WTNP125 - Negative mascon of a Summarized

tank:
The test presented here makes it possible to check the good performance of the elements of joints with hydraulic coupling in saturated medium.

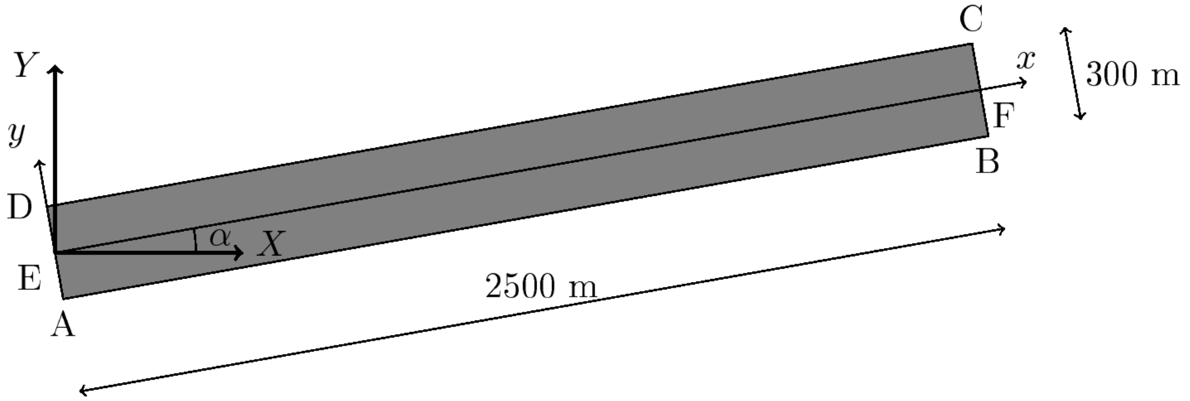
The negative mascon of a tank is modelled (reduction of the importance of a layer because of its operating). This one is initially entirely crossed by a discontinuity and contains single liquid. The constitutive laws of the interface used are the cubic model for the flow and the model of Bandis for the mechanics.

1 Problem of reference

One takes again the benchmark suggested by Guiducci and al.[gui]

1.1 Geometry

One considers a tank separated in two equal parts by a horizontal discontinuity $[EF]$.



The reference (x,y) is defined by discontinuity you it edge of structure. One notes α the angle between the reference (x,y) and the total reference (X,Y).

Coordinates of the points (in meters) in the reference (x,y) :

	x	y		x	y
A	0	-150	D	0.150	
B	2500	-150	E	0	0
C	2500	0	F	2500	0

1.2 Properties of the material

•Properties of the fluid intersticiel (liquid water):

Density	$1000\,kg.m^{-3}$
Viscosity	$1.10^{-3}\,Pa.s$
Compressibility	$3.10^{9}\,Pa$

•Properties of the rock matrix:

The matrix is elastic and has the following properties:

Young modulus	$200\,MPa$
Poisson's ratio	0,25
intrinsic	0,4055

Porosity Permeability	$1{,}688.10^{-17} m^2$

•Properties of discontinuity:

The constitutive laws of discontinuity are detailed in documentation [R7.02.15][docR].

The structural mechanics behavior of discontinuity is given the model of Bandis.

One notes ε the opening of crack, $U_{\max}$ the asymptrotic opening under stress null and $U=U_{\max}-\varepsilon$ the crack closing.

In the normal direction with crack, one has

$$d\,\sigma'_n=-K_{\mathrm{ni}}\frac{dU}{\left(1-\frac{U}{U_{max}}\right)^{\gamma}} \quad (1.2.1)$$

In the tangential direction, one has

$$\sigma'_t=K_t[\![u_t]\!] \quad (1.2.2)$$

normal Stiffness initial K_{ni}	$1.10^9 \, Pa.m^{-1}$
asymptotic Opening U_{max}	$2{,}17 \, mm$
Coefficient γ	2
Tangencial stiffness K_{t}	$1.10^{12} \, Pa.m^{-1}$

flow in crack is given by the cubic model.

1.3 Initial conditions

the initial conditions are the following ones:
•initial opening ε_0 : $3{,}04.10^{-4} m$
•initial pressure in the solid mass: $48{,}7 \, MPa$
•compressive stress in the two directions of the plane: $62 \, MPa$

1.4 Boundary conditions

the mechanical and hydraulic boundary conditions are given by figures 1.4.1 to 1.4.3.

On $[AB]$: displacements blocked in y and hydraulic flux no one
On $[BC]$: displacements blocked in x and hydraulic flux no one
On $[CD]$: mechanical pressure of $62 \, MPa$ and hydraulic flux no one
On $[DA]$: mechanical pressure of $62 \, MPa$ and imposed pressure p^*

the evolution of the pressure p^* imposed by the well located $x=0$ is the following one (see also figure 1.4.3):

•Linear reduction in $48{,}7\,MPa$ with $33{,}7\,MPa$ during $7{,}5$ the first years of operating
•Maintains with $33{,}7\,MPa$ for $12{,}5$ the following years.

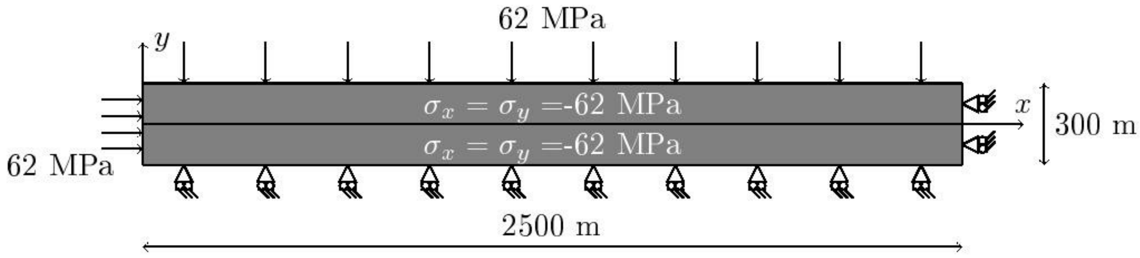


Illustration 1.4.1: Boundary conditions and initial mechanical

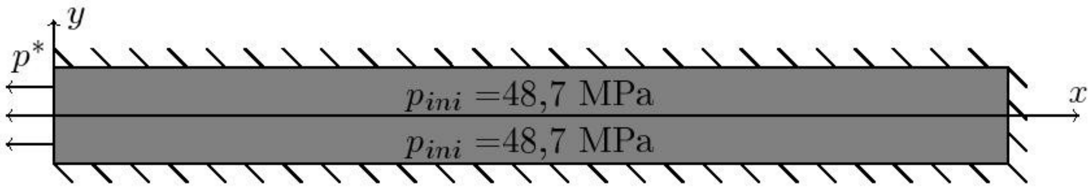


Illustration 1.4.2: Boundary conditions and initial hydraulic

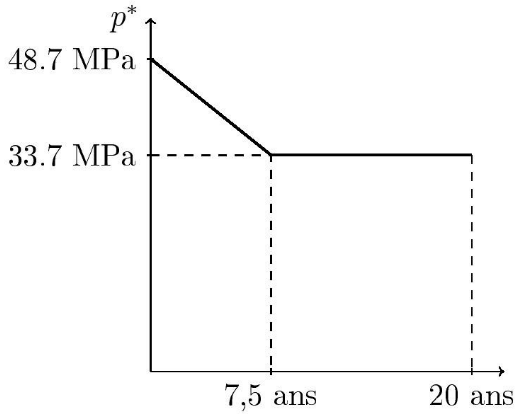


Illustration 1.4.3: Scenario of operating

2 Reference solution

One compares the results with those obtained by *LAGAMINE*, the code of finite elements for the géomechanics of the University of Liege.

2.1 bibliographical References

[1] Guiducci, C., Hake, F., Radu, J.P., Pellegrino, A., Charlier, R., “Numerical modeling of Hydro-Mechanical fracture behavior”, ISRM 2003-Technology roadmap for rock'n'roll mechanics, South African Institute of Mining and Metallurgy, 2003

[2] “Modelization of cracks with hydraulic coupling in porous environment saturated”, Handbook of reference of *Code_Aster*, R7.02.15

3 Modelization A

3.1 Characteristic of the modelization A

the total reference is selected so that discontinuity is horizontal in this reference ($\alpha=0°$ thus an Eulerian angle of $90°$).

The modelization is realized in plane strain with 1092 elements `QU4` for the solid mass and 91 elements `QU4` for discontinuity.

Discretization in time:
- 25 time step for $7{,}5$ first years
- 25 time step for $12{,}5$ the following years.

3.2 Quantities tested and results

One compares the results got with *Code_Aster* with those obtained by code *LAGAMINE*.

One presents the profile of pressure along discontinuity to $7{,}5$ and 20 years (figure 3.2.1), the variations of the opening along discontinuity with $7{,}5$ and 20 years (figure 3.2.2) and outgoing flux of crack on the level of the well per day (figure 3.2.3).

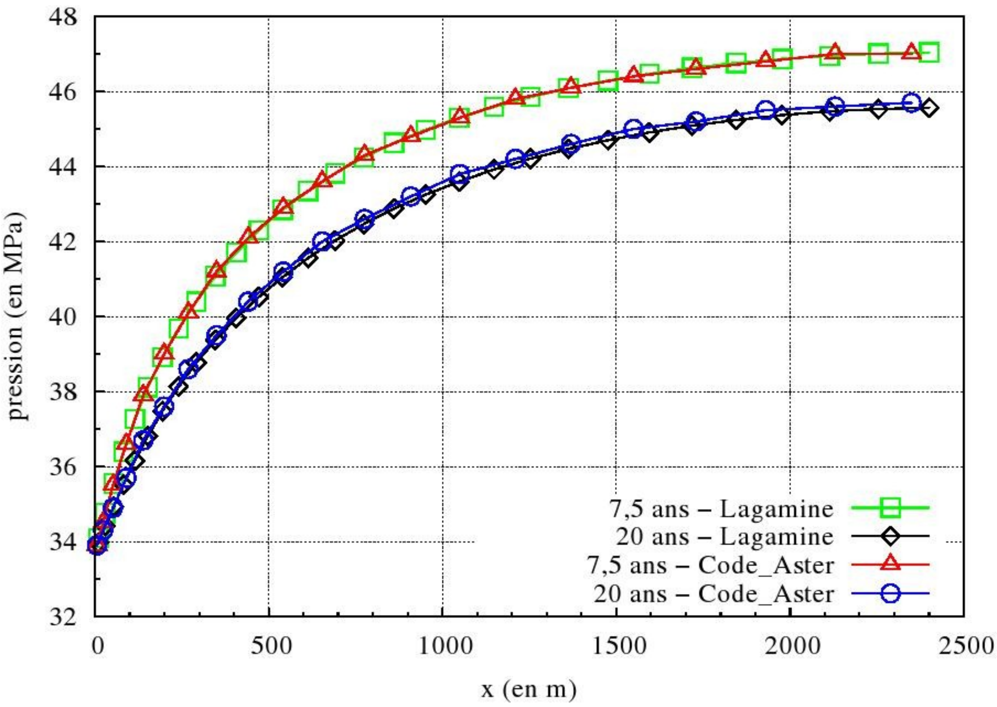


Illustration 3.2.1: Pressure along discontinuity with 7,5 years and 20 years and comparison with the results of *LAGAMINE*

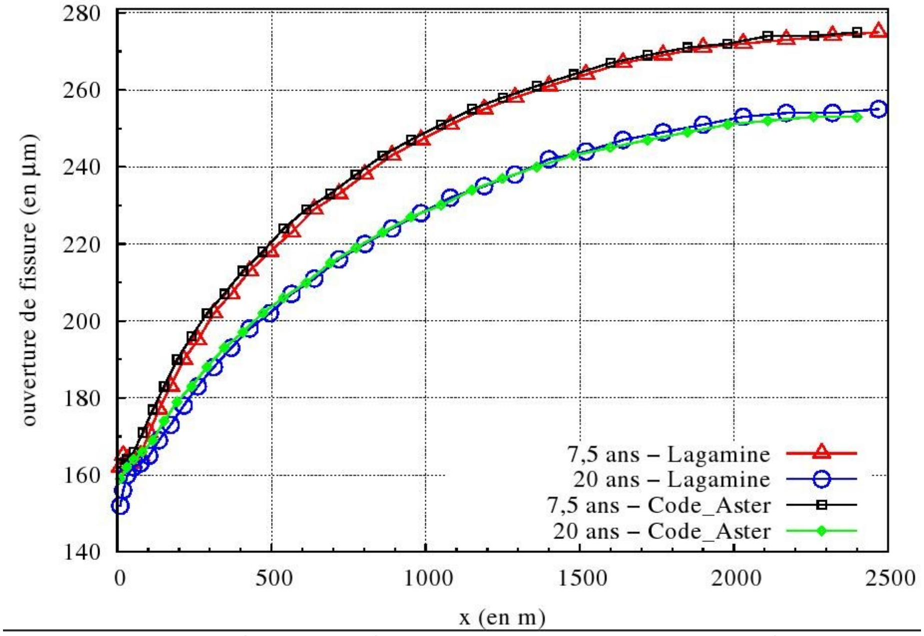


Illustration 3.2.2: Opening of discontinuity along the tank after 7,5 and 20 years and comparison with the results of *LAGAMINE*

the results are almost identical to those obtained with *LAGAMINE*.

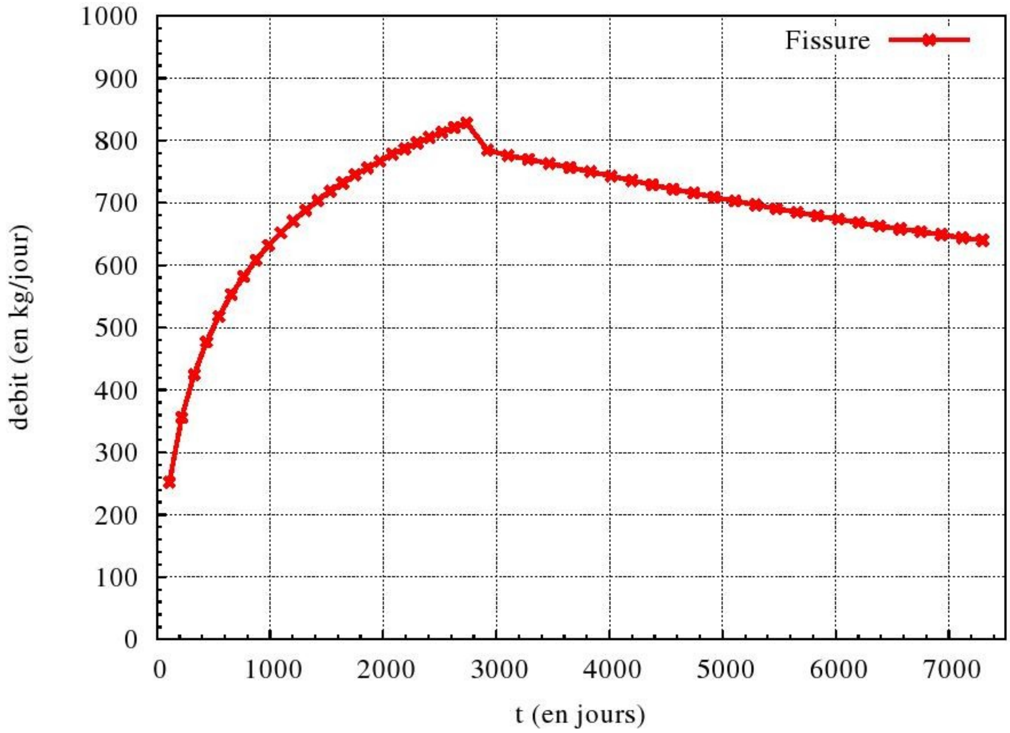


Illustration 3.2.3: Outgoing mass throughput of crack on the level of the well per day during the time obtained with *Code_Aster*

the values of reference are those obtained with *LAGAMINE*.

$X(m)$	$Y(m)$	**Time (years)**	**Reference** $PRE1$ **(** MPa **)**	**Tolerance (** $\%$ **)**
256,97	0.7,5		39,95	1.0%
516,51	0.7,5		42,68	1.0%
256,97	0	20	38,45	1.0%
516,51	0	20	40,98	1.0%

$X(m)$	$Y(m)$	**Times (years)**	**Reference** $V1$ **(** m **)**	**Tolerance (** $\%$ **)**
516,51	0.7,5		2,20E-04	1.0%
516,51	0	20	2,04E-04	1.0%

One adds a case of non regression:

$X(m)$	$Y(m)$	**Time (years)**	**Reference** $FH11X$ $(kg.m^{-1}.s^{-1})$	**Tolerance (** $\%$ **)**
516,51	0.7,5		-7,0189E-03	0.10%
516,51	0	20	-5,3847E-03	0.10%

4 Modelization B

4.1 Characteristic of the modelization

In order to check that the results are independent of the directional sense of discontinuity (given by the Eulerian angles defined in AFFE_CARA_ELEM), one takes again the modelization A with a rotation of $\alpha=-90°$. The direct reference defined by the norm and the tangent in crack is then identical to the total reference. The Eulerian angle is thus equal to zero.

4.2 Quantities tested and results

$X(m)$	$Y(m)$	**Time (years)**	**Reference** $PRE1$ **(** MPa **)**	**Difference (** $\%$ **)**
256,97	0.7,5		39.95	1.0%
516,51	0.7,5		42,68	1.0%
256,97	0	20	38,45	1.0%
516,51	0	20	40,98	1.0%

$X(m)$	$Y(m)$	**Times (years)**	**Reference** $V1$ (m)	**Difference (** $\%$ **)**
516,51	0.7,5		2,20E-04	1.0%
516,51	0	20	2,04E-04	1.0%

One adds a case of non regression:

$X(m)$	$Y(m)$	**Time (years)**	**Reference** $FH11X$ $(kg.m^{-1}.s^{-1})$	**Difference (** $\%$ **)**
516,51	0.7,5		-7,0189E-03	0.10
516,51	0	20	-5,3847E-03	0.10

5 Summary of the results

One tests here the element of joint with hydraulic couplings with several crack directional senses. One obtains in all the cases with *Code_Aster* of the results identical to those obtained with *LAGAMINE*.