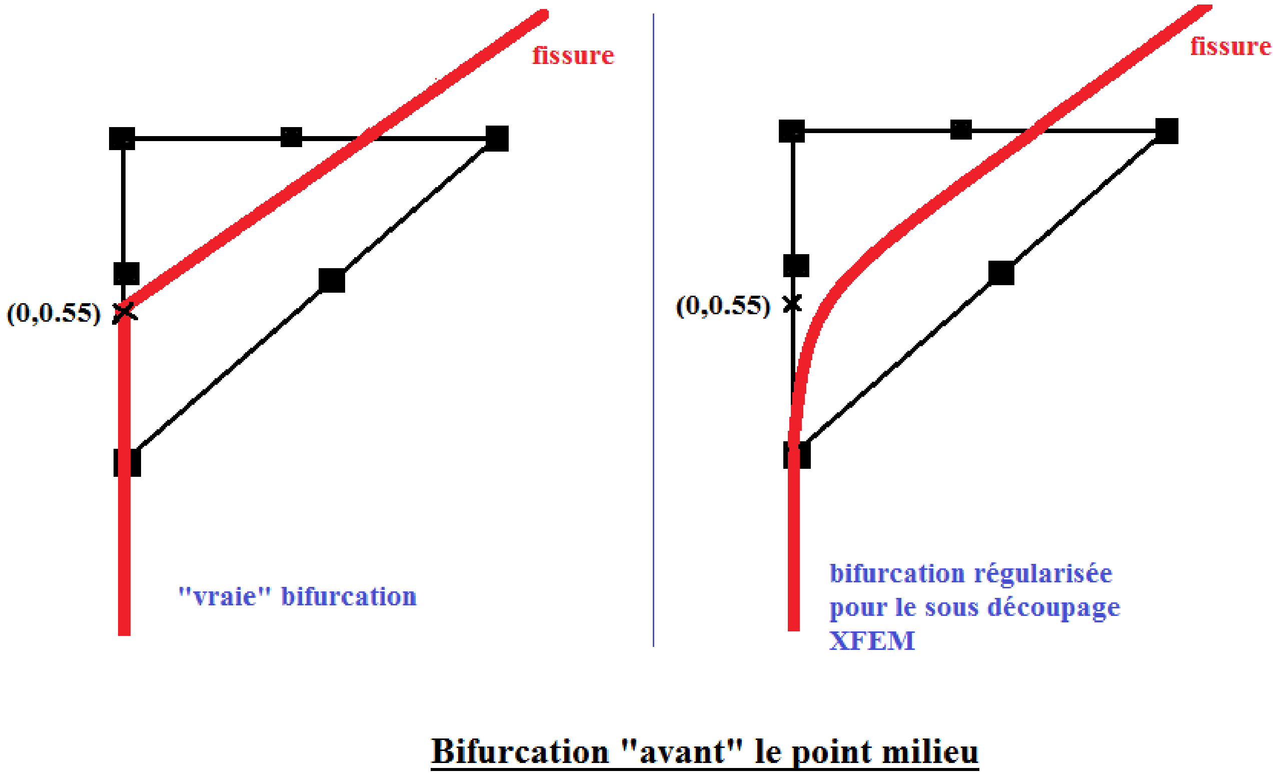

Figure 1.1-2 : "zoom" in the vicinity of the point of junction

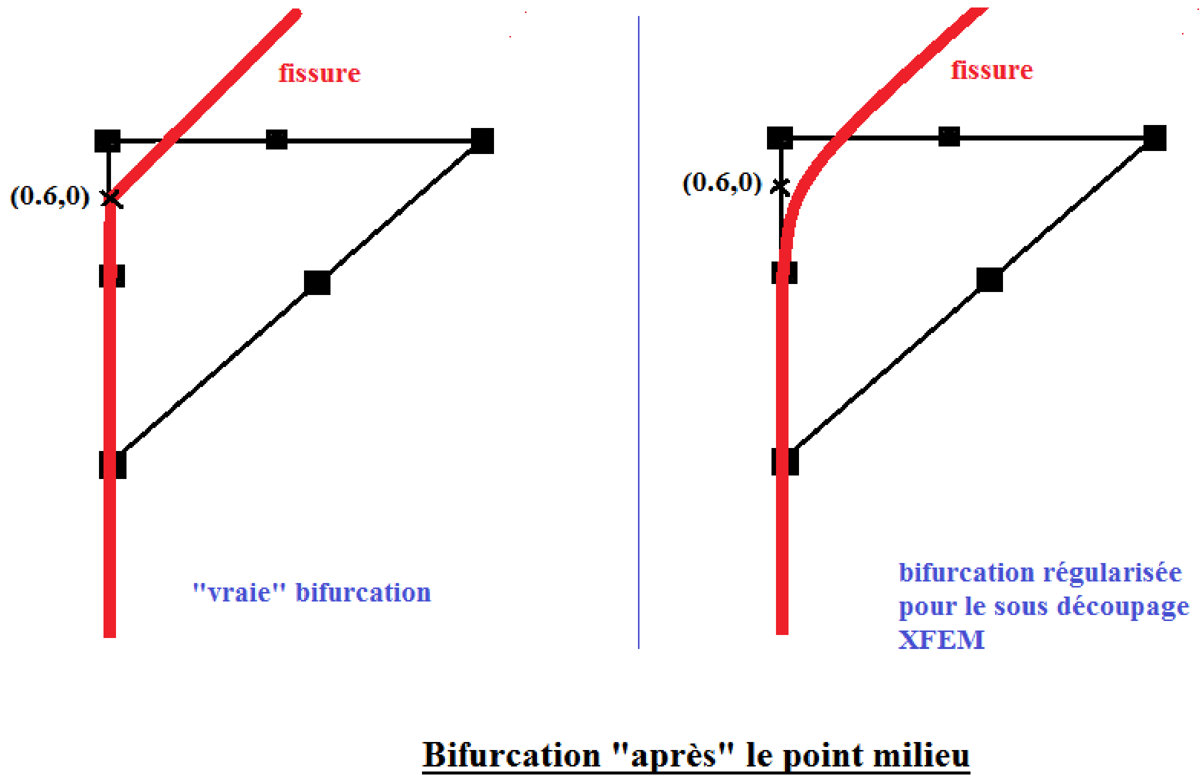

Figure 1.1-3 : "zoom" in the vicinity of the point of junction

1.2 Properties of material

Young modulus: $E=210\,10^{9}\,Pa$
Poisson's ratio: $\nu=0$

1.3 Boundary conditions and loadings

Modeling A :

The interface cuts the field in 2 under-fields. One imposes the solution in displacement on each under-field, thanks to the conditions of Dirichlet on the edges:
•on the edge $LIG2$: $DX=-1$ and $DY=0$
•on the edge $LIG4$: $DX=+1$ and $DY=0$

There is no contact on the level of the interface. One is interested just in displacements of the 2 blocks, which can interpenetrate.

The imposed conditions of Dirichlet block also the rigid movements of body of the 2 under-fields.

Modelings B , C and D :

Even loading that in modeling A .

1.4 Reference solution

Modeling A :

By construction, the field of displacement is uniform on each under-block.

•On the under-field on the right, one a: $DX=-1$ and $DY=0$
•On the under-field on the left, one a: $DX=+1$ and $DY=0$

Modeling B :
Even analytical solution that modeling A

Modeling C :
Even analytical solution that modeling A

Modeling D :
Even analytical solution that modeling A

1.5 Bibliographical references

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

2 Modeling A

2.1 Characteristics of the grid

The structure is modelled by a regular grid composed of 8×8 TRIA6, respectively along the axes x, y . The interface is not with a grid.

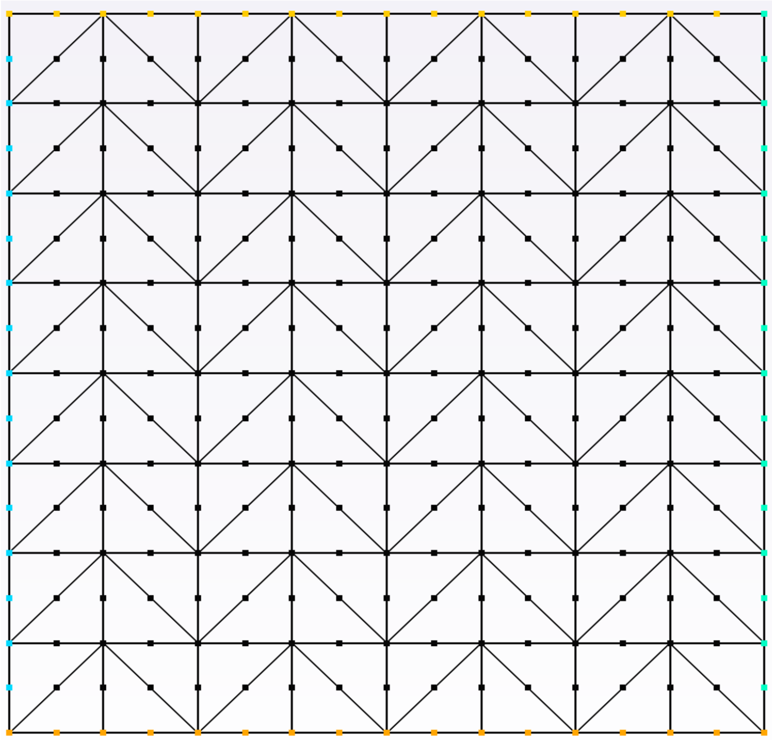

Figure 2.1-1: Grid of plate (TRI6)

2.2 Sizes tested and results

The junction is located along an edge, on the segment of nodes tops $(0, 0.5)$, $(0, 0.625)$ and of node medium $(0, 0.5625)$. The junction takes place precisely at the point $(0, 0.55)$ and interfaces it does not pass by the node medium.

One then tests displacement on the node medium positioned in $(0, 0.5625)$, to check that it is positioned "good" side of the interface.

Identification	Reference	Tolerance
DEPL_X		
NO_M: H1X	1.0	1E-12%
NO_M: DX	1.0	1E-12%

2.3 Complementary results

One finds the “regularization” of the junction in the vicinity of the point of coordinates $(0, 0.55)$.

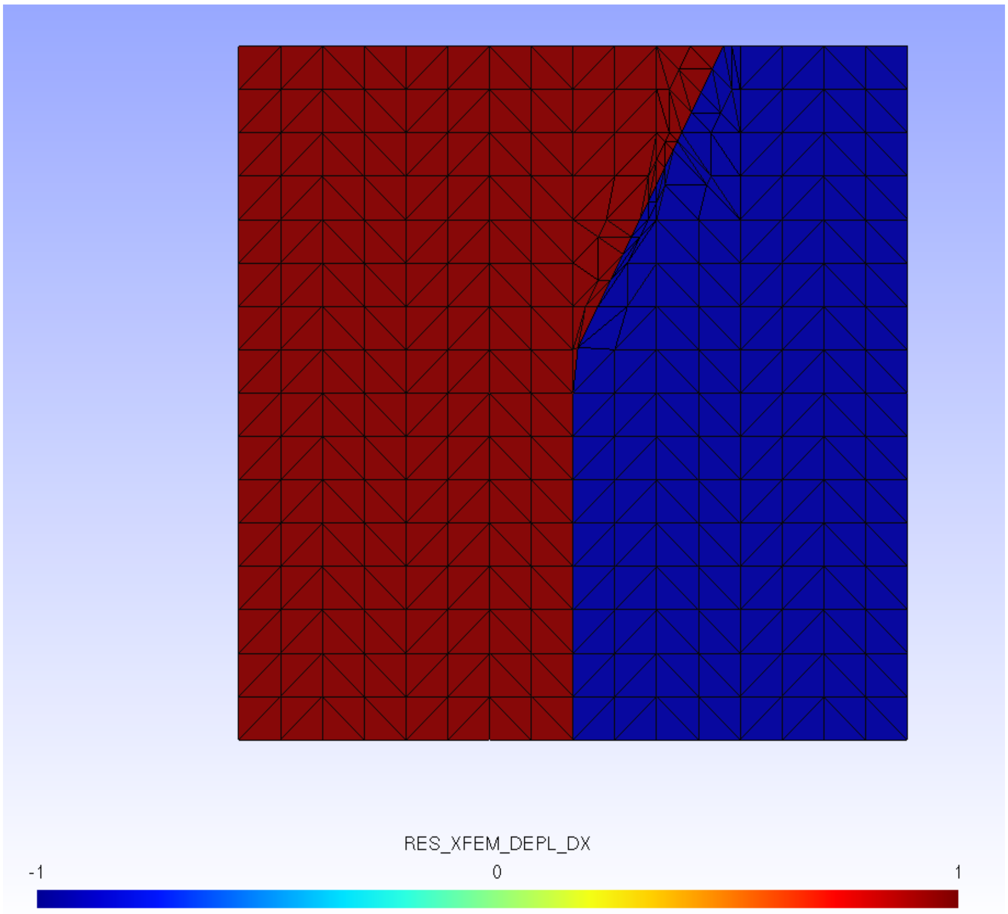

Figure 2.3-1: Field of displacement following X for the junction “before” the point medium

3 Modeling B

3.1 Characteristics of the grid

The structure is modelled by a regular grid composed of 8×8 QUAD8, respectively along the axes x, y. The interface is not with a grid.

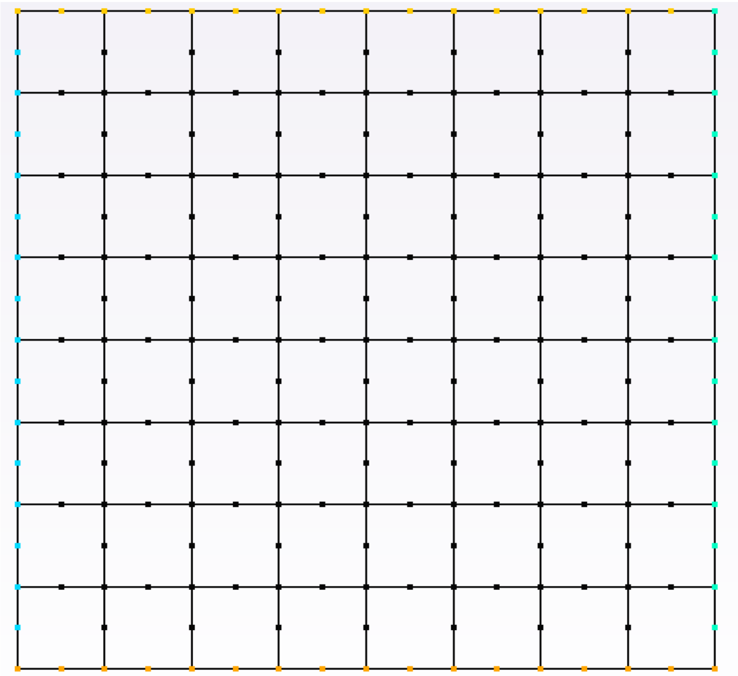

Figure 3.1-1: Grid of the plate F (Quad8)

3.2 Sizes tested and results

Same sizes tested as in modeling A.

Identification	Reference	Tolerance
DEPL_X		
NO_M: H1X	1.0	1E-12%
NO_M: DX	1.0	1E-12%

4 Modeling C

4.1 Characteristics of the grid

Even grid that in modeling A.

4.2 Sizes tested and results

The junction is located along an edge, on the segment of nodes tops $(0,0.5)$, $(0,0.625)$ and of node medium $(0,0.5625)$. The junction takes place precisely at the point $(0,0.6)$ and interfaces it does not pass by the node medium.

One then tests displacement on the node medium positioned in $(0,0.5625)$, to check that it is positioned “good” side of the interface.

Identification	Reference	Tolerance
DEPL_X		
NO_M: H1X	1.0	1E-12%
NO_M: DX	1.0	1E-12%

4.3 Complementary results

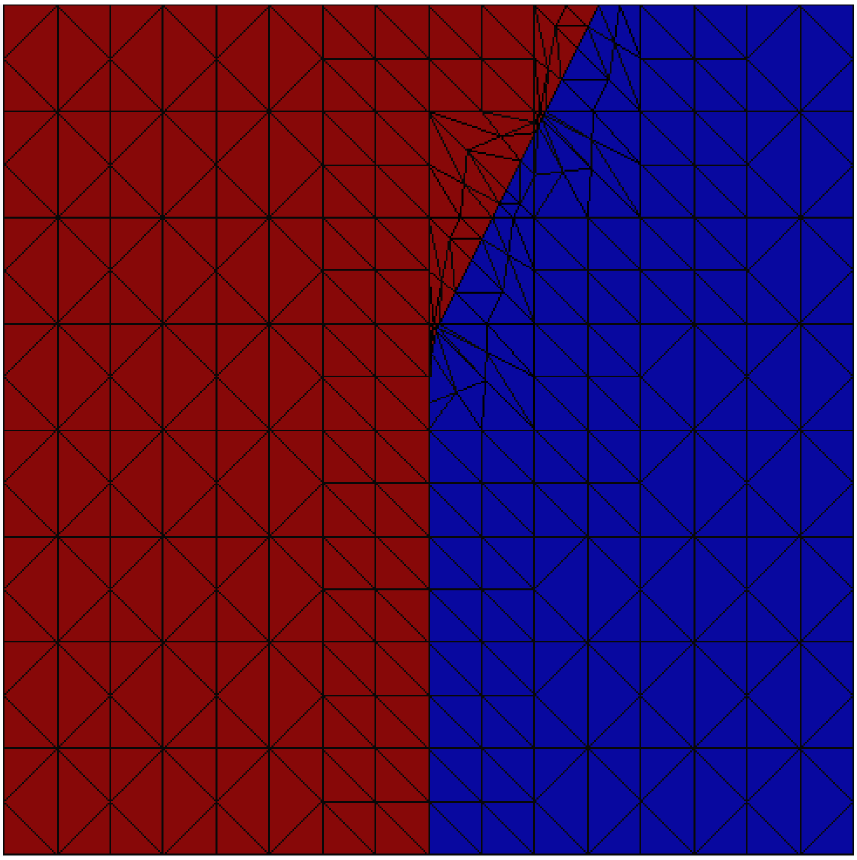

Figure 4.3-1 : Field of displacement following X for the junction “after” the point medium

5 Modeling D

5.1 Characteristics of the grid

Even grid that in modeling B.

5.2 Sizes tested and results

Same sizes tested as in modeling C .

Identification	Reference	Tolerance
DEPL_X		
NO_M: H1X	1.0	1E-12%
NO_M: DX	1.0	1E-12%

6 Summaries of the results

The goal of this test is achieved: to validate a configuration of particular cutting XFEM with quadratic elements 2D (TRIA6 and QUAD8).