ZZZZ346 – The purpose of bifurcation of a right crack XFEM

Summarized

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

In this test, one is interested in a configuration of particular cutting: the bifurcation of a crack along an edge, within an element.

2 modelizations are considered:

1. modelization A : X-FEM 2D with elements TRI6.
2. modelization B : X-FEM 2D with elements QUA8.

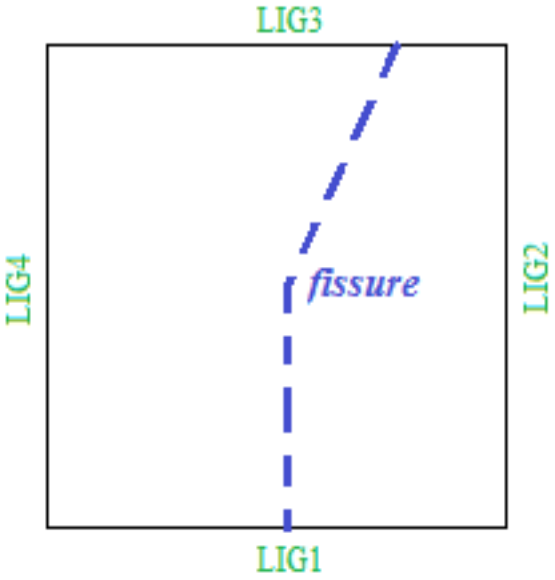
1 Problem of reference

1.1 Geometry

the structure $2D$ is a unit square plate ($LX=0,1$, $LY=0,1$). A “right” crack cuts the field in 2 subdomains.
The crack is analytically defined by the union of 2 line segments, whose respective equations are:
- $X=0$ for the vertical segment.
- $Y=2\,x+0.55$ for the oblique segment.

The point of intersection of the 2 line segments $(0,0.55)$, is calculated to be located on the edge where the crack forks.

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



Appear 1.1-a: Geometry of the fissured plate

1.2 Properties of the material

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

1.3 Boundary conditions and loadings

Modelization A :

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

the conditions of Dirichlet imposed, block also motions of rigid bodies of the 2 subdomains.

Modelization B :

Even loading that in the modelization A .

1.4 Reference solution

Modelization A :

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

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

Modelization B :
Even analytical solution that the modelization A

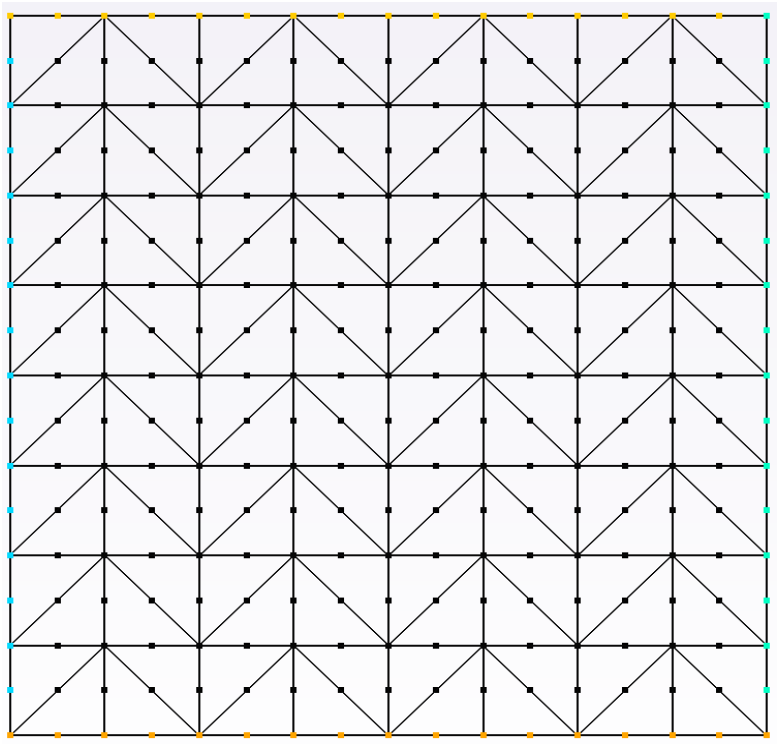
1.5 bibliographical References

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

2 Modelization A

2.1 Characteristic of the mesh

the structure is modelled by a regular mesh composed of 8×8 TRI6, respectively along the axes x , y . The crack is not with a grid.



Appear 2.1-a: Mesh of the fissured plate (TRI6)

2.2 Quantities tested and results

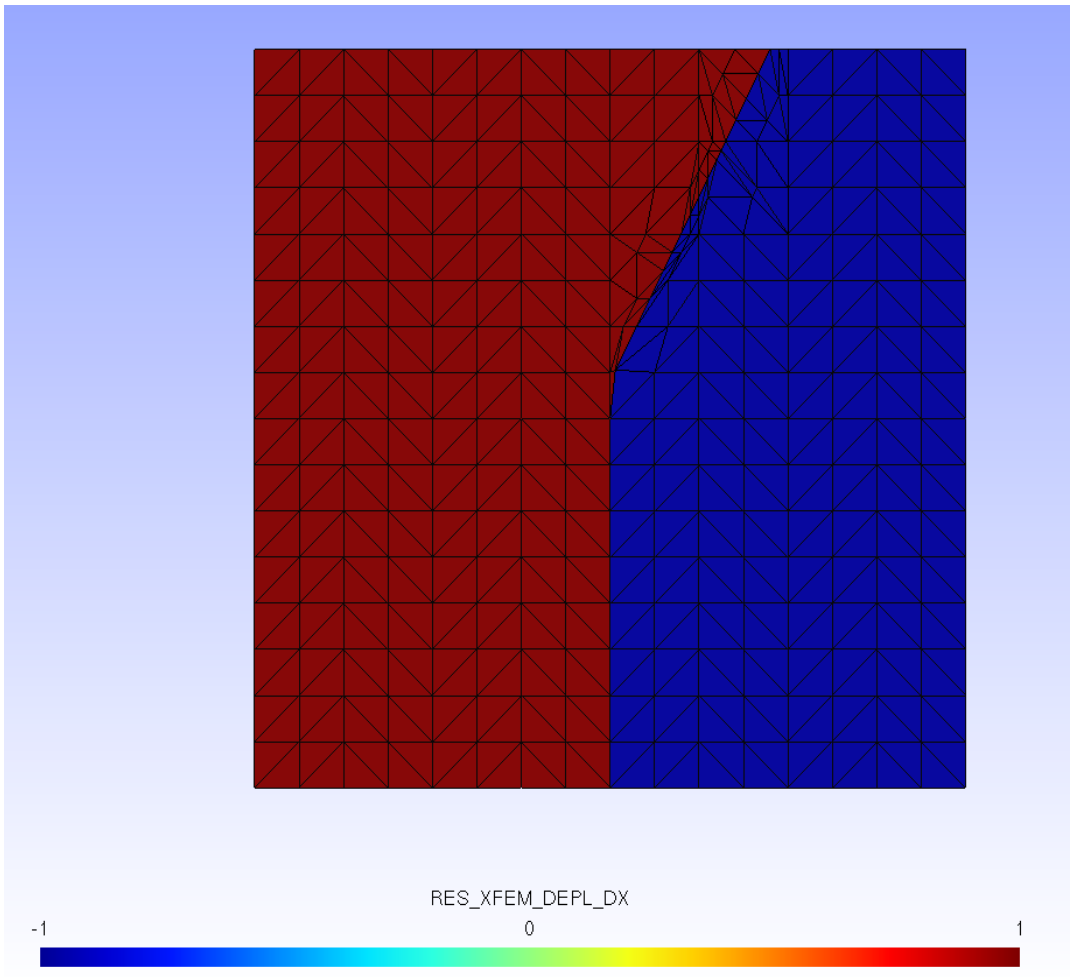
the bifurcation is along an edge, on the segment of nodes tops $(0,0.5)$, $(0,0.625)$ and of medium node $(0,0.5625)$. The bifurcation takes place at the point precisely $(0,0.55)$ and the crack does not pass by the medium node.

One then tests displacement on the medium node 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: Complementary	DX	0,0

2.3 1E-12% Results

the crack are theoretically formed by the union of 2 segments, but one observes numerically because of discretization of the level-set, 3 segments in postprocessing. Indeed, in the upper part of crack, the level-set is obtained starting from the points of intersection between the elements and the mesh, without use of the make-to-vertex. In the lower part (vertical segment intersecting of the edges), the nodes tops and the nodes mediums are on $lsn=0$. In the intermediate part, the top node $(0,0.5)$ belongs to $lsn=0$. The "segment" corresponds to an interpolation of the level-set between the top node and the point of intersection on the opposite edge.

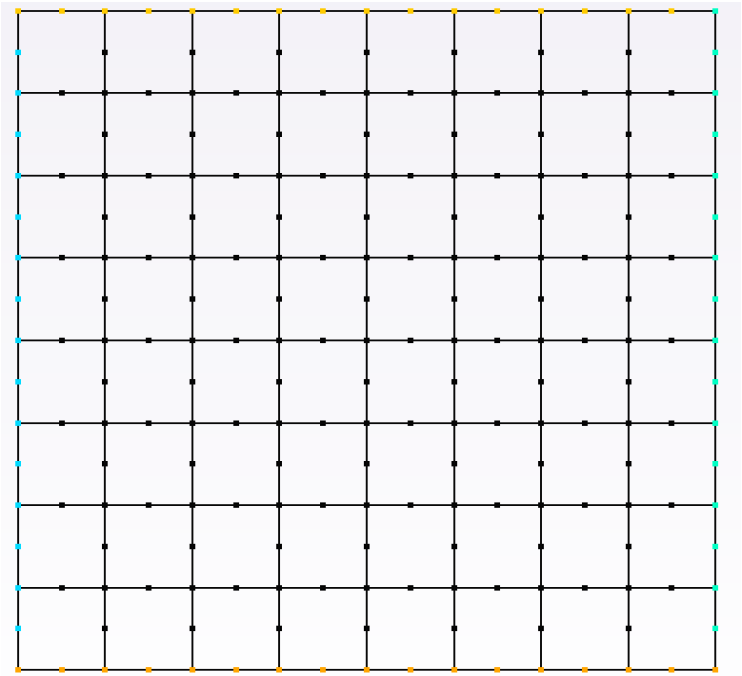


Appear 2.3-a: Field of displacement following X

3 Modelization B

3.1 Characteristic of the mesh

the structure is modelled by a regular mesh composed of 8×8 QUAD8, respectively along the axes x , y . Crack N" is not with a grid.



Appear 3.1-a: Mesh of the fissured plate (Quad8)

3.2 Quantities tested and results

Same quantities tested as in the modelization A .

Identification	Reference	Tolerance
DEPL_X		
NO_M: H1X	1,0	1E-12%
NO_M: DX	0,0	1E-12%

4 Summaries of the results

the purpose of this test is reached: to validate a configuration of particular cutting XFEM with elements 2D quadratic (TRI6 and QUAD8).