SSNV180 - Taking into account of thermal thermal expansion and the creep of desiccation in models BETON_UMLV_FP and Summarized

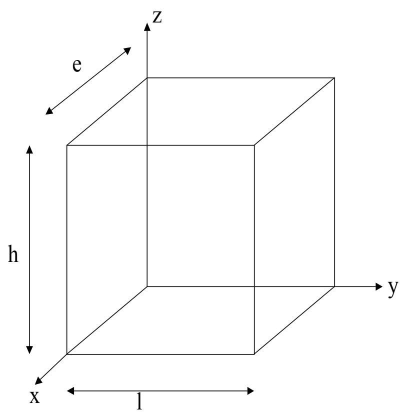
BETON_BURGER_FP:

This test makes it possible to validate the taking into account of thermal thermal expansion and the creep of desiccation in constitutive laws BETON_UMLV_FP and BETON_BURGER_FP. The results of this test are compared with a numerical solution obtained with Scilab 2.7.2 in the case of a modelization 3D (BETON_UMLV_FP) and a numerical solution obtained with python for BETON_BURGER_FP (SSNV180B.44).

Modelization a: Creep test with thermal thermal expansion for the model BETON_UMLV_FP
Modelization b: Creep test with thermal thermal expansion for the model BETON_BURGER_FP

1 Problem of reference

1.1 Geometry



Height:	$h=1{,}00[m]$
Width:	$l=1{,}00[m]$
Thickness:	$e=1{,}00[m]$

1.2 Properties of the material

$E=31\ [GPa]$	elasticity modulus
$\nu=0{,}2$	Poisson's ratio
$k_{re}=60\ [\mu m/m]$	endogenous coefficient of shrinkage
$k_{rd}=10\ [\mu m/m.m^3/l]$	coefficient of shrinkage of thermal
$\alpha=10\ [\mu m/m/°C]$	desiccation coefficient of thermal expansion

Here one informs also the curved sorption-desorption which connects the water content C to the hygroscopy h.
In this case one supposed that the two quantities were connected by the following linear relation:
C [l/m3] = h [%].

Parameters specific to the creep of desiccation:

$$\eta_{fd}=5.30E+4\ [MPa.s]$$

Parameters specific to BETON_UMLV_FP :

$k_r^s = 1{,}20E+5 \ [MPa]$	spherical part: stiffness connects associated with the squelette formed by blocks with hydrates on a spherical left
$k_i^s = 6{,}22E+4 \ [MPa]$	mesoscopic scale: stiffness connects intrinsically associated with the hydrates on a deviatoric left
$k_r^d = 3{,}86E+4 \ [MPa]$	microscopic scale: stiffness associated with the capacity with water adsorbed to transmit loads (*load bearing toilets*)
$\eta_r^s = 2{,}21E+10 \ [MPa.s]$	spherical part: viscosity connects associated with the mechanism with diffusion within spherical left
$\eta_i^s = 4{,}16E+10 \ [MPa.s]$	capillary porosity: viscosity connects associated with the mechanism with deviatoric diffusion
$\eta_r^d = 6{,}19E+10 \ [MPa.s]$	interlamellaire left: viscosity associated with the water adsorbed by the averages with hydrates
$\eta_i^d = 1{,}64E+12 \ [MPa.s]$	left deviatoric: viscosity of free water.

Parameters specific to BETON_BURGER_FP :

$k_r^s = 1{,}20E+5 \ [MPa]$	spherical part: stiffness connects associated with the reversible field with the differed strains
$k_r^d = 3{,}86E+4 \ [MPa]$	deviatoric part: stiffness associated associated with the reversible field with the differed strains
$\eta_r^s = 2{,}21E+10 \ [MPa.s]$	spherical part: viscosity connects associated with the reversible field with the differed strains
$\eta_i^s = 4{,}16E+10 \ [MPa.s]$	spherical part: viscosity connects associated with the mechanism with deviatoric left
$\eta_r^d = 6{,}19E+10 \ [MPa.s]$	irreversible diffusion: viscosity associated with the reversible field with the differed strains
$\eta_i^d = 1{,}64E+12 \ [MPa.s]$	deviatoric part: viscosity connects associated with the irreversible mechanism of diffusion
$\kappa = 3.0 \times 10^{-3}$	Normalizes unrecoverable deformations controlling to it not linearity applied to the modulus of the long-term strains

1.3 Boundary conditions and loadings

In this test, one creates a homogeneous field of drying in structure varying linearly over period a 750 days, initial moisture is worth 100% (condition of a sealed test-tube) and decrease gradually until 50% with the 750ème day.

The degree of hydration varies linearly from 0 to 1 between initial time and the 28th day.

The reference temperature is worth $20°C$. The thermal loading corresponds to a rise in temperature varying from $20°C$ and $40°C$ between initial time and final moment.

The mechanical loading corresponds to an one-way compression according to the vertical direction (z in $3D$); its intensity is of $12[MPa]$. The load is applied in $1s$ and is maintained constant for 100 days.

1.4 Initial conditions

the beginning of computation is supposed with time -1. A this time there is neither field of drying, nor forced mechanical.

To time 0, one applies a field of drying corresponding to 100% hygroscopy, a field of hydration corresponding to a null advance and a thermal field with the reference temperature.

2 Reference solution

2.1 Method of calculating

One did not develop the analytical solution for this hydro-mechanical loading. Also, the reference solution is obtained numerically by means of the software Scilab 2.7.2 for BETON_UMLV_FP or python for BETON_BURGER_FP. Each component of strain is calculated separately:

the strains of endogenous shrinkage are given from the relation:

$\varepsilon_{re} = k_{re}.\beta$ where β the degree of hydration of the material indicates

the strains of shrinkage of desiccation are given from the relation:

$\dot{\varepsilon}_{rd} = k_{rd}.\dot{C}$ where C the water content of the material indicates

the strains of thermal thermal expansion are given from the relation:

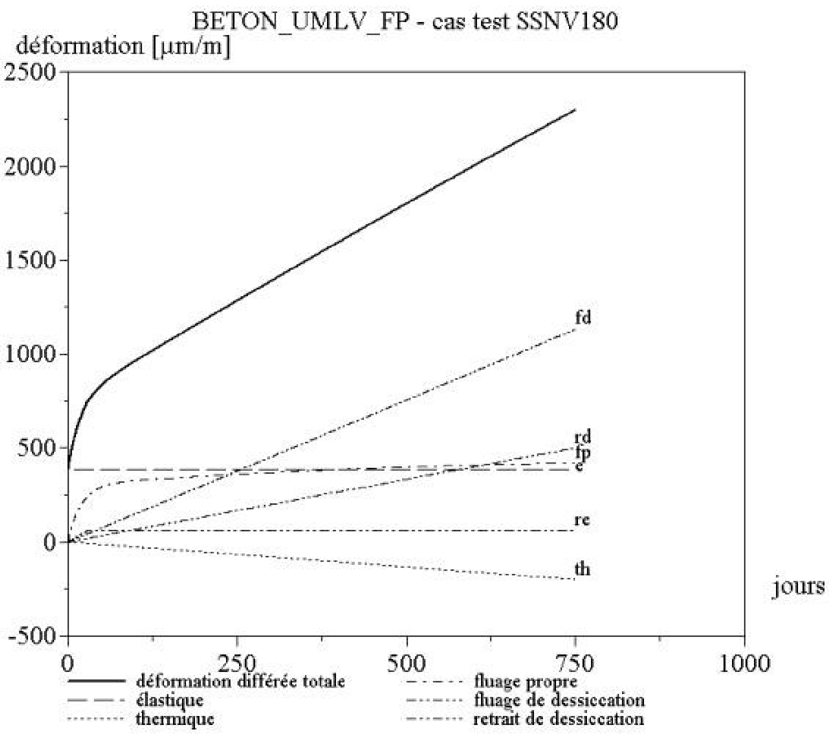
$\varepsilon_{th} = \alpha(T - T_{ref})$ where T and T_{ref} indicate the temperature at time respectively running and the reference temperature of the material

the strains of clean creep are calculated numerically by means of a discretization identical to that established in *the Code_Aster* for BETON_UMLV_FP and an establishment according to an explicit diagram for BETON_BURGER_FP. The temporal discretization is then necessarily finer for the explicit diagram.

the strains of creep of desiccation are calculated analytically from the relation:

$\dot{\varepsilon}_{fd} = \frac{1}{\eta_{fd}}|\dot{h}|\sigma$ where $h = f(C)$ the moisture of the material indicates

the results of computation with Scilab are presented in the figure below.



2.2 Quantities and results of reference

the test is homogeneous. One tests the strain in an unspecified node.

2.3 Uncertainties on the solution

Result numerical obtained with Scilab 2.7.2 or python (SSNV180B.44)

2.4 bibliographical References

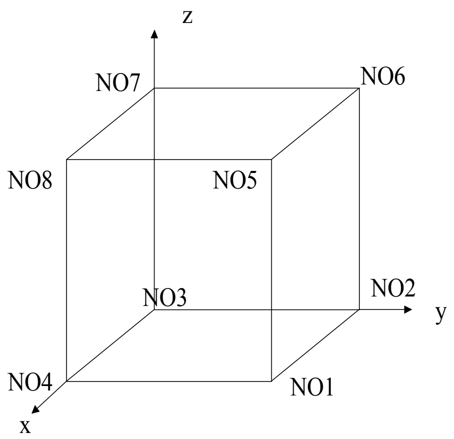
[1] LE POPE Y.: Behavior model UMLV for the clean creep of the concrete, Documentation of reference of *Code_Aster*, [R7.01.06] 16 p (2002).

[2] FOUCAULT A.: Behavior model BETON_BURGER_FP for the clean creep of the concrete, Documentation of reference of Code-Aster, [R7.01.35], 2011.

3 Modelization A

3.1 Characteristic of the modelization

Modelization 3D



3.2 Characteristic of the mesh

Many nodes:	8
Number of meshes:	1 of type HEXA 8
	6 of type QUAD4

One defines the meshes following ones:

S_ARR	*NO3 NO7 NO8 NO4*
S_AVT	*NO1 NO2 NO6 NO5*
S_DRT	*NO1 NO5 NO8 NO4*
S_GCH	*NO3 NO2 NO6 NO7*
S_INF	*NO1 NO2 NO3 NO4*
S_SUP	*NO5 NO6 NO7 NO8*

The boundary conditions in displacement imposed are:

On the nodes $NO1$ $NO2$, $NO3$ and $NO4$: $DZ=0$
On the nodes $NO3$ $NO7$, $NO8$ and $NO4$: $DY=0$
On the nodes $NO2$ $NO6$, $NO7$ and $NO8$: $DX=0$

The loading is consisted by the same field of drying and of the same nodal force, $1/4$ applied to the four nodes of S_SUP .

3.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
ε_{xx} to the node $NO6$ to time 64800	"SOURCE_"	-4.081E-04	0.50%
ε_{xx} to the node $NO6$ to time 648000	"ANALYTIQUE"	-5.25E-04	0.50%
ε_{xx} to the node $NO6$ to time 6480000	"ANALYTIQUE"	-9.065E-04	0.50%
ε_{xx} to the node $NO6$ to time 64800000	"ANALYTIQUE"	-2.299E-03	0.50%

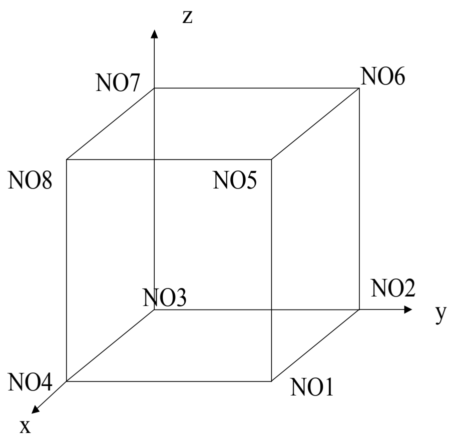
One of the mesh test the strains due to the creep of desiccation as well as the strains related to the command variables on the first Gauss point M_1 :

Standard	identification of reference	Value of reference	Tolerance
EPTHER_L to time 49	"NON_REGRESSION"	8.3E-6	0.10%
EPTHER_T to time 49	"NON_REGRESSION"	8.3E-6	0.10%
EPTHER_T to time 49	"NON_REGRESSION"	8.3E-6	0.10%
EPSECH to time 49	"NON_REGRESSION"	-2.075E-5	0.10%
EPHYDR to time 49	"NON_REGRESSION"	-6.0E-5	0.10%
EPXX to time 49	"NON_REGRESSION"	0.	0.10%
EPYY to time 49	"NON_REGRESSION"	0.	0.10%
EPZZ to time 49	"NON_REGRESSION"	-4.69811E-5	0.10%

4 Modelization B

4.1 Characteristic of the modelization

Modelization `3D`



4.2 Characteristic of the mesh

Many nodes:	8
Number of meshes:	1 of type `HEXA 8`
	6 of type `QUAD4`

One defines the meshes following ones:

S_ARR	*NO3 NO7 NO8 NO4*
S_AVT	*NO1 NO2 NO6 NO5*
S_DRT	*NO1 NO5 NO8 NO4*
S_GCH	*NO3 NO2 NO6 NO7*
S_INF	*NO1 NO2 NO3 NO4*
S_SUP	*NO5 NO6 NO7 NO8*

The boundary conditions in displacement imposed are:

On the nodes *NO1* *NO2* , *NO3* and *NO4* : $DZ=0$
On the nodes *NO3* *NO7* , *NO8* and *NO4* : $DY=0$
On the nodes *NO2* *NO6* , *NO7* and *NO8* : $DX=0$

The loading is consisted by the same field of drying and of the same nodal force, $1/4$ applied to the four nodes of S_SUP .

4.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
ε_{zz} to the node $NO6$ to time 64800	"SOURCE_EXTERNE"	-4.15E-04	0.50%
ε_{zz} to the node $NO6$ to time 648000	"SOURCE_EXTERNE"	-5.82E-04	0.50%
ε_{zz} to the node $NO6$ to time 6480000	"SOURCE_EXTERNE"	-1.36E-03	0.50%
ε_{zz} to the node $NO6$ to time 64800000	"SOURCE_EXTERNE"	-4.38E-03	0.50%

One of the mesh test the strains due to the creep of desiccation as well as the strains related to the command variables on the first Gauss point M_1 for sequence number 49 of result concept:

Standard	identification of reference	Value of reference	Tolerance
EPTHER_L	"ANALYTIQUE"	8.3E-6	0.10%
EPTHER_T	"ANALYTIQUE"	8.3E-6	0.10%
EPTHER_T	"ANALYTIQUE"	8.3E-6	0.10%
EPSECH	"ANALYTIQUE"	-2.075E-5	0.10%
EPHYDR	"ANALYTIQUE"	-6.0E-5	0.10%
EPXX (Creep of desiccation)	"ANALYTIQUE"	0.	0.10%
EPYY (Creep of desiccation)	"ANALYTIQUE"	0.	0.10%
EPZZ (Creep of desiccation)	"ANALYTIQUE"	-4.69811E-5	0.10%

5 Summary of the results

the values obtained with *Code_Aster* is in agreement with the numerical values of the solution of reference.