WTNP114 - Case test of reference for the calculation of the mechanical deformations

Summary:

This test aims to validate the postprocessing of the mechanical deformations in THM: EPSI_ELGA and EPSI_ELNO.

With this two-dimensional problem is dealt with a modeling $2D$.

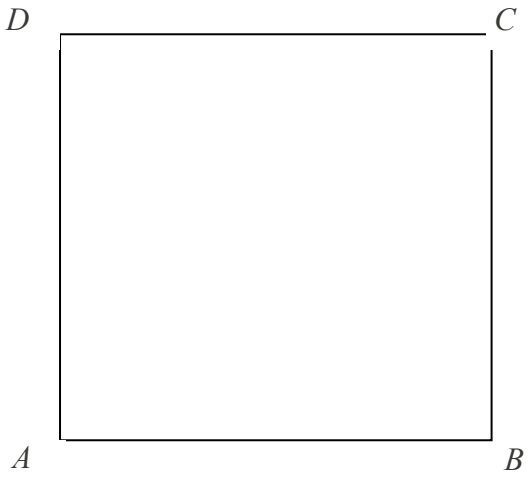
The treated features are, in particular:

- pressure distributed,
- strains and stresses with the nodes,

The reference solution is an analytical solution.

1 Problem of reference

1.1 Geometry



Coordinates of the points:

	A	B	C	D
x	-1.	1.	1.	-1
y	-1.	-1.	1.	1

1.2 Material properties

Elastic properties

$E=5800\,MPa$

$\nu=0.3$

Parameters of the mixing rate

These data, although present in the command file do not play any part in the analytical solution since one imposes a condition to block the thermohydraulic part.

1.3 Boundary conditions and loadings

Conditions of symmetry :
- Segment AB : $DY=0$.
- Segment AD : $DX=0$.

Loading :
- Segment CD : pressure distributed $P_1=15.4\,MPa$
- Segment BC : pressure distributed $P_1=11\,MPa$
- On all the geometry: Pressure of the liquid $P_l=0\,MPa$

2 Reference solution

2.1 Method of calculating used for the reference solution

It is about an analytical solution.

Indeed, although the introduced law is a law of THM, only the mechanical part is active here because the pressure of liquid is imposed worthless everywhere on the field.
Moreover with regard to the mechanical part, one imposed an elastic law by choosing it KIT_THM ELAS like mechanical law.

Thus, being given the boundary conditions and the loading, one a:

$\sigma_{xx}=11\ MPa$ on all surface
$\sigma_{yy}=15.4\ MPa$ on all surface
Moreover, we are in plane deformations is $\varepsilon_{zz}=0$

However like $\varepsilon=\frac{1+\nu}{E}\sigma-\frac{\nu}{E}Tr(\sigma)\ I$

That is to say $\varepsilon_{zz}=0=\frac{\sigma_{zz}}{E}-\frac{\nu}{E}\sigma_{xx}-\frac{\nu}{E}\sigma_{yy}$
From where $\sigma_{zz}=\nu(\sigma_{xx}+\sigma_{yy})$

Thus $\sigma_{zz}=7.92\ MPa$

One thus obtains the values of the deformations thanks to the elastic law

$\varepsilon_{xx}=6.9034482759\ 10^{-4}$
$\varepsilon_{yy}=1.67655172414\ 10^{-3}$

The other values of the tensor of the strains (and stresses) are worthless.

One calculates also the displacement of the structure.

$$\varepsilon_{xx}=\frac{\partial u_x}{\partial x}$$
$$\varepsilon_{yy}=\frac{\partial u_y}{\partial y}$$

$u_x(x,y)=\varepsilon_{xx}x+u_x(0,0)$
$u_y(x,y)=\varepsilon_{yy}y+u_y(0,0)$

However by reason of symmetry $u_A=u(-1,-1)=0$, therefore
$u_x(0,0)=\varepsilon_{xx}$
$u_y(0,0)=\varepsilon_{yy}$
one is interested in displacement at the point C, of coordinates $(1,1)$
One thus has:

$$u_x(C)=2\,\varepsilon_{xx}=1.3806896551\ 10^{-3}$$
$$u_y(C)=2\,\varepsilon_{yy}=3.35310344828\ 10^{-3}$$

2.2 Results of reference

Displacements u_x and u_y at the point C and deformations $\left(\varepsilon_{xx},\ \varepsilon_{yy}\right)$ at the points A, B, C and D

2.3 Uncertainty on the solution

Analytical solution

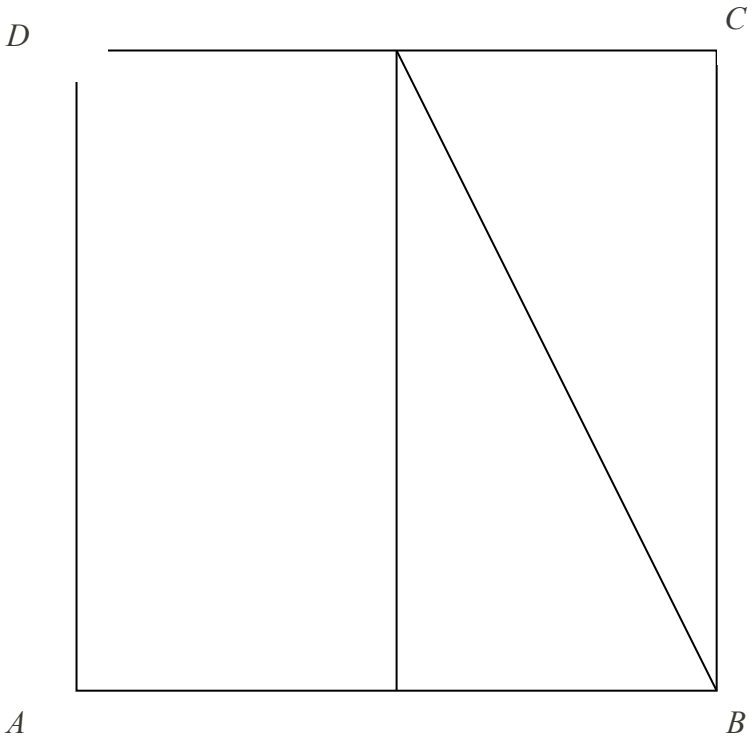
2.4 Bibliographical references

1. C. CHAVANT: Modelings THHM. General information and algorithms, R7.01.10 document
2. C. CHAVANT, B. CIREE: Law of behavior to double Drücker-Prager criterion for the cracking and the compression of the concrete, R7.01.03 document

3 Modeling A

3.1 Characteristics of modeling

Elements $2D$ (QUAD8 and TRIA6)



Limiting conditions:
- line AB blocked in dy
- line AD blocked in dx
- pressure on the line BC : $p=11.$
- pressure on the line CD : $p=15.4$
- Names of the nodes:
  - $A=N1$
  - $B=N2$
  - $C=N3$
  - $D=N4$

3.2 Characteristics of the grid

Many nodes: 14
Many meshs and types: 1 QUA8, 2 TRIA6 and 6 SEG3

3.3 Sizes tested and results

Localization	Size	Reference	% tolerance
A	ε_{xx}	-6.9034482759000 10^{-4}	<10^{-4}
	ε_{vv}	-1.6765517241400 10^{-3}	<10^{-4}

B	ε_{xx}	-6.9034482759000 10^{-4}	$<10^{-4}$
	ε_{yy}	-1.6765517241400 10^{-3}	$<10^{-4}$
C	u_x	-1.3806896558000 10^{-3}	$<10^{-4}$
	u_y	-3.3531034482800 10^{-3}	$<10^{-4}$
	ε_{xx}	-6.9034482759000 10^{-4}	$<10^{-4}$
	ε_{yy}	-1.6765517241400 10^{-3}	$<10^{-4}$
D	ε_{xx}	-6.9034482759000 10^{-4}	$<10^{-4}$
	ε_{yy}	-1.6765517241400 10^{-3}	$<10^{-4}$

4 Summary of the results

The results got by Code_Aster are perfectly in conformity with the analytical references.