WTNA110 – Axisymmetric modelization of the swelling of a clay with the model ELAS_GONF

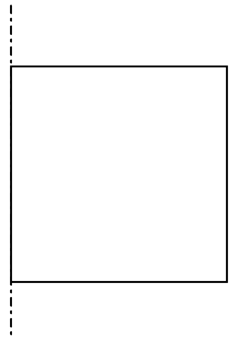
Summarized:

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 5.2. 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. The geometry is axisymmetric here.

1 Problem of reference

1.1 Geometry



height: $h=1\mathrm{m}$
width (radius): $l=1\,m$

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
	$Pr(Pa)$	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

a: $t=0$

- $Pgaz=1\text{atm}$
- $S=0,5$ (that is to say $Pc=44,7\,Mpa$ and $p_w=-44.6\,Mpa$)
- Forced total null.

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 $-10\,Mpa$.

1.5 Bibliography

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 Modelization A

2.1 Characteristic of the modelization

Axis_HH2MS `Modelization` on 1 Quad8 `mesh`.

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	

1 second is simulated by 500 time step.

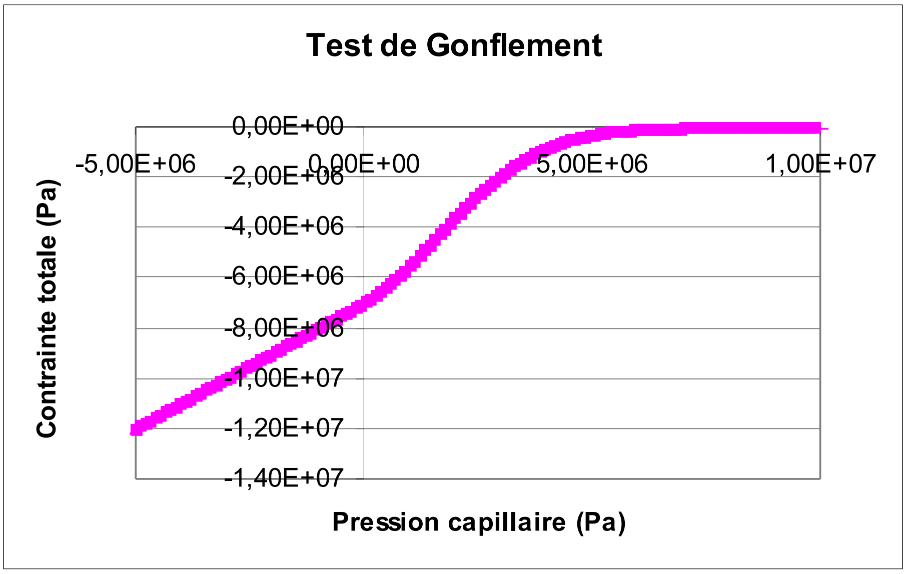
2.2 Result of the modelization To

Appear 2.2-a watch evolution of the total stress according to the capillary pressure (homogeneous in any point, the post processing is made here with the node $N3$). In the saturated part ($Pc \leq 0$) 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 5.2 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:

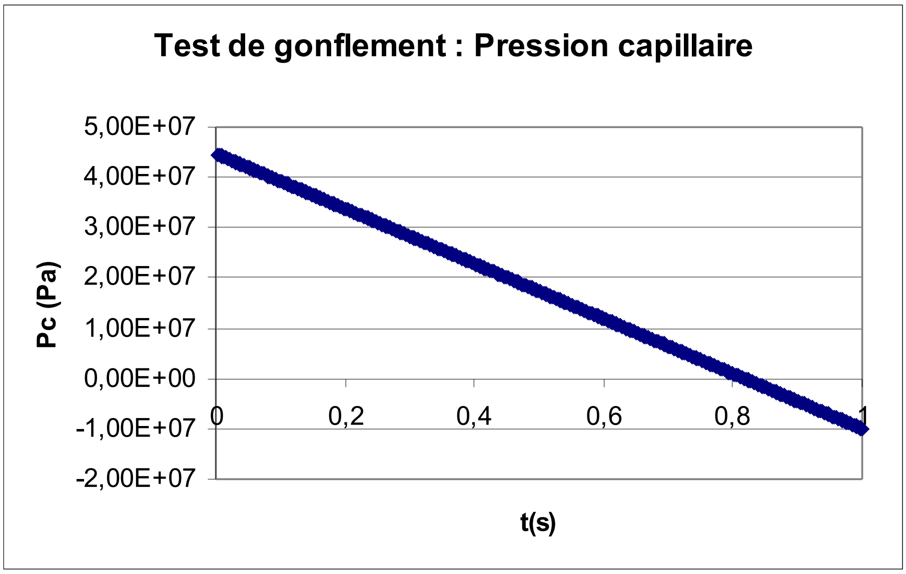
$$\frac{P_{gf}}{A} = \frac{\sqrt{\pi}}{2\sqrt{\beta_m}} + \frac{1}{2\beta_m}$$

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



Appear 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 problem:



Appear 2.2-b : capillary pressure ($N3$)

2.3 Values tested

This benchmark 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	**Time (s)**	$SIXX$ **Aster**	**authorized relative Error ($\%$)**
$N3$	0,6	$-4{,}56.10^{4}$	0.1%
$N3$	0.8163	$-5{,}67.10^{6}$	0.1%

3 Modelization B

3.1 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.

3.2 Quantities tested and Time

N	results (s)	$SIXX$ Aster	authorized relative Error (%)
$N3$	0,6	-4,56.104	0.1%
$N3$	0.8163	-5,67.106	0.1%

4 Modelization C

4.1 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.

4.2 Quantities tested and Time

N	**results (s)**	$SIXX$ ***Aster***	**authorized relative Error ($\%$)**
$N3$	0,6	-4,56.104	0.1%
$N3$	0.8163	-5,67.106	0.1%

5 Modelization D

5.1 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.

5.2 Quantities tested and Time

N	**results (s)**	$SIXX$ ***Aster***	**authorized relative Error (%)**
$N3$	0,6	$-4,56.10^{4}$	0.1%
$N3$	0.8163	$-5,67.10^{6}$	0.1%