

SSNV180 - Taking into account of thermal dilation and the creep of desiccation in the models BETON_UMLV and BETON_BURGER

Summary:

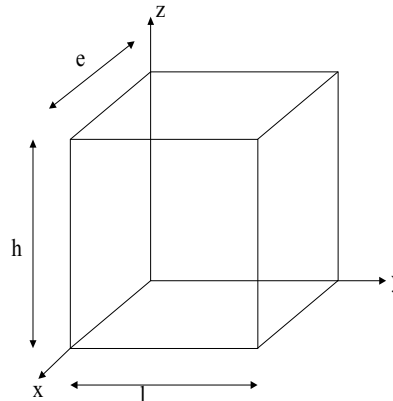
This test makes it possible to validate the taking into account of thermal dilation and the creep of desiccation in the laws of behavior `BETON_UMLV` and `BETON_BURGER`. The results of this test are compared with a digital solution obtained with Scilab 2.7.2. in the case of a modeling 3D (`BETON_UMLV`) and a digital solution obtained with python for `BETON_BURGER` (SSNV180B.44).

Modeling a: Creep test with thermal dilation for the model `BETON_UMLV`

Modeling b: Creep test with thermal dilation for the model `BETON_BURGER`

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 material

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

Here one informs also the curved sorption-desorption which connects the water content C with the hygroscopy h .

In this case one supposed that the two quantities were connected by the following linear relation:

$$C [l/m^3] = h [\%].$$

Parameters specific to the creep of desiccation:

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

Parameters specific to BETON_UMLV :

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

Parameters specific to BETON_BURGER :

$k_r^s = 1,20E + 5$ [MPa]	spherical part: rigidity connects associated with the reversible field with the differed deformations
$k_r^d = 3,86E + 4$ [MPa]	deviatoric part: rigidity associated associated with the reversible field with the differed deformations
$\eta_r^s = 2,21E + 10$ [MPa.s]	spherical part: viscosity connects associated with the reversible field with the differed deformations
$\eta_i^s = 4,16E + 10$ [MPa.s]	spherical part: viscosity connects associated with the irreversible mechanism of diffusion
$\eta_r^d = 6,19E + 10$ [MPa.s]	deviatoric part: viscosity associated with the reversible field with the differed deformations
$\eta_i^d = 1,64E + 12$ [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 module of the long-term deformations

1.3 Boundary conditions and loadings

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

The degree of hydration varies linearly from 0 to 1 between the initial moment and the 28^{ème} day.

The temperature of reference is worth 20°C. The thermal loading corresponds to a rise in temperature varying from 20°C and 40°C between the initial moment and the 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 calculation is supposed at the moment -1 . At this moment there is neither field of drying, nor forced mechanical.

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

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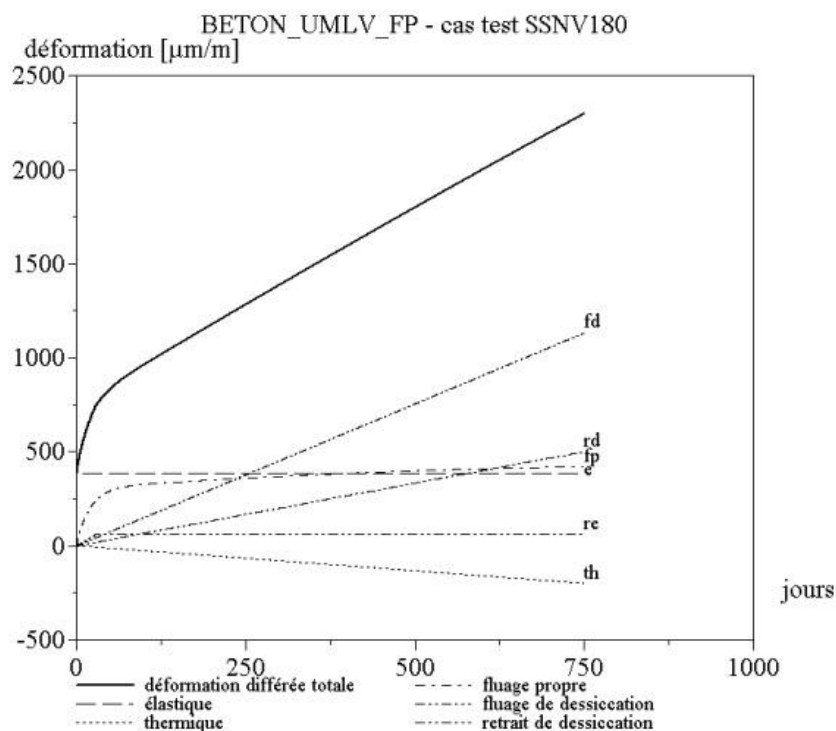
2 Reference solution

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 using the software Scilab 2.7.2 for BETON_UMLV or python for BETON_BURGER. Each component of deformation is calculated separately:

- the deformations of endogenous withdrawal are given starting from the relation:
 - $\varepsilon_{re} = k_{re} \cdot \beta$ where β indicate the degree of hydration of material
- the deformations of withdrawal of desiccation are given starting from the relation:
 - $\dot{\varepsilon}_{rd} = k_{rd} \cdot \dot{C}$ where C indicate the water content of material
- the deformations of thermal dilation are given starting from the relation:
 - $\varepsilon_{th} = \alpha(T - T_{ref})$ where T and T_{ref} the temperature at the moment running and the temperature of reference of material indicate respectively
- the deformations of clean creep are calculated numerically by using a discretization identical to that established in Code_Aster for BETON_UMLV and an establishment according to a diagram clarifies for BETON_BURGER. The temporal discretization is then necessarily finer for the explicit diagram.
- the deformations of creep of desiccation are calculated analytically starting from the relation:
 - $\dot{\varepsilon}_{fd} = \frac{1}{\eta_{fd}} \left| \dot{h} \right| \sigma$ where $h = f(C)$ indicate the moisture of material

The results of calculation with Scilab are presented in the figure below.



2.2 Sizes and results of reference

The test is homogeneous. One tests the deformation in an unspecified node.

2.3 Uncertainties on the solution

Digital result got with Scilab 2.7.2 or python (SSNV180B.44)

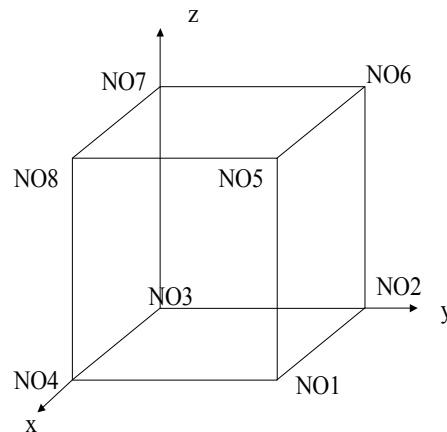
2.4 Bibliographical references

- [1] POPE Y.: Relation of behavior UMLV for the clean creep of the concrete, Reference material of *Code_Aster*, [R7.01.06] 16 p (2002).
- [2] FOUCAULT A.: Relation of behavior `BETON_BURGER` for the clean creep of the concrete, Reference material of *Code-Aster*, [R7.01.35], 2011.

3 Modeling A

3.1 Characteristics of modeling

Modeling 3D



3.2 Characteristics of the grid

Many nodes: 8
Many meshes: 1 of type HEXA 8
6 of type QUAD 4

The following meshes are defined:

```
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 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
ε_{xx} with the node NO6 at moment 64800	'SOURCE_'	-4.081E-04	0,50%
ε_{xx} with the node NO6 at moment 648000	'ANALYTICAL'	-5.25E-04	0,50%
ε_{xx} with the node NO6 at moment 6480000	'ANALYTICAL'	-9.065E-04	0,50%
ε_{xx} with the node NO6 at moment 64800000	'ANALYTICAL'	-2.299E-03	0,50%

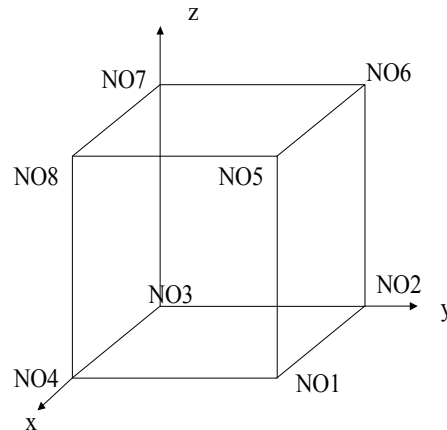
One tests the deformations due to the creep of desiccation as well as the deformations related to the variables of orders on the first point of Gauss of the mesh M_1 :

Identification	Type of reference	Value of reference	Tolerance
EPHER_L at the moment 49	'NON_REGRESSION'	8.3E-6	0,10%
EPHER_T at the moment 49	'NON_REGRESSION'	8.3E-6	0,10%
EPHER_T at the moment 49	'NON_REGRESSION'	8.3E-6	0,10%
EPSECH at the moment 49	'NON_REGRESSION'	-2.075E-5	0,10%
EPHYDR at the moment 49	'NON_REGRESSION'	-6.0E-5	0,10%
EPXX at the moment 49	'NON_REGRESSION'	0.	0,10%
EPYY at the moment 49	'NON_REGRESSION'	0.	0,10%
EPZZ at the moment 49	'NON_REGRESSION'	-4.69811E-5	0,10%

4 Modeling B

4.1 Characteristics of modeling

Modeling 3D



4.2 Characteristics of the grid

Many nodes: 8
Many meshes: 1 of type HEXA 8
6 of type QUAD 4

The following meshes are defined:

```
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 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
ε_{zz} with the node NO6 at moment 64800	'SOURCE_EXTERNE'	-4.15E-04	0,50%
ε_{zz} with the node NO6 at moment 648000	'SOURCE_EXTERNE'	-5.82E-04	0,50%
ε_{zz} with the node NO6 at moment 6480000	'SOURCE_EXTERNE'	-1.36E-03	0,50%
ε_{zz} with the node NO6 at moment 64800000	'SOURCE_EXTERNE'	-4.38E-03	0,50%

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

Identification	Type of reference	Value of reference	Tolerance
EP_THER_L	'ANALYTICAL'	8.3E-6	0,10%
EP_THER_T	'ANALYTICAL'	8.3E-6	0,10%
EP_THER_T	'ANALYTICAL'	8.3E-6	0,10%
EPSECH	'ANALYTICAL'	-2.075E-5	0,10%
EPHYDR	'ANALYTICAL'	-6.0E-5	0,10%
EPXX (Creep of desiccation)	'ANALYTICAL'	0.	0,10%
EPYY (Creep of desiccation)	'ANALYTICAL'	0.	0,10%
EPZZ (Creep of desiccation)	'ANALYTICAL'	-4.69811E-5	0,10%

5 Summary of the results

Values obtained with Code_Aster are in agreement with the digital values of the solution of reference.