WTNV149 – Contact on the level of a junction of cohesive interfaces for the hydraulic case

Summary:

It is about one analytical test of validation of the good taking into account of the contact in the presence of a junction of cohesive interfaces for the hydraulic case coupled with the wide finite element method (XFEM). The test being purely mechanical, all the degrees of freedom associated with the liquid phase are blocked to 0. Modeling A is two-dimensional while modeling B is three-dimensional.

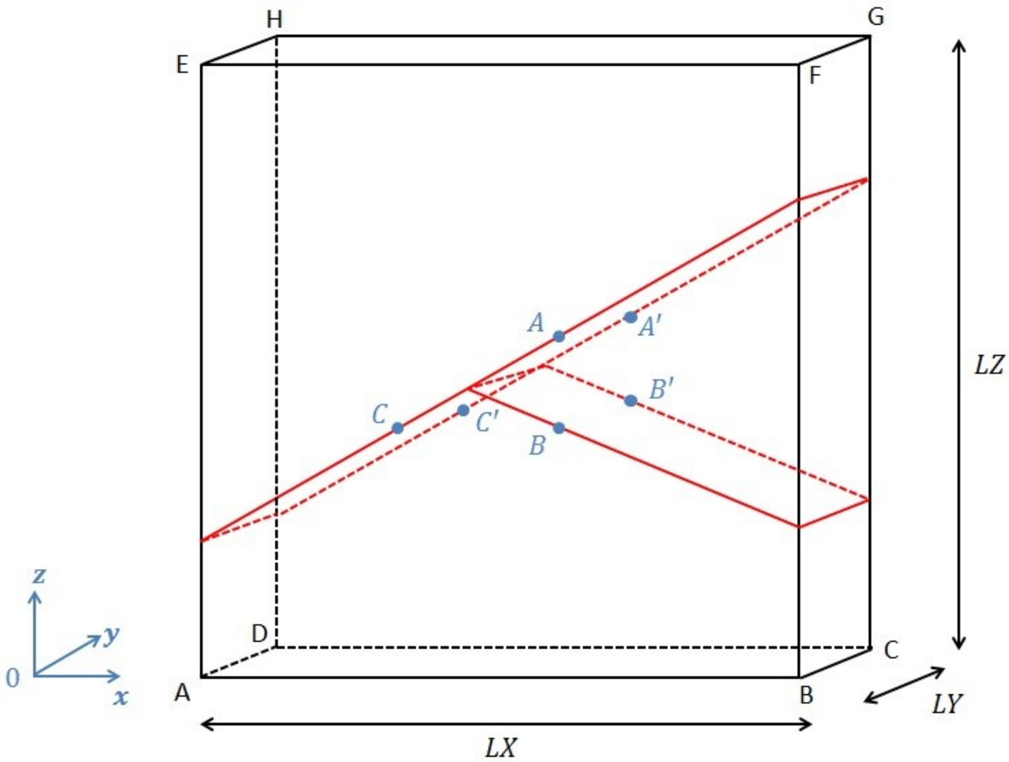
1 Problem of reference

1.1 Geometry of the problem

It is about a block height $LZ=10\,m$, length $LX=10\,m$ and of width $LY=2\,m$. This block has two discontinuities of the type interfaces cohesive (interface nonwith a grid introduced into the model in the shape of a contour (level-set) thanks to the operator `DEFI_FISS_XFEM`). First is located by the level-set normal of equation $lsn_1=Z-0.5X-0.2$ and entirely the block in the horizontal direction crosses. The second interface is located by the level-set normal of equation $lsn_2=Z+0.5X+0.2$. It connects on the lower lip of the first interface. The second interface thus exists only in the part of the block such as $lsn_1<0$. The curve of junction between the two interfaces checks $lsn_1=lsn_2=0$ and has as an equation $\begin{cases}X=-0.4\\Z=0\end{cases}$. The field is thus cut out in 3 blocks, a lower block, a higher block and an intermediate block located between the two interfaces. Points $A(6,0,5.7)$, $A'(6,2,5.7)$ $B(6,0,4,3)$, $B'(6,2,4.3)$, $C(4,0,4.7)$ and $C'(4,2,4.7)$ will be used for the evaluation of the sizes tested.

One represents on the Figure 1.1-a geometry of the block.

Figure 1.1-a: Geometry of the problem



1.2 Properties materials

Parameters given in the Table 1.2-1 correspond to the parameters used for modeling in the hydro-mechanical coupled case. The mixing rate used is `'LIQU_SATU'` . The type of cohesive model is `'MORTAR'` and the cohesive law used is `'CZM_LIN_MIX'`

Liquid (water)	Viscosity $\mu_w (en\ Pa.s)$	10^{-3}
	Module of compressibility $\frac{1}{K_w} (en\ Pa^{-1})$	5.10^{-10}
	Density of the liquid $\rho_w (en\ kg/m^3)$	1
Elastic parameters	Young modulus $E(en\ MPa)$	5800
	Poisson's ratio ν	0.2
	Thermal dilation coefficient $\alpha(en\ K^{-1})$	0
Parameters of coupling	Coefficient of Biot b	1
	Initial homogenized density $r_0 (en\ kg/m^3)$	2,5
	Intrinsic permeability $K^{\text{int}} (en\ m^2)$	$1{,}01937^{-19}$
Parameters of the cohesive law	Critical stress $\sigma_c (en\ MPa)$	0.5
	Cohesive energy $G_c (en\ Pa.m)$	900
	Coefficient of increase r	10

Table 1.2-1 : Properties of material

In addition, the forces related to gravity (in the conservation equation of the momentum) are neglected. The pressure of pore of reference is taken worthless $p_1^{\text{ref}} = 0\ MPa$ and the porosity of material is $\varphi = 0{,}15$.

1.3 Boundary conditions and loadings

Case 2D

Conditions of Dirichlet that one applies are:

- displacements according to x are blocked in on the flat rim and imposed equal to $U = 10^{-4} m$ on the left edge of the field,
- displacements according to y are blocked on the lower face and imposed equal to $-U = -10^{-4} m$ on the higher edge of the field.

Case 3D

Conditions of Dirichlet that one applies are:

- displacements according to x are blocked in on the flat rim and imposed equal to $U=10^{-4} m$ on the left edge of the field,
- displacements according to z are blocked on the lower face and imposed equal to $-U=-10^{-4} m$ on the higher edge of the field,
- displacements according to y are blocked in all the domainE.

2 Reference solution

2.1 Method of calculating

The bar is subjected to an isotropic compression. The interfaces which cross the block are cohesive thus the bar should behave like a bar not fissured. Moreover material is elastic. One thus expects to observe the isotropic compression of an elastic material.

2.2 Sizes and results of reference

Displacements are then given by:

$$u_x=(x)=U\left(1-\frac{x}{LX}\right)$$
$$u_y(y)=0$$
$$u_z(z)=-U\frac{z}{LZ}$$

2.3 Uncertainty on the solution

No, it is about an analytical solution.

3 Modeling A

3.1 Characteristics of modeling

It is about a modeling `D_PLAN_HM` using quadratic elements HM-XFEM.

3.2 Characteristics of the grid

The block on which one carries out modeling is divided into 25 `QUAD8`.

3.3 Sizes tested and results

One tests the value of displacement vertical for the nodes A , B and C who are located on each of the three branches of interfaces. The tolerance is fixed at 10^{-6} . These values are summarized in the table below:

Sizes tested	Type of reference	Value of reference	Tolerance
DY (node With)	'ANALYTICAL'	4.E5	1, E-06
DY (node B)	'ANALYTICAL'	4.E5	1, E-06
DY (node C)	'ANALYTICAL'	6.E5	1, E-06
DX (node With)	'ANALYTICAL'	-5.7E5	1, E-06
DX (node B)	'ANALYTICAL'	-4.3E5	1, E-06
DX (node C)	'ANALYTICAL'	-4.7E5	1, E-06

3.4 Remarks

One also has visualized the field of displacements according to Lbe direction x and y (Figure 3.4-a and Appears 3.4-b). It is checked that the bar behaves like a bar not fissured.

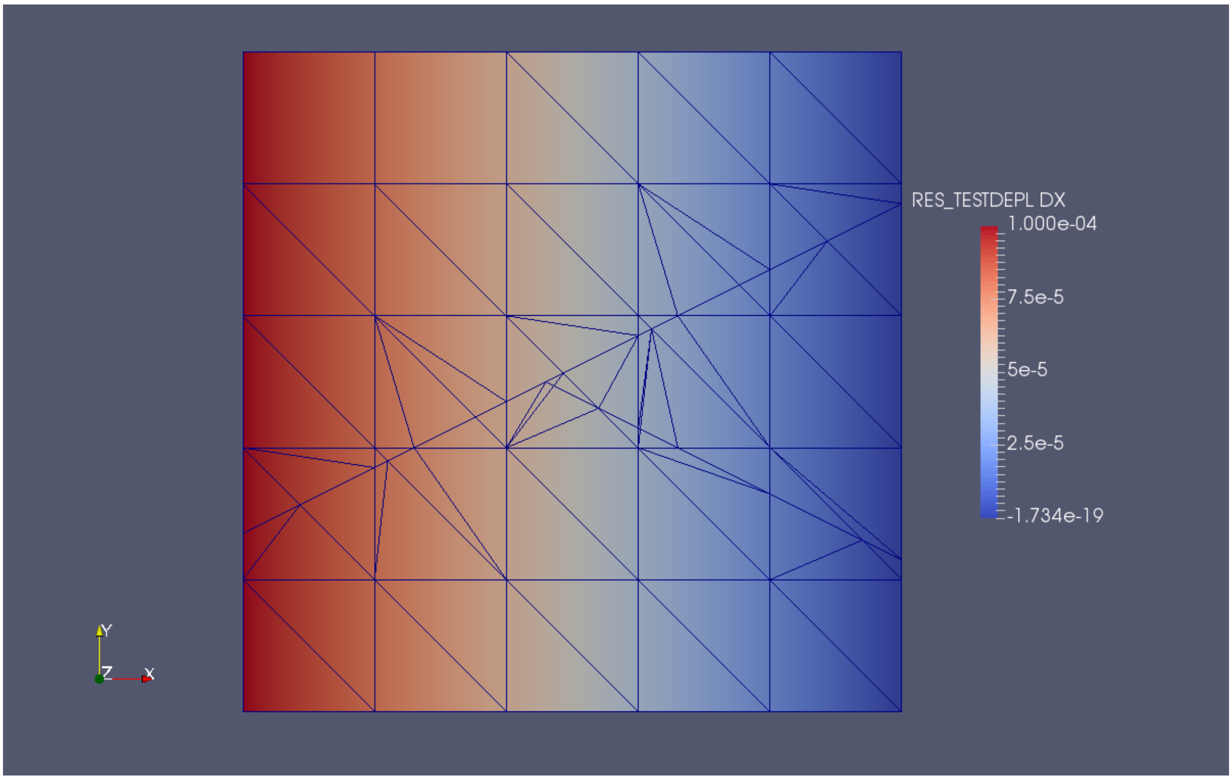


Figure 3.4-a: Field of displacements according to the direction (OX)

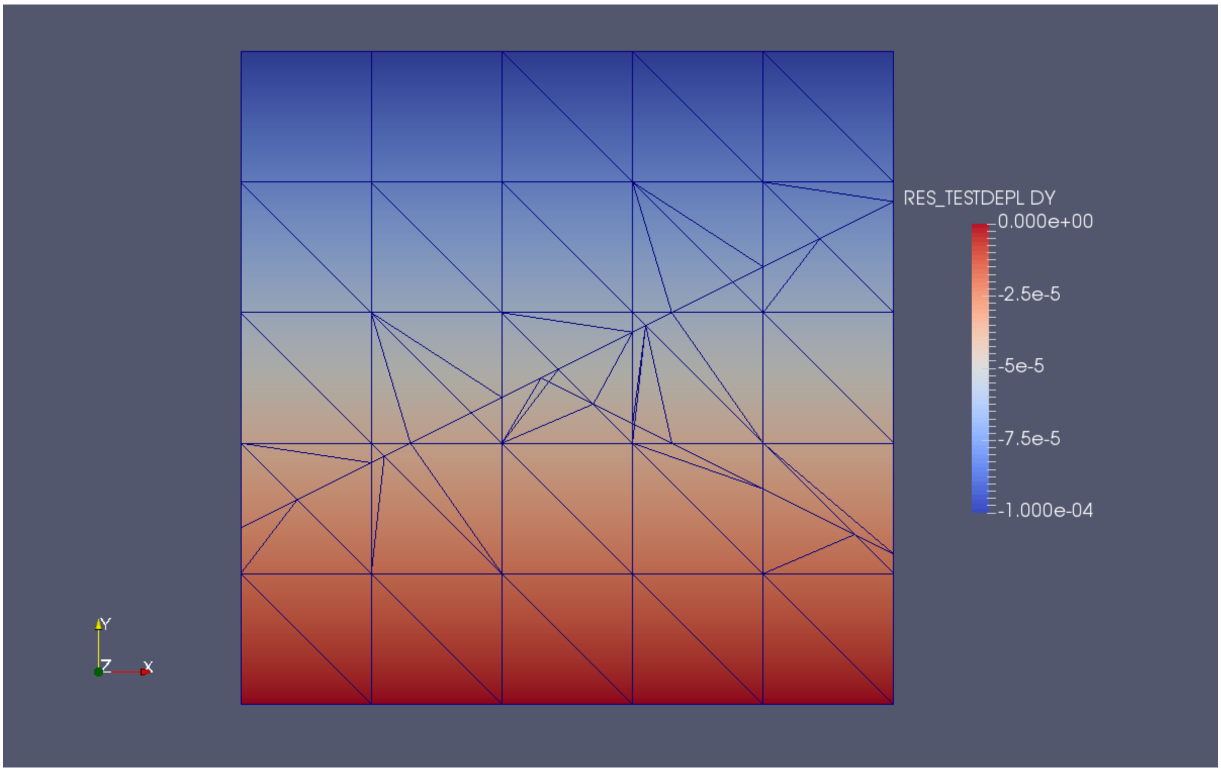


Figure 3.4-b: Field of displacements according to the direction (Othere)

4 Modeling B

4.1 Characteristics of the modélisatioN

It is about a modeling `3D_HM` using quadratic elements HM-XFEM.

4.2 Characteristics of the grid

The block on which one carries out modeling is divided into 25 `HEXA20`.

4.3 Sizes tested and Results

One tests the value of displacement vertical for the nodes A , A' , B , B' , C and C' on both sides of the interface. The tolerance is fixed at 10^{-6} . These values are summarizedES in the table below:

Sizes tested	Type of reference	Value of reference	Tolerance
DZ (node With)	'ANALYTICAL'	4.E5	1, E-06
DZ (node A')	'ANALYTICAL'	4.E5	1, E-06
DZ (node B)	'ANALYTICAL'	4.E5	1, E-06
DZ (node B')	'ANALYTICAL'	4.E5	1, E-06
DZ (node C)	'ANALYTICAL'	6.E5	1, E-06
DZ (node It)	'ANALYTICAL'	6.E5	1, E-06
DX (node With)	'ANALYTICAL'	-5.7E5	1, E-06
DX (node A')	'ANALYTICAL'	-5.7E5	1, E-06
DX (node B)	'ANALYTICAL'	-4.3E5	1, E-06
DX (node B')	'ANALYTICAL'	-4.3E5	1, E-06
DX (node C)	'ANALYTICAL'	-4.7E5	1, E-06
DX (node It)	'ANALYTICAL'	-4.7E5	1, E-06

4.4 Remarks

One also has visualized the field of displacements according to Lhas direction z (Figure 4.4-a and Appears 4.4-b). It is checked that the bar behaves like a bar not fissured.

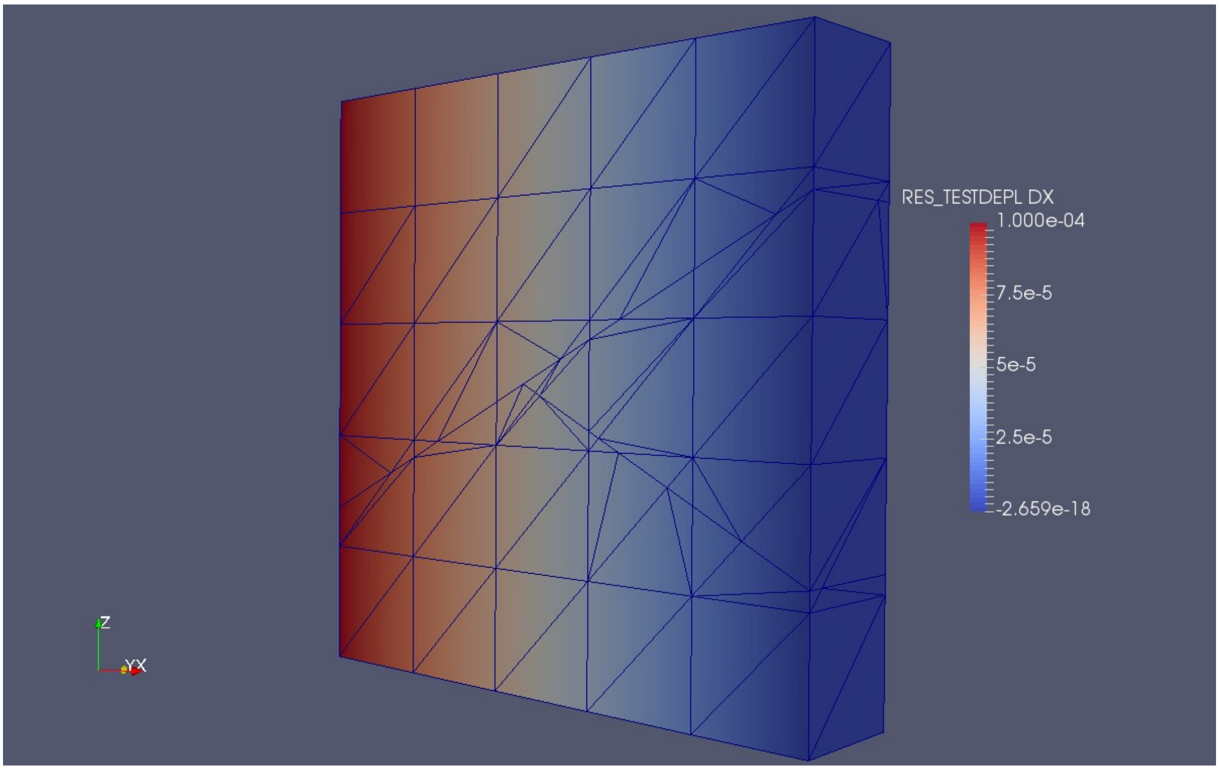


Figure 4.4-a: Field of displacements according to the direction (OX) and deformation

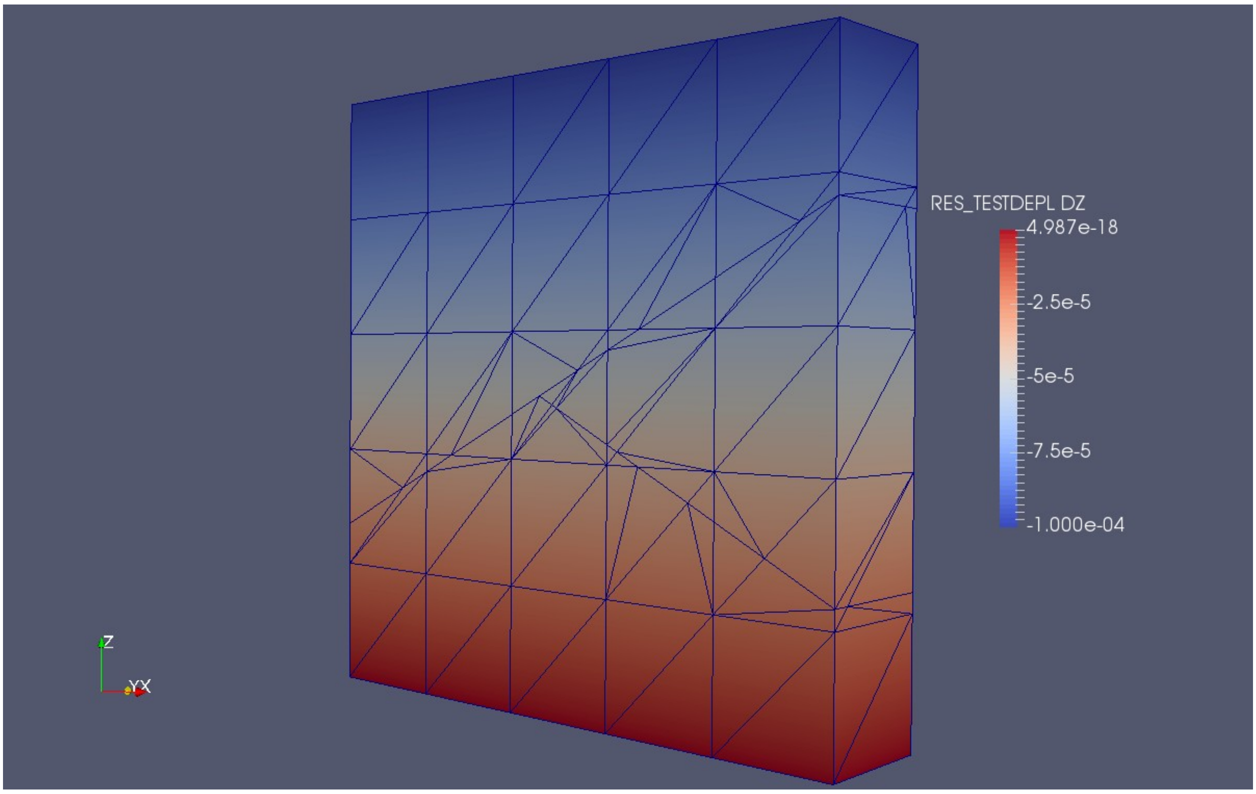


Figure 4.4-b: Field of displacements according to the direction (OZ) and deformation

5 Conclusion

For modeling D_PLAN_HM and modeling 3D_HM, the results agree with the analytical solution. For elements HM-XFEM multi-Heaviside cohesive,, the following features from now on are validated:

- MODI_MODELE_XFEM
- POST_CHAM_XFEM

In the presence of a junction of cohesive interfaces, the fissured bar behaves in compression like a bar not fissured. The contact thus is well taken into account in each branch of interface and on the level of the junction.