WTNV150 – Flow in a junction of interfaces within a porous solid mass: use of method XFEM

Summary:

It is about one test of flow in two cohesive interfaces XFEM hydraulic, the second being connected on the first. One checks the opening of the cohesive zone under the action of the injection of a fluid and the development of a hydraulic fracture. This test comprises only one two-dimensional modeling.

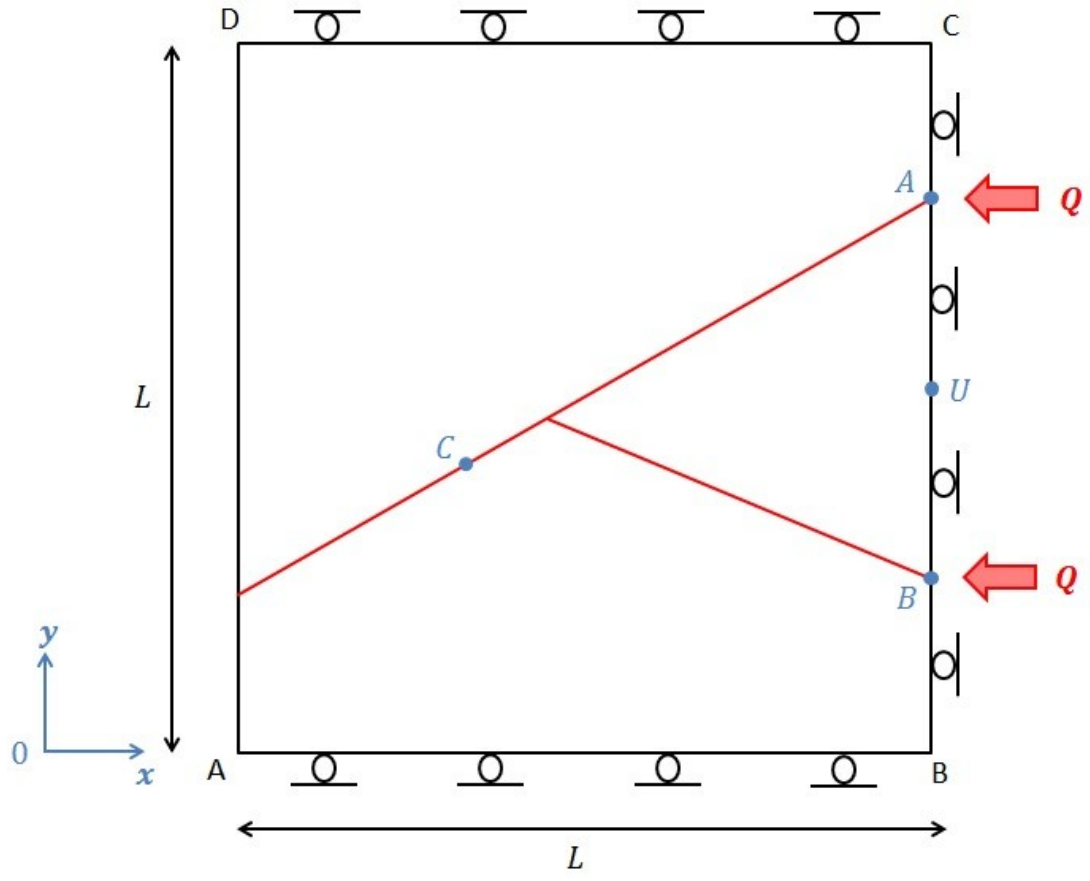
1 Problem of reference

1.1 Geometry of the problem

It is about a block square on side $L=10\,m$. 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). The center of the square and the origin of the reference mark Oxy are confused. First is located by the level-set normal of equation $lsn_1=Y-0.5\,X-0.2$ and entirely the block in the horizontal direction crosses. The second interface is located by the level-set normal of equation $lsn_2=Y+0.5\,X+0.2$. It connects on the lower lip of the first interface. The second interface thus exists only in the part of the block such as $lsn_1<0$. LE not of junction between the two interfaces checks $lsn_1=lsn_2=0$ and has for coordinates $\begin{cases}X=-0.4\\Y=0\end{cases}$. 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 $A(5,2.7)$, $B(5,-2.7)$, $C(-1,-0,3)$, and $U(5,0)$ will be used for the imposition of the boundary conditions and 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	0.25
	Thermal dilation coefficient $\alpha(en\ K^{-1})$	0
Parameters of coupling	Coefficient of Biot b	0,8
	Initial homogenized density $r_0(en\ kg/m^3)$	2,5
	Intrinsic permeability $K^{\text{int}}(en\ m^2)$	10^{-15}
Parameters of the cohesive law	Critical stress $\sigma_c(en\ MPa)$	0.11
	Energy cohesive $G_c(en\ Pa.m)$	50
	Coefficient of increase r	2

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 $\varphi = 0,1$.

1.3 Boundary conditions and loadings

Conditions of Dirichlet that one applies are:

- blocking Dbe displacements according to x on the flat rim field;
- blocking Dbe displacements according to y on Lbe edges inferior and superior of the field;
- blocking D be vertical displacements in the block of the medium;
- blocking Dbe displacements according to y at the point U .

ON injects a flow of specific fluid $Q=0.04\ kg.s^{-1}$ in the interface cohesive withX points A and B for one length of time $t=50\ s$.

2 Sizes and results of reference

2.1 Sizes and results of reference

Under the action of the injection of fluid at the points A and B, the cohesive interfaces open and of the hydraulic fractures develop. One tests the value of the pressure of fluid and the vertical opening on the level of the two injection points A and B on the level of the point U.

2.2 Uncertainty on the solution

One check the not-regression of the computation results.

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 49 QUAD8.

3.3 Sizes tested and results

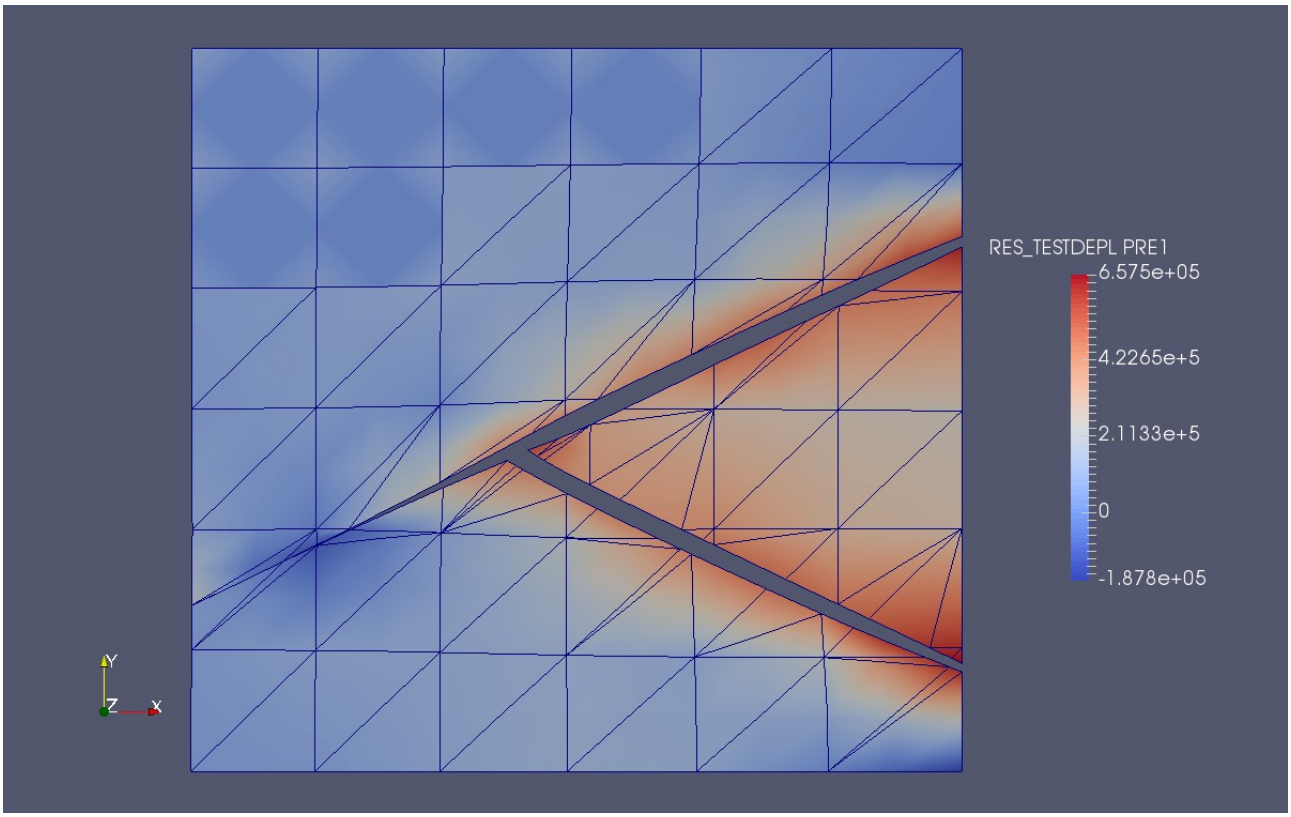
The value of displacement is testedS vertical for the nodes A , B and C who are located on each of the three branches of interfaces as well as the value of the pressure of the fluid in the interface in these 3 points. These values are summarizedES in the table below:

Sizes tested	Type of reference	Value of reference
DY (node With in lower part)	'NON_REGRESSION'	-3.334386E6 m
DY (node With in top)	'NON_REGRESSION'	1.12056089E4 m
DY (node B in lower part)	'NON_REGRESSION'	-6.262943E5 m
DY (node B in top)	'NON_REGRESSION'	7.36284608E5 m
DY (node C in lower part)	'NON_REGRESSION'	8.077092E7 m
DY (node C in top)	'NON_REGRESSION'	6.88647E5 m
PRE_FL1 (node With)	'NON_REGRESSION'	646077 Pa
PRE_FL1 (node B)	'NON_REGRESSION'	579537 Pa
PRE_FL1 (node C)	'NON_REGRESSION'	343080 Pa

3.4 Remarks

One also has visualized the field of pressure of pore as well as the amplified deformation (X1000) (Figure 3.4-a). It is checked that the two branches of hydraulic interfaces fed in fluid propagate until the junction, meet and feed then the third hydraulic branch of interface.

Figure 3.4-a: Field of preSSion of pore and amplified deformation (X1000)



4 Conclusion

This test makes it possible to validate the operation of the junctions of interfaces hydraulicsS with elements HM-XFEM.