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

Summary:

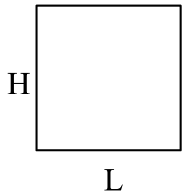
This test makes it possible to validate the model known as ELAS_GONF who was developed by Dashnor Hoxha (LAEGO) and was used and validated within the framework of a benchmark on the modeling of the cells of waste C (see bibliography). This model nonlinear rubber band depend on suction, described the 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 constraint and suction (suction is the capillary pressure).

This test represents the pressure of swelling of a clay cell which one fills with water. This CAS-test 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 material

Elastic properties:

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

Parameters specific to the model `ELAS_GONF` :

$$\beta_m=0.1142$$

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

Hydraulic properties:

Liquid water	Density ($kg.m^{-3}$)	1.10^{3}
	Heat with constant pressure ($J.K^{-1}$)	4180
	thermal dilation coefficient of the liquid (K^{-1})	10^{-4}
	Compressibility ($Pa-1$)	5.10^{-10}
	Viscosity ($Pa.s$)	10^{-3}
Gas	Molar mass ($kg.\,Mol^{-1}$)	0.002
	Heat with constant pressure ($J.K^{-1}$)	1000
	Viscosity ($Pa.s$)	$9.\,10^{-6}$
Skeleton	Heat-storage capacity with constant constraint ($J.K^{-1}$)	1000
Constants	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.
	Gas pressure (Pa)	10

1.3 Initial conditions

With $t=0$:

$Pgaz=1\text{atm}$

$S=0{,}5$ (either $Pc=44{,}7\,Mpa$ and $p_w=-44.6\,Mpa$)

Worthless total constraint.

1.4 Boundary conditions and loadings

All displacements are blocked at the edge ($DX=DY=0$).
Flows are worthless.

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

For that one imposes on the whole of the field a loading in capillary pressure decreasing linearly in 1s enter $44{,}7\,Mpa$ 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 Modeling A

3.1 Characteristics of modeling

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

Coordinates of the nodes of the grid (unit):

Nodes	X	Y
$N1$	0	0
$N2$	1	0
$N3$	1	1
$N4$	0	1
$N5$	0.5	0
$N6$	1	0.5
$N7$	0.5	1
$N8$	0	0.5

One second is simulated by 500 pas de time.

3.2 Results

Figure 3.2-a watch the evolution of the total constraint 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 constraint grows linearly. It is noted that the slope of the curve is continuous.

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 constraint of swelling and one checks that the curve cuts the y-axis well ($P_c = 0$) with a value of $7\,Mpa$.

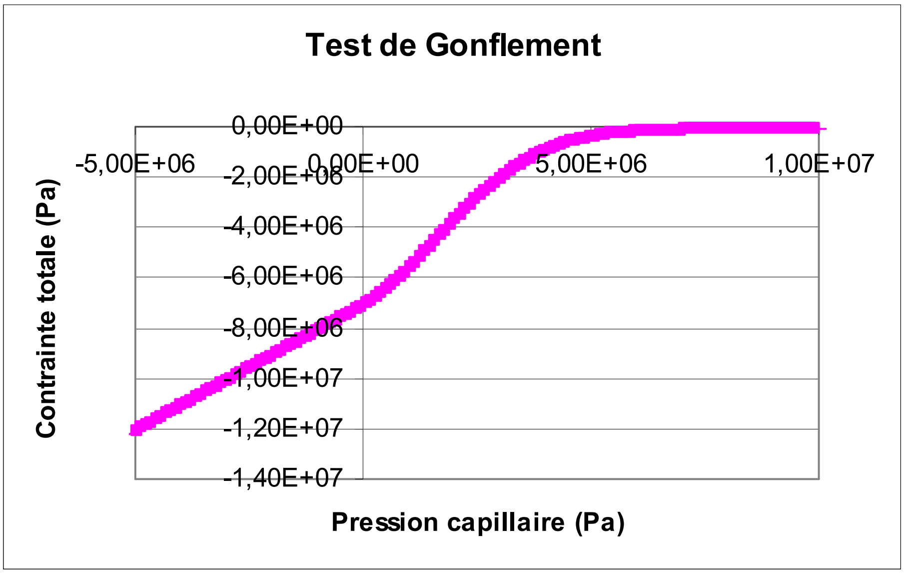


Figure 3.2-a test of swelling

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

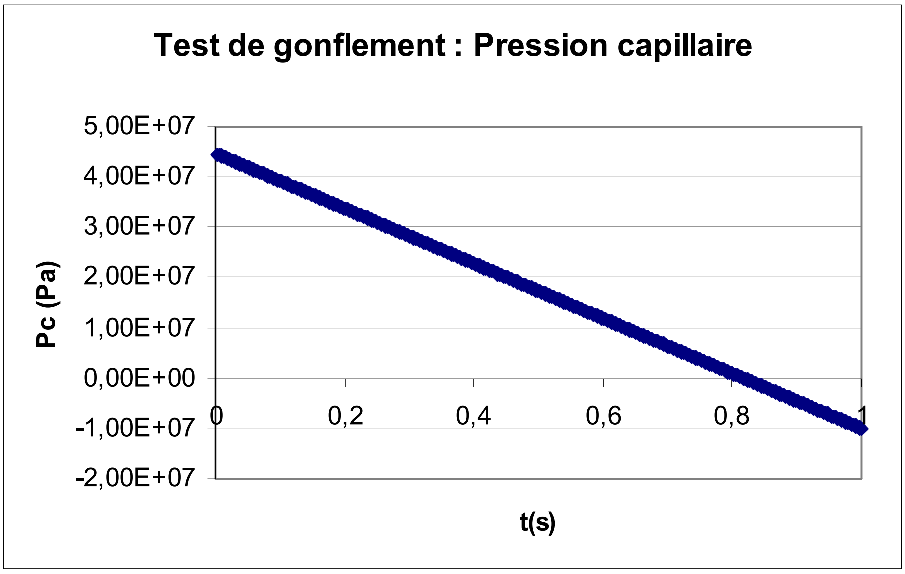


Figure 3.2-b : capillary pressure ($N3$ **)**

3.3 Sizes tested and results

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

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

4 Modeling B

4.1 Characteristics of modeling

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

4.2 Sizes tested and results

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

5 Modeling C

5.1 Characteristics of modeling

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

5.2 Sizes tested and results

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

6 Modeling D

6.1 Characteristics of modeling

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

6.2 Sizes tested and results

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

7 Modeling E

7.1 Characteristics of modeling

It is a question in this modeling of starting from a completely désaturé state ($S=0{,}0099$ instead of $S=0{,}5$ previously) in order to see the aptitude of the code to treat this kind of borderline case. That makes it possible to validate the routines of regularization of the permeability used in this case.

The hydraulic law of behavior is `LIQU_AD_GAZ`, all the rest is identical to modeling has (`D_PLAN_HH2MS`).

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

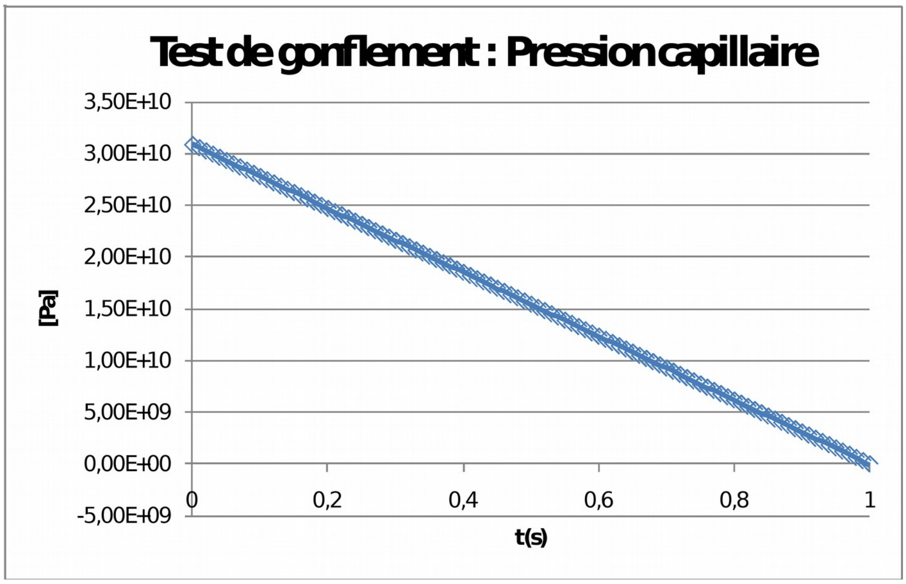


Figure 7.1-a : capillary pressure ($N3$ **)**

7.2 Sizes 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 of them a case of nonregression.

One carries out tests on two values:

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