SSNV105 - Model `BETON_GRANGER_V` : creep test with taking into account of the relative humidity and ageing.

Summary:

This CAS-test of nonlinear quasi-static mechanics simulates a uniaxial creep test. It aims to validate the relation of behavior of “Granger”, making it possible to model the clean creep of the concretes. This model makes it possible to take into account the effects of the hygroscopy and ageing.

It is about a CAS-test on the material point, realized using the order `SIMU_POINT_MAT`.
The pressure applied is constant. One studies separately the effect hygroscopy and ageing:

- ssnv105a: relative humidity decrease linearly, the concrete is not-growing old;
- ssnv105b: the relative humidity is constant and equal to the value of reference, the concrete is growing old.

Results got by *Code_Aster* are compared with the analytical solution of reference.

1 Problem of reference

1.1 Geometry

The test is carried out on the material point, using the order SIMU_POINT_MAT.

1.2 Properties of materials

Isotropic elasticity (keyword ELAS_FO)

$E=30000\,MPa$
$\nu=0,2$
$\alpha=10^{-5}$

Function of ageing (keyword V_BETON_GRANGER)

$$k(t_c)=\frac{28^{0,2}+0,1}{t_c^{0,2}+0,1}$$

Clean creep: properties of the chains of Kelvin (keyword BETON_GRANGER)

$J_1=1,2\cdot10^{-7}\,MPa^{-1}$	$\tau_1=2\cdot10^{-3}$ jours
$J_2=2,6\cdot10^{-7}\,MPa^{-1}$	$\tau_2=2\cdot10^{-2}$ jours
$J_3=2,7\cdot10^{-6}\,MPa^{-1}$	$\tau_3=2\cdot10^{-1}$ jours
$J_4=2,71\cdot10^{-6}\,MPa^{-1}$	$\tau_4=2$ jours
$J_5=8,08\cdot10^{-6}\,MPa^{-1}$	$\tau_5=2\cdot10$ jours
$J_6=1,808\cdot10^{-5}\,MPa^{-1}$	$\tau_6=2\cdot10^{2}$ jours
$J_7=1,901\cdot10^{-5}\,MPa^{-1}$	$\tau_7=2\cdot10^{3}$ jours
$J_8=1,139\cdot10^{-5}\,MPa^{-1}$	$\tau_8=2\cdot10^{4}$ jours

Table 1.2-1

function of desorption (to be informed under keyword ELAS_FO) described the pace of the relative humidity h according to the water content C (which corresponds to the variable of Code_Aster order SECH).

- For modeling A, this function is linear if $50\,kg/m^3\leq C\leq 100\,kg/m^3$ and constant with the outside of these terminals; moisture varies between the initial value $h_0=1$ and the end value $h_f=0,5$ and, as shown in Figure 1.2-1.
- For modeling B, it is constant and equal to $h=1$ (ou 100%)

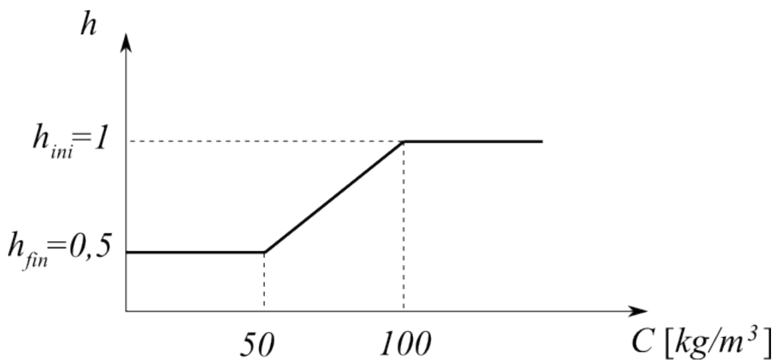

Figure 1.2-1

1.3 Boundary conditions and loadings

- **Boundary conditions in mechanics** : uniaxial traction. The imposed constraint (component SIZZ) is equal to $\sigma_{zz}=\sigma_0=10\ MPa$. One maintains the loading during 1 year.
- **Temperature** : one uniformly imposes on the structure a constant temperature of $T=20°C$, equalizes at the temperature of reference. So the thermal withdrawal is null.
- **Water content** :
  - For modeling A, this function takes a linear form. It is worth $C_0=100$ at initial time $t_0=0$ and $C_f=50$ at final time $t_f=365$ days.
  - For modeling B, it is constant and equal to $h=h_0=1$ $(\text{ou } 100\%)$

2 Reference solution

2.1 Method of calculating used for the reference solution

It is about a test 1D . The uniaxial constraint is worth: $\sigma=\sigma_0\cdot H(t_0)$ where t_0 is the moment of loading. The function of Heavyside $H(t_0)$ allows to apply the loading σ_0 instantaneously.

The equivalent constraint is defined $S(t)=h(t)\cdot\sigma(t)$. One a: $S_0=S(t_0)=\sigma_0\cdot h_0$.
One can clarify the initial jump of constraint by writing the deformation of creep in the following way:

$$\varepsilon^{fl}(t)=S_0 J(t,t_0)+\int_{\tau=t_0}^{\tau=t} J(t,\tau)\dot{S}\,\mathrm{d}\tau$$

2.1.1 Modeling A

In modeling A, one a:

- For $t>t_0^+$ one a: $S(t)=\sigma_0\left(h_0+(h_f-h_0)\dfrac{t-t_0}{t_f-t_0}\right)$ thus: $\dot{S}=\sigma_0\dfrac{h_f-h_0}{t_f-t_0}$
- $J(t,\tau)=\sum_{s=1}^{8} J_s\cdot\left(1-\exp\left[-\dfrac{t-\tau}{\tau_s}\right]\right)$

$$\varepsilon^{fl}(t)=\sigma_0 h_0 J(t,t_0)+\int_{\tau=t_0}^{\tau=t} J(t,\tau)\sigma_0\frac{h_f-h_0}{t_f-t_0}\,\mathrm{d}\tau$$

While replacing $J(t,\tau)$ one a:

$$\varepsilon^{fl}(t)=\sigma_0 h_0 J(t,t_0)+\sigma_0\frac{h_f-h_0}{t_f-t_0}\sum_{s=1}^{8} J_s\int_{\tau=t_0}^{\tau=t}\left(1-\exp\left[-\frac{t-\tau}{\tau_s}\right]\right)\mathrm{d}\tau$$

One obtains:

$$\varepsilon^{fl}(t)=\sigma_0 h_0\sum_{s=1}^{8} J_s\left(1-\exp\left[-\frac{t-t_0}{\tau_s}\right]\right) -\sigma_0\frac{h_f-h_0}{t_f-t_0}\sum_{s=1}^{8}\tau_s J_s\left(1-\exp\left[-\frac{t-t_0}{\tau_s}\right]\right)+\sigma_0\frac{h_f-h_0}{t_f-t_0}\left(\sum_{s=1}^{8} J_s\right)(t-t_0)$$

The total deflection is calculated as the sum of the deformation of creep and the elastic strain:

$$\varepsilon(t)=\varepsilon^e(t)+\varepsilon^{fl}(t)=\frac{\sigma_0}{E}+\varepsilon^{fl}(t)$$

2.1.2 Modeling B

In modeling B, one a:

- For $t>t_0^+$ one a: $S(t)=\sigma_0 h_0=constante$ thus: $\dot{S}=0$
- $J(t,\tau)=k(\tau)\sum_{s=1}^{8} J_s\cdot\left(1-\exp\left[-\frac{t-\tau}{\tau_s}\right]\right)$

One thus has:

$$\varepsilon^{fl}(t)=\sigma_0 h_0\sum_{s=1}^{8} k(t_0)J_s.\left(1-\exp\left[-\frac{t-t_0}{\tau_s}\right]\right)$$

The total deflection is worth:

$$\varepsilon(t)=\varepsilon^e(t)+\varepsilon^{fl}(t)=\frac{\sigma_0}{E}+\varepsilon^{fl}(t)$$

2.2 Results of reference

One will be interested in the values of the deformations at 365 days.

3 Modeling A

3.1 Characteristics of modeling

It is about a test on the material point.
The relative humidity varies in a linear way on the time interval considered in the study: $h_0=1$ at initial time $t_0=0$ and $h_f=50$ at final time $t_f=365$ days.
There is no ageing.

3.2 Characteristics of the grid

Nothing

3.3 Sizes tested and results

The value of the longitudinal deflection is tested (in the direction of the loading) ε_{zz}^{fl} at 365 days.

Variables	Moment	Reference
ε_{zz}^{fl}	31536000.0 dryness (365 days)	0.0005328650

Table 3.3-1

4 Modeling B

4.1 Characteristics of modeling

It is about a test on the material point.
The relative humidity is constant on the time interval considered in the study: $h_0=1$.
The moment initial of calculation is $t_0=0$, the final moment is $t_f=365$ days.
One takes into account ageing. The material is charged at three different ages: 2.10 and 28 days.
In order to modify the age of loading, one initializes the corresponding internal variable (V55) in ETAT_INIT of STAT_NON_LINE.

4.2 Characteristics of the grid

Nothing

4.3 Sizes tested and results

One tests the values of the longitudinal deflection ε_{zz}^{fl} with the sequence numbers corresponding to 365 days.

Old with the loading	Variable tested	Moment	Reference
2	ε_{zz}^{fl}	365 days	0.0008647473
10	ε_{zz}^{fl}	365 days	0.0007271718
28	ε_{zz}^{fl}	365 days	0.0006574566

Table 4.3-1

5 Summary of the results

Results got with *Code_Aster* are close to those of the reference solution (variations $<10^{-4}\%$)