WTNV136 – Modeling 3D of the swelling of a clay with the model ELAS_GONF

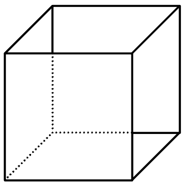
Summary:

This test makes it possible to validate the model known as " ELAS_GONF " which 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. 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 geometry $3D$.

1 Problem of reference

1.1 Geometry



A cube of $1\,m$ of with dimensions.

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 $pw=-44.6\,Mpa$)
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 $-10\,Mpa$.

1.5 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.

2 Modeling A

2.1 Characteristics of modeling

Modeling 3D _HH2MS on 1 mesh HEXA20.

1 second is simulated by 500 pas de time.

2.2 Result of modeling A

Figure 2.2-a watch evolution of the total constraint according to the homogeneous capillary pressure in any point. The post treatment is made here with the node $N8$ coordinates $(0,5\ ;0,5\ ;0,5)$. In the saturated part ($Pc \leq 0$), 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 Error: Reference source not found so as to find a pressure of swelling of $7\,MPa$. 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 ($PC=0$) with a value of $7\,Mpa$.

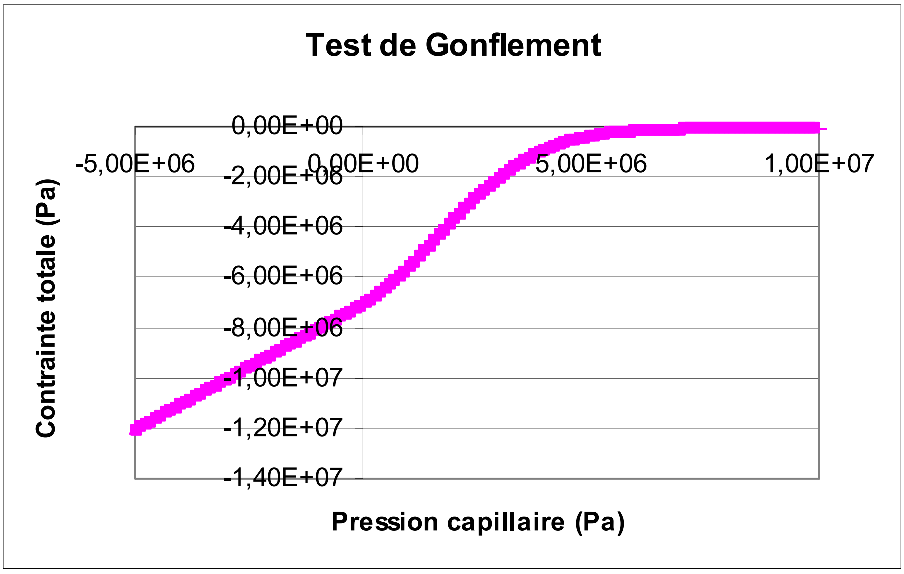


Figure 2.2-a test of swelling

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

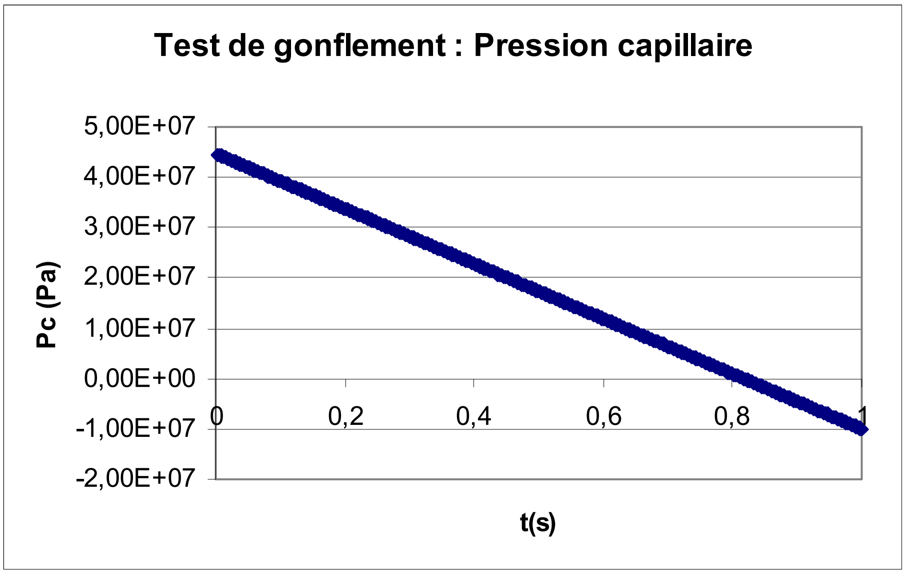


Figure 2.2-b : capillary pressure (N3)

2.3 Sizes tested and results

This CAS-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	Authorized relative error (%)
$N8$	0.6	-4,56.10 [4]	0.1%
$N8$	0.8163	-5,67.10 [6]	0.1%

3 Modeling B

3.1 Characteristics of modeling

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

3.2 Sizes tested and results

N	Time (s)	$SIXX$ Aster	Authorized relative error ($\%$)
$N8$	0.6	$-4{,}56.10^{4}$	0.1%
$N8$	0.8163	$-5{,}67.10^{6}$	0.1%

4 Modeling C

4.1 Characteristics of modeling

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

4.2 Sizes tested and results

N	Time (s)	$SIXX$ Aster	Authorized relative error ($\%$)
$N8$	0.6	$-4{,}56.10^{4}$	0.1%
$N8$	0.8163	$-5{,}67.10^{6}$	0.1%

5 Modeling D

5.1 Characteristics of modeling

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

5.2 Values tested

N	Time (s)	$SIXX$ Aster	Authorized relative error (%)
$N8$	0.6	$-4{,}56.10^{4}$	0.1%
$N8$	0.8163	$-5{,}67.10^{6}$	0.1%