SSNV173 – Bar fissured with X-FEM

Summary

The purpose of this test is to validate two aspects of elementary calculation within the framework of X-FEM [R7.02.12]:

- the integration of a discontinuous size thanks to a under-cutting of the element,
- the enrichment of the functions of form by the Heaviside function.

This test brings into play a parallelepipedic bar fissured on all its section (one will speak then about interface), subjected to an imposed displacement, which has as a consequence the separation of the two parts of the structure.

The influence of the grid and the boundary conditions is also studied.

One also studies in $2D$ the case of a plate.

1 Problem of reference

1.1 Geometry 3D

The structure is a right parallelepiped at square base. Dimensions of the bar (see [Figure 1.1-a]) are: $LX=5\,m$, $LY=5\,m$ and $LZ=25\,m$.

The crack (or rather the interface) is introduced by functions of level (level sets) directly into the file orders using the operator `DEFI_FISS_XFEM` [U4.82.08]. The interface is present in the middle of the structure by the means of its representation by a level set LSN (see [Figure 1.1-a]) of equation:

$$LSN \text{ (for the plan of the interface): } Z-\frac{LZ}{2}$$

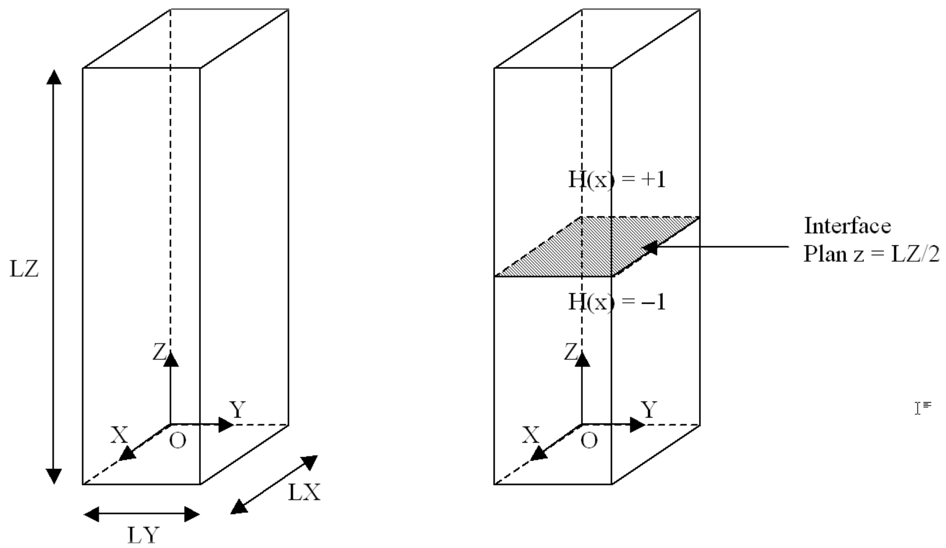

Figure 1.1-a : Geometry of the bar and positioning of the interface

1.2 Geometry 2D

The structure is a rectangle. Dimensions of the bar (see [Figure 1.2-a]) are: $LX=1\,m$, $LY=5\,m$.

The interface is introduced by a function of level (level set) directly into the file orders using the operator `DEFI_FISS_XFEM` [U4.82.08]. The interface is present in the middle of the structure by the means of its representation by a level set LSN (see [Figure 1.2-a]) of equation:

$$LSN \text{ (for the plan of the interface): } Y-\frac{LY}{2}$$

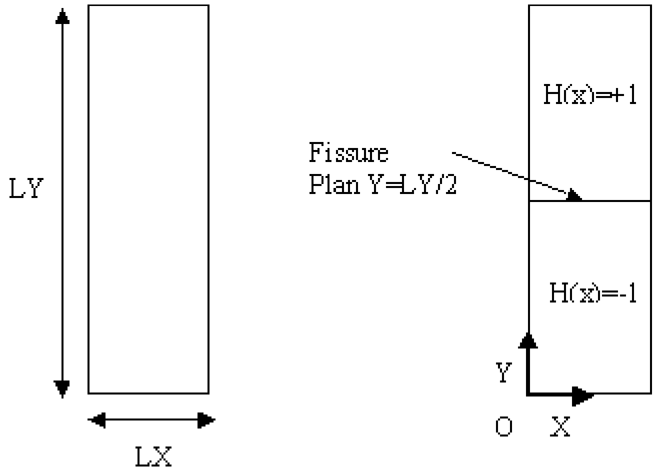

Figure 1.2-a : Geometry of the plate and positioning of the interface

1.3 Propriétés of material

Young modulus: $E=205000\ MPa$

Poisson's ratio: $\nu=0.3$

1.4 Boundary conditions and loadings

The nodes of the lower face of the bar are embedded and a displacement is imposed on those of the higher face. One wishes to show here the possibility of separating a finite element into two with X - FEM.

2 Modeling A

2.1 Characteristics of the grid

The structure is with a grid by only one nets of type HEXA8. The interface is thus present within this element by the means as of level sets.

2.2 Boundary conditions

Let us recall that displacement under X-FEM is the sum of a continuous displacement and a discontinuous displacement. In the case of an interface, bottomless of crack in the following way, the approximation of displacement is written:

$$u^h(x)=\sum_{i\in N_n(x)} a_i \varphi_i(x)+\sum_{j\in N_n(x)\cap K_+} b_j \varphi_j(x)\left(-2\chi_-(lsn(x))\right)+\sum_{j\in N_n(x)\cap K_-} b_j \varphi_j(x)\left(2\chi_+(lsn(x))\right)$$

Where:
a_i and b_i are the degrees of freedom of displacement to the node i,
ϕ_i functions of form associated with the node i,
$N_n(x)$ is the whole of the nodes whose support contains the point x,
K_- is the whole of the nodes located in the field $lsn(x)<0$, and whose support is entirely cut by the interface,
K_+ is the whole of the nodes located in the field $lsn(x)>0$, and whose support is entirely cut by the interface,
$\chi_-(x)$ is a function characteristic of field defined by $\chi_-(x)=\begin{cases}1 & \text{si } x<0\\ 0 & \text{si } x\geq 0\end{cases}$,
$\chi_+(x)$ is a function characteristic of field defined by $\chi_+(x)=\begin{cases}0 & \text{si } x<0\\ 1 & \text{si } x\geq 0\end{cases}$,
$lsn(x)$ is the normal value of the level-set at the point x

For more details, to refer to the reference material X-FEM [R7.02.12].

Considering the nodes close to the interface, i.e. here the 8 nodes of the grid are enriched by additional degrees of freedom, the boundary conditions are written a little differently. That is relating to the enrichment of the classical functions of forms [R7.02.12] by the functions characteristic of fields $\chi_-(x)$ and $\chi_+(x)$.

To impose a null displacement on the nodes of the lower face amounts writing a linear relation between the degrees of freedom. For each node, one imposes $a_{ix}=0$ (idem according to y and z) when the interface is not in conformity with the nodes of the grid. However if the interface were in conformity with the nodes, to impose null displacement on the interface, also underlies an assumption with respect to the jump of displacement through the interface. That introduced an additional relation due to continuity/jump of displacement. It is then advisable to impose the following condition on the degrees of freedom of discontinuity $2\mathrm{b}_{ix}=\Delta u=0$.

For the nodes of the higher face, one imposes a following displacement z being worth 10^{-6} and no one following the two other directions, i.e. $a_{ix}=0$, $a_{iy}=0$ and $a_{iz}=10^{-6}$.

These relations are imposed **automatically** when the keyword is used DDL_IMPO on a node X-FEM. For example, the imposition of following displacement X no one of node X-FEM $N1$ is thus done in the classical way:

```
DDL_IMPO=_F (NOEUD=' N1', DX=0)
```

2.3 Analytical resolution

The solution of such a problem is of course obvious. It is seen well that mechanically speaking, the two parts of the structure will be detached: the lower part will have a null displacement and the upper part will have an overall movement equal to displacement forced (see [Figure 2.3-a]).

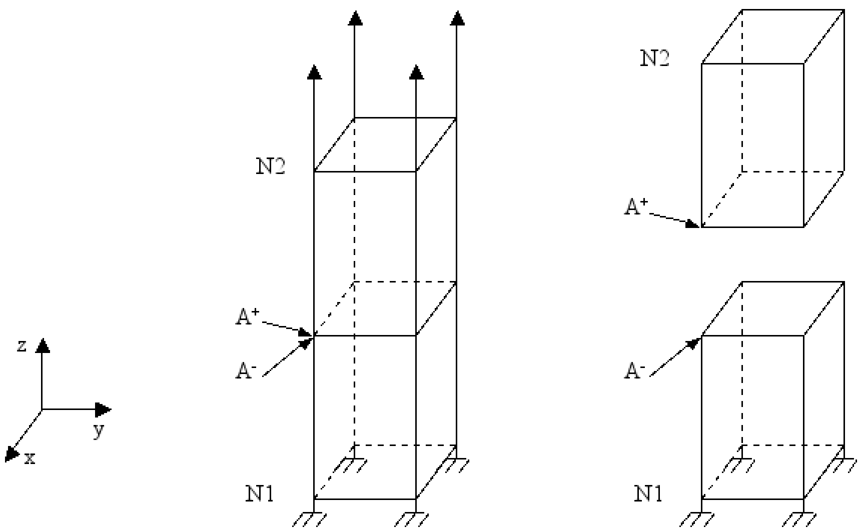

Figure 2.3-a : States initial and final of the structure

The analytical solution is then the following one: all displacements according to x and y are worthless, all displacements according to z below the level set are worthless and all displacements according to z with the top of the level set are equal to imposed displacement u_z at the top of the structure.

2.4 Sizes tested and results

The operator `POST_MAIL_XFEM` allows to net the cracks represented by method X-FEM. The operator `POST_CHAM_XFEM`, then allows to export results X-FEM on it new grid. These two operators are to be only used posterior way with calculation at sights of postprocessing. They make it possible to generate nodes right in lower part and with the top of the interface and to display their displacements.

The values of displacement are thus tested just in lower part and with the top of the interface after convergence of the iterations of the operator `STAT_NON_LINE`. It is checked that one finds well the values determined with [the §2.3].

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	0.00	1.0E-16
DZ for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

2.5 Comments

One notices the discontinuity of the field of displacements while crossing the interface which is possible thanks to the enrichment of the elements with the degree of Heaviside freedom.

3 Modeling B

3.1 Characteristics of the grid

One discretizes the structure in 5 meshs of the type HEXA8.

The nodes on both sides of the interface are nodes nouveau riches, therefore the three central meshs having such nodes are also enriched. Only the two extreme meshs are classical meshs having only classical nodes.

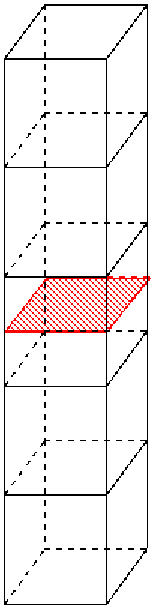

Figure 3.1-a : grid with 5 HEXA8

3.2 Boundary conditions

The boundary conditions applied represent the same physical phenomenon that for modeling A. One embeds the nodes of the lower face and one imposes a displacement of the nodes of the higher face:

Lower face (Nodes $N1$, $N6$, $N11$, $N16$): $DX=0$, $DY=0$ and $DZ=0$
Higher face (Nodes $N21$, $N22$, $N23$, $N24$): $DX=0$, $DY=0$ and $DZ=uz$
This constitutes the 1st case of loading.

In fact, one takes freedom to move the upper part of the structure according to the three directions, one will thus choose like 2ème case of loading:
Lower face (Nodes $N1$, $N6$, $N11$, $N16$): $DX=0$, $DY=0$ and $DZ=0$
Higher face: $DX=ux$, $DY=uy$ and $DZ=uz$

$$ux=1.10^{-6}$$
$$uy=2.10^{-6}$$
$$uz=3.10^{-6}$$

3.3 Analytical resolution

The solution of such a problem is of course still obvious. All displacements according to x and y are worthless, all displacements according to x, y and z below the level set are worthless and all displacements according to x, y and z with the top of the level set are equal to imposed displacement u_x, u_y and u_z at the top of the structure.

3.4 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §3.3] for the 2 cases of loadings.

One obtains the following table for 1er case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	0.00	1.0E-16
DZ for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

One obtains the following table for the 2ème case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	1.0E-6	1.0E-9%
DY for all the nodes just with the top of the interface	2.0E-6	1.0E-9%
DZ for all the nodes just with the top of the interface	3.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

3.5 Comments

One notices the discontinuity of the field of displacements while crossing the interface which is possible thanks to the enrichment of the elements with the degree of Heaviside freedom.

4 Modeling C

4.1 Characteristics of the grid and the interface

One considers a structure of dimensions $LX=5m$, $LY=5m$ and $LZ=25m$. This structure is discretized with 5 meshs HEXA8. One is interested in a plane interface of normal

$$n=\begin{pmatrix}-1\\1\\1\end{pmatrix}$$

passing by the point A coordinates $(5,5\delta,5)$. [Figure 4.1-a] watch a zoom of the 2ème element where the trace of the interface is represented in red.

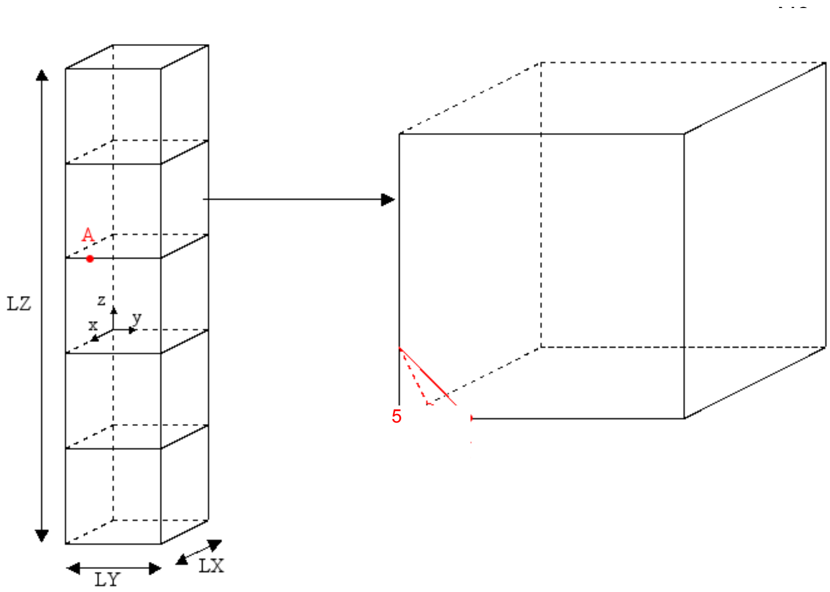

Figure 4.1-a : Grid C and zoom

The interface is characterized by the level set normal having for Cartesian equation:

$$lsn=-x+y+z-5\delta$$

Note:

With the new enrichment of jump of displacement [R7.02.12], we do not note a fall of precision on the solution in displacement in the vicinity of the interface and of problem of conditioning, although the interface is shaving compared to the nodes of the grid.

4.2 Boundary conditions

The boundary conditions are the same ones as those of modeling B. the nodes of the lower face are embedded and one imposes a displacement of traction on the nodes of the higher face:

Lower face: $DX=0$, $DY=0$ and $DZ=0$
Higher face: $DX=0$, $DY=0$ and $DZ=10^{-6}$

4.3 Sizes tested and results

The good progress of calculation allows *a priori* to validate the case. The values of displacement are thus tested just with the top of the interface after convergence of the iterations of the operator STAT_NON_LINE.

Identification	Reference	Tolerance
DZ for all the nodes just with the top of the interface	$1.0\text{E}-6$	1.0E-3%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

5 Modeling D

This modeling is based on modeling A.
The type of element chosen for the grid is the only difference between these two modelings.

5.1 Characteristics of the grid

One discretizes the structure in 6 finite elements TETRA4
The interface is present within these 6 elements by the means of the level sets.

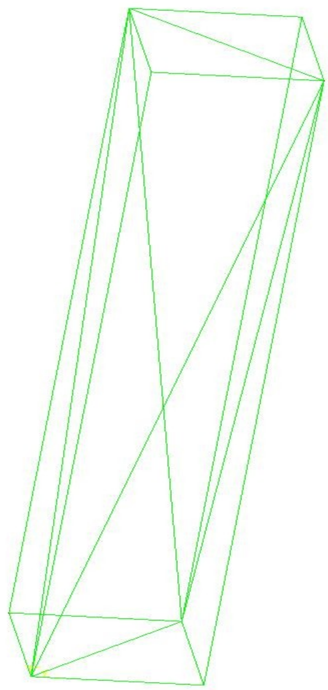

Figure 5.1-a : Grid

5.2 Boundary conditions

The boundary conditions are those of modeling a: one embeds the nodes of the lower face and one imposes a displacement of the nodes of the higher face.

5.3 Analytical resolution

The analytical solution is that presented in modeling A [§2.3]: all degrees of freedom according to x and y are worthless and all the degrees of freedom according to z are worth $uz/2$, where $uz=10^{-6}$

5.4 Sizes tested and results

The values of displacement are tested just in lower part and with the top of the interface after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §2.3].

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	0.00	1.0E-16
DZ for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

5.5 Comments

One notices the discontinuity of the field of displacements while crossing the interface which is possible thanks to the enrichment of the elements with the degree of Heaviside freedom.

6 Modeling E

This modeling is based on modeling B.
The type of element chosen for the grid is the only difference between these two modelings.

6.1 Characteristics of the grid

Each mesh HEXA8 modeling B is broken up into 6 TETRA4 for modeling E.
Thus the structure is discretized in 30 finite elements TETRA4.

The nodes on both sides of the interface are nodes nouveau riches, therefore the tetrahedrons contained in the three central meshs of modeling B having such nodes are also nouveau riches. Only the tetrahedrons contained in the two extreme hexahedrons of modeling B are classical meshs having only classical nodes.

One will be able to thus impose boundary conditions on the extreme meshs in the usual way.

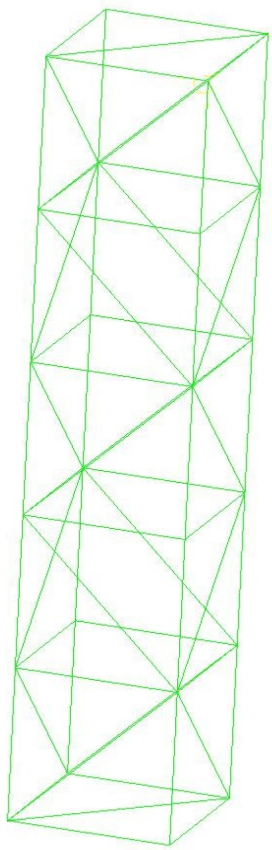

Figure 6.1-a : Grid

6.2 Boundary conditions

The nodes of the lower face are embedded and one imposes a displacement of the nodes of the higher face:

Lower face: $DX=0$, $DY=0$ and $DZ=0$
Higher face: $DX=0$, $DY=0$ and $DZ=uz$.
This constitutes the 1st case of loading.

In fact, one takes freedom to move the upper part of the structure according to the three directions, one will thus choose like 2ème case of loading:
Lower face: $DX=0$, $DY=0$ and $DZ=0$
Higher face: $DX=ux$, $DY=uy$ and $DZ=uz$

$$ux=10^{-6}$$
$$uy=2.10^{-6}$$
$$uz=3.10^{-6}$$

6.3 Analytical resolution

The solution of such a problem is of course still obvious: all displacements according to x and y are worthless, all displacements according to z below the level set are worthless and all displacements according to z with the top of the level set are equal to imposed displacement u_z at the top of the structure.

6.4 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator `STAT_NON_LINE`. It is checked that one finds well the values determined with [the §3.3] for the 2 cases of loadings.

One obtains the following table for 1er case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	0.00	1.0E-16
DZ for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

One obtains the following table for the 2ème case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	1.0E-6	1.0E-9%
DY for all the nodes just with the top of the interface	2.0E-6	1.0E-9%
DZ for all the nodes just with the top of the interface	3.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

6.5 Comments

One notices the discontinuity of the field of displacements while crossing the interface which is possible thanks to the enrichment of the elements with the degree of Heaviside freedom.

7 Modeling F

7.1 Characteristics of the grid

One discretizes the structure in 5 finite elements QUAD4.

The nodes on both sides of the interface are nodes nouveau riches, therefore the three central meshs having such nodes are also enriched. Only the two extreme meshs are classical meshs having only classical nodes.

One will be able to thus impose boundary conditions on the extreme meshs in the usual way.

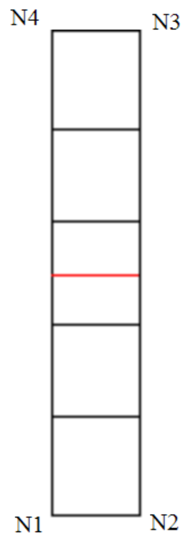

Figure 7.1-a : Grid F

7.2 Boundary conditions

The boundary conditions applied represent the same physical phenomenon that for modeling A. One embeds the nodes of the lower face and one imposes a displacement of the nodes of the higher face:

Lower face (Nodes $N1$ and $N2$): $DX=0$ and $DY=0$
Higher face (Nodes $N3$ and $N4$): $DX=0$, $DY=uy=10^{-5}$.

7.3 Analytical resolution

The solution of such a problem is of course still obvious: all displacements according to x are worthless, all displacements according to y below the level set are worthless and all displacements according to y with the top of the level set are equal to imposed displacement u_y at the top of the structure.

7.4 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §7.3].

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16

DY for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

One tests also the values of displacement resulting from the order POST_CHAM_XFEM. One test in fact the value of the sum of the absolute values of displacements of the nodes of the fissured grid. It is a test of not-regression compared to the values obtained with version 8.2.13 for DX and 9.0.21 for DY.

Identification	Reference	Difference
SOMM_ABS (DX)	0,000	1.E-12
SOMM_ABS (DY)	1.3E-05	1.0E-04%

7.5 Comments

One notices the discontinuity of the field of displacements while crossing the interface which is possible thanks to the enrichment of the elements with the degree of Heaviside freedom.

8 Modeling G

8.1 Characteristics of the grid

The structure is modelled by only one finite element of type QUAD4. The interface is thus present within this element by the means of the level sets.

8.2 Boundary conditions

One takes again the same reasoning as for modeling A.

On the lower face one imposes a null displacement:
$a_{ix}-b_{ix}=0$ and $a_{iy}-b_{iy}=0$.
On the higher face one imposes a displacement according to the axis Y :
$a_{ix}+b_{ix}=0$ and $a_{iy}+b_{iy}=10^{-6}$.

These relations are imposed **automatically** when the keyword is used DDL_IMPO on a node X-FEM.

8.3 Analytical resolution

The solution of such a problem is of course still obvious: all displacements according to x are worthless, all displacements according to y below the level set are worthless and all displacements according to y with the top of the level set are equal to imposed displacement u_y at the top of the structure.

8.4 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §8.3].

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

8.5 Comments

One notices the discontinuity of the field of displacements while crossing the interface which is possible thanks to the enrichment of the elements with the degree of Heaviside freedom.

9 Modeling H

This modeling is based on modeling F.
The type of element chosen for the grid is the only difference between these two modelings.

9.1 Characteristics of the grid

Each mesh `QUAD4` modeling F is broken up into 2 `TRIA3` for modeling H.
Thus the structure is discretized in 10 finite elements `TRIA3`.

The nodes on both sides of the interface are nodes nouveau riches, therefore the triangles contained in the three central meshs of modeling F having such nodes are also nouveau riches. Only the triangles contained in the two extreme quadrilaterals of modeling F are classical meshs having only classical nodes.

One will be able to thus impose boundary conditions on the extreme meshs in the usual way.

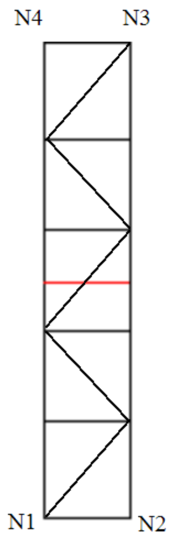

Figure 9.1-a : Grid H

9.2 Boundary conditions

The nodes of the lower face are embedded and one imposes a displacement of the nodes of the higher face:

Lower face (Nodes $N1$, $N2$): $DX=0$, and $DY=0$
Higher face (Nodes $N3$, $N4$): $DX=0$ and $DY=uy$

9.3 Analytical resolution

The solution of such a problem is of course still obvious: all displacements according to x are worthless, all displacements according to y below the level set are worthless and all displacements according to y with the top of the level set are equal to imposed displacement u_y at the top of the structure.

9.4 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator `STAT_NON_LINE`. It is checked that one finds well the values determined with [§9.3].

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

9.5 Comments

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

10 Modeling I

This modeling is exactly the same one as modeling A. the only difference is that the finite element used is a quadratic element instead of a linear element.

10.1 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §2.3].

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	0.00	1.0E-16
DZ for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

11 Modeling J

This modeling is exactly the same one as modeling B. the only difference is that the finite elements used are quadratic elements instead of linear elements.

11.1 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §3.3] for the 2 cases of loadings.
One obtains the following table for 1er case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	0.00	1.0E-16
DY for all the nodes just with the top of the interface	0.00	1.0E-16
DZ for all the nodes just with the top of the interface	1.0E-6	1.0E-9%

One obtains the following table for the 2ème case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-16
DY for all the nodes just below the interface	0.00	1.0E-16
DZ for all the nodes just below the interface	0.00	1.0E-16
DX for all the nodes just with the top of the interface	1.0E-6	1.0E-9%
DY for all the nodes just with the top of the interface	2.0E-6	1.0E-9%
DZ for all the nodes just with the top of the interface	3.0E-6	1.0E-9%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

One tests also the values of displacement resulting from the order POST_CHAM_XFEM . One tests in fact the value of the sum of the absolute values of displacements of the nodes of the fissured grid. It is a test of not-regression compared to the values obtained with version 8.2.13 for DX and 9.0.21 for DY

Identification	Reference	Tolerance
SOMM_ABS (DX)	0,000	1.0E-12
SOMM_ABS (DY)	1.3E-05	1.0E-04%

12 Modeling K

This modeling is exactly the same one as modeling B. the only difference is that first with mechanical calculation, one calls Lobster to refine certain meshs HEXA8. This process generates meshs PYRA5.

12.1 Sizes tested and results

One tests the values of displacement after convergence of the iterations of the operator STAT_NON_LINE. It is checked that one finds well the values determined with [the §3.3] for the 2ème case of loading.

Identification	Reference	Tolerance
DX for all the nodes just below the interface	0.00	1.0E-9
DY for all the nodes just below the interface	0.00	1.0E-9
DZ for all the nodes just below the interface	0.00	1.0E-9
DX for all the nodes just with the top of the interface	1.0E-6	1.0E-7%
DY for all the nodes just with the top of the interface	2.0E-6	1.0E-7%
DZ for all the nodes just with the top of the interface	3.0E-6	1.0E-7%

To test all the nodes in only once, one tests the MINIMUM and the maximum of column.

13 Summaries of the results

The goals of this test are achieved:

- It is a question of validating the taking into account of enrichment by the Heaviside function of the classical functions of form.
- Moreover, modeling B makes it possible to show that the position of the interface does not affect the robustness of calculation and the reliability of the results, with the new formulation of the jump of displacement X-FEM [R7.02.12]
- The quality of the results (displacements) was not disturbed by the change of the type of mesh (HEXA towards TETRA).