WTNP119 – Modelization the model planes swelling of a clay with ELAS_GONF

Summarized:

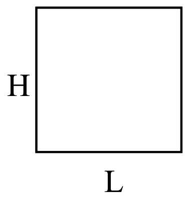
This test makes it possible to the model validate known as ELAS_GONF which was developed by Dashnor Hoxha (LAEGO) and was used and validated in the frame of a benchmark on the modelization of the cells of waste C (see bibliography). This nonlinear elastic model depend on suction, described the inflating behavior of certain types of clay. Typically it is used to model the behavior of the stoppers of clay compacted - or bentonite - used to close the cells of storage of radioactive waste.

This model is written according to the couple of variables according to: the clear stress and suction (suction is the capillary pressure).

This test represents the pressure of swelling of a clay cell which one fills with water. This benchmark is the variation of the case test WTNA110 to a plane geometry.

1 Problem of reference

1.1 Geometry



height: $H=1\text{m}$
width $L=1\,m$

1.2 Properties of the material

elastic Properties:

$$E=150\,10^{6}\,Pa$$
$$\nu=0.3$$

Parameters specific to model `ELAS_GONF` :

$\beta_m=0.1142$
Pressure of reference $A=1.\,Mpa$

hydraulic Properties:

Liquid water	Density ($kg.m^{-3}$)	1.103
	Heat with constant pressure ($J.K^{-1}$)	4180
	thermal coefficient of thermal expansion of the fluid (K^{-1})	10-4
	Compressibility ($Pa-1$)	5.10-10
	Viscosity ($Pa.s$)	10-3
Gases	Molar mass ($kg.\,Mol^{-1}$)	0,002
	Heat with pressure constant ($J.K^{-1}$)	1000
	Viscosity ($Pa.s$)	9. 10-6
Squelette	Heat capacity with constant stress ($J.K^{-1}$)	1000
Constant	Constant of perfect gases	8,315
homogenized Coefficients	homogenized Density ($kg.m^{-3}$)	2000
	Coefficient of Biot	1
	Parameters of the model of Van-Genuchten	
	N	1,61
	$Pr(Mpa)$	16.10^{6}

	Sr	0
State of reference	Porosity	0,366
	Temperature (K)	303
	capillary Pressure (Pa)	0.
	Pressure of gas (Pa)	10

1.3 Initial conditions

To $t=0$:

$Pgaz=1\text{atm}$

$S=0,5$ null ($Pc=44,7\,Mpa$ formula $p_w=-44.6\,Mpa$ formula

) total Stress.

1.4 Boundary conditions and loadings

All displacements are blocked with edge ($DX=DY=0$).
The flux are null.

Initial saturation is of $50\,\%$: one increases saturation and one follows the evolution of the total stress. By definition, the pressure of swelling is the stress obtained with complete resaturation.

For that one imposes on the group of the field a loading in capillary pressure decreasing linearly in 1s enters $44,7\,Mpa$ and $-10\,Mpa$.

2 Bibliographical references

1 Gerard, P., Charlier R., Barnichon, J.D., Known, K. Shao, J-F, Duveau, G., Giot, R., Chavant, C. Hake, F. “Numerical modeling of coupled mechanics and gas transfer” Newspaper of Theoretical and Applied Mechanics, Sofia, 2008, vol. 38, No 1, pp. 101-120.

3 Modelization A

3.1 Characteristic of the modelization

Modelization `D_PLAN_HH2MS` on a single mesh `QUAD8`.

Coordinates of the nodes of the mesh (unit):

Nodes	X	Y
$N1$	0	0
$N2$	1	0
$N3$	1	1
$N4$	0	1.0,5
$N5$		0
$N6$	1.0,5.0,5	
$N7$		1
$N8$	0.0,5	

One second is simulated by 500 time step.

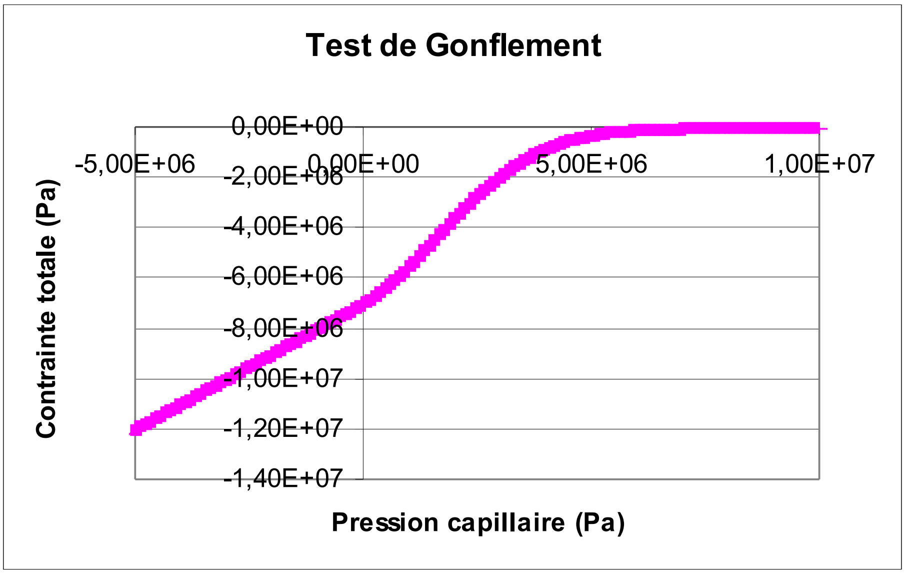
3.2 Results

Appear 3.2-a watch evolution of the total stress according to the capillary pressure (homogeneous in any point, postprocessing is made here with the node $N3$). In the saturated part ($P_c \leq 0$) the capillary pressure decrease corresponds to an increase in pressure of water and the total stress grows linearly. It is noted that the slope of the curve is continuous.

The parameters A and β_m were calculated so as to find a pressure of swelling of 7MPa . Indeed, when saturation reaches 1 (or the capillary pressure 0), the pressure of swelling is given by the following formula:

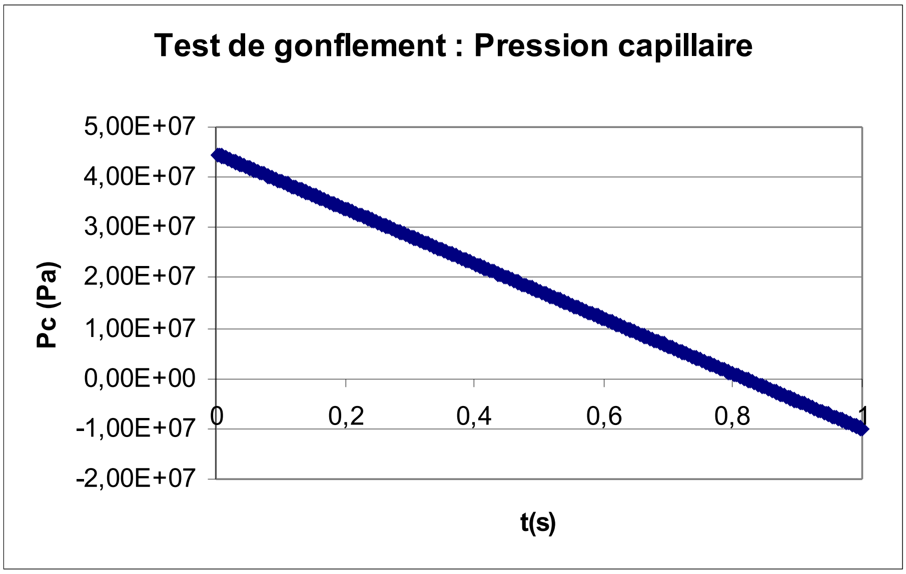
$$\frac{P_{gf}}{A} = \frac{\sqrt{\pi}}{2\sqrt{\beta_m}} + \frac{1}{2\beta_m}$$

One thus finds well the classical pace of the stress of swelling and one checks that the curve cuts well the y-axis ($P_c = 0$) with a value of $7\,Mpa$.



Appear 3.2-a test of swelling

One recalls on the figure the evolution of the capillary pressure according to time corresponding to the loading of problem:



Appear 3.2-b : capillary pressure ($N3$)

3.3 Quantities tested and results

This case test does not have a value of reference, one thus makes a case of non regression of them. One carries out tests on two values:

N	**Times (s)**	$SIXX$ **Aster**
$N3$	$0,6$	$-4,56.10^4$
$N3$	0.8163	$-5,67.10^6$

4 Modelization B

4.1 Characteristic of the modelization

Even modelization that the modelization A but in HH2MS, suction being imposed the results which depend on it does not change.

4.2 Quantities tested and Time

N	results (s)	$SIXX$ Aster
$N3$	0,6	$-4{,}56.10^{4}$
$N3$	0.8163	$-5{,}67.10^{6}$

5 Modelization C

5.1 Characteristic of the modelization

Even modelization that the modelization A but in THH2MS, suction being imposed the results which depend on it does not change.

5.2 Quantities tested and Time

N	results (s)	$SIXX$ **Aster**
$N3$	0,6	$-4{,}56.10^{4}$
$N3$	0.8163	$-5{,}67.10^{6}$

6 Modelization D

6.1 Characteristic of the modelization

Even modelization that the modelization B but in THHMS, suction being imposed the results which depend on it does not change.

6.2 Quantities tested and Time

N	results (s)	$SIXX$ Aster
$N3$	0.6	$-4{,}56.10^{4}$
$N3$	0.8163	$-5{,}67.10^{6}$

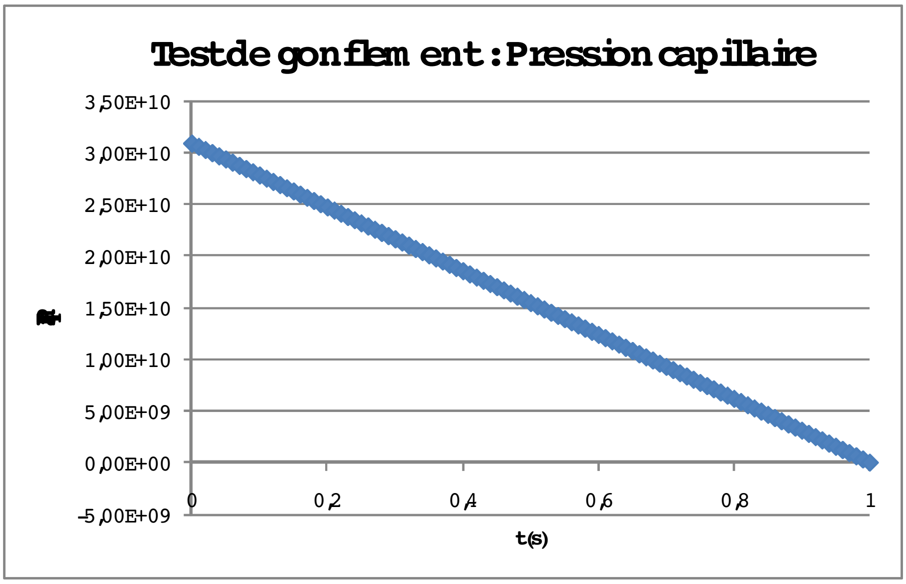
7 Modelization E

7.1 Characteristic of the modelization

It acts in this modelization to start from a state completely désaturé ($S=0,0099$ instead of $S=0,5$ previously) in order to see the aptitude of the code for treating this kind of borderline case. That makes it possible to validate the routines of regularization of the permeability used in this case.

The hydraulic constitutive law is `LIQU_AD_GAZ`, all the rest is identical to the modelization has (`D_PLAN_HH2MS`).

Capillary pressure according to the time corresponding in the same way to the loading of problem:



Appear 7.1-aa : capillary pressure ($N3$)

7.2 Quantities tested and results

the behavior is well that expected and corresponds to that observed in preceding simulations if it is not that the resaturation is logically later.

This case test does not have values of reference, one thus makes a case of non regression of them.

One carries out tests on two values:

N	**Time (** s **)**	$SIXX$ **Aster**
$N3$	$0,8$	$0.$
$N3$	1	$-1,7.10^7$