SSNV142 - Clean creep test: model Summarized

Granger:

This benchmark of nonlinear quasi-static mechanics simulates a uniaxial creep test. It aims to validate the behavior model of “Granger”, making it possible to model the clean creep of the concretes. This linear viscoelastic model (grouping of rheological models of Kelvin in series) makes it possible to take into account the effects of the stress, the temperature and the hygroscopy.

In this test, the pressure applied, the temperature and the hygrometrical state are constant.

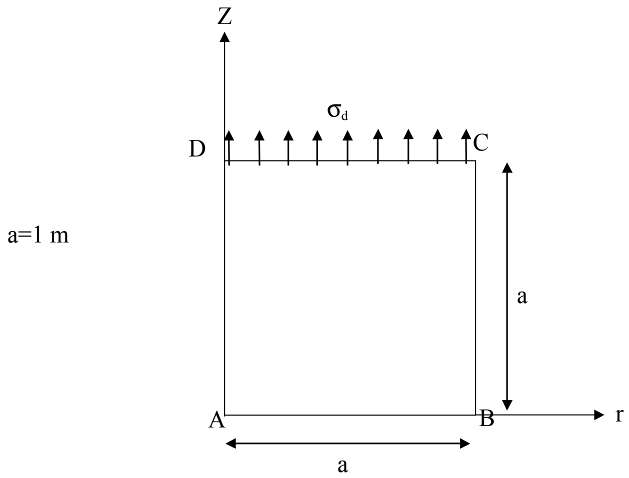
In the modelization A, the cylinder is modelled into axisymmetric by four elements quadrangles with 8 nodes. In the modelization B, the structure is a bar, and in the modelization C, it is a multifibre beam. The modelization D milked the same problem on a cube $3D$.

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

1 Problem of reference

1.1 uniaxial

State Geometry: cylindrical test-tube or ground volume $3D$ or bar, of dimension unit.



1.2 Material properties

isotropic Elasticity
$E=31000\,MPa$
$\nu=0.2$

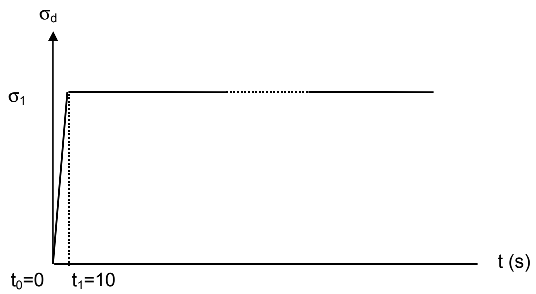
Behavior model of clean creep “Granger”.
$J_1=3{,}226\,10^{-5}\,MPa^{-1}$
$\tau_1=432000\,s$
$J_2=6{,}452\,10^{-5}\,MPa^{-1}$
$\tau_2=4320000\,s$

Table 1.2-1

One takes account neither of the phenomenon of aging, nor of the effect of the temperature in the behavior model of Granger.

1.3 Boundary conditions and loadings

On the side AB : $u_z=0$
One uniformly imposes on the structure a constant temperature of $T=20\,°C$ and a constant hygroscopy $h=1$.
Loading: one charges in tension with 0 $20\,MPa$ in $10\,s$. (pressure imposed such as $\sigma_{zz}=-\sigma_1 . t$) and one maintains the loading during 1 year.



2 Reference solution

2.1 Method of calculating used for the reference solution

being given nature of the requests, the solution (forced σ , strains ε) is homogeneous.

That is to say the loading: $\begin{pmatrix} 0 & 0 & 0 \\ 0 & \sigma_d(t) & 0 \\ 0 & 0 & 0 \end{pmatrix}$

The model of clean creep of Granger is such that the viscoelastic strain corresponding to the case of a constant loading σ_0 applied to time t_0 is worth: (cf [R7.01.01])

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

The model also depends on the temperature and the hygroscopy in the following way:

$$\varepsilon^{fl}(t)=\sigma_0 h\cdot\frac{T-248}{45}\cdot\sum_{k=1}^{8} J_k . \left(1-\exp\left[-\frac{t-t_0}{\tau_s}\right]\right)$$

but in this test the fields of temperature and hygroscopy are selected constant and such queet h $\frac{T-248}{45}$ is worth 1 respectively.

When the stress evolves with time then:

$$\varepsilon^{fl}(t)=\sum_{k=1}^{8} \int_{\tau=0}^{t} J_k . (1-\exp\left[-\frac{t-\tau}{\tau_s}\right]) . \frac{\partial\sigma}{\partial\tau} . d\tau$$

one thus has for the case present:

$$\varepsilon_{yy}^{fl}=\sum_{k=1}^{2} \int_{\tau=0}^{t=t_1} J_k . (1-\exp\left[-\frac{t-\tau}{\tau_s}\right]) . \frac{\sigma_1}{t_1} . d\tau$$

the loading remaining constant beyond T1. That is to say:

$$\varepsilon_{yy}^{\mathrm{fl}}=\sigma_1 \sum_{k=1}^{k=2} J_k . \left(1-\exp(-\frac{t-t_1}{\tau_s})\right) \underbrace{\frac{\tau_k}{t_1}\left(1-\exp(\frac{-t_1}{\tau_s})\right)}_{\approx 1}$$

A longitudinal deflection of creep is accompanied by a transverse strain such as:

$$\varepsilon_{xx}^{fl}=-\nu\,\varepsilon_{yy}^{fl}$$

The uniaxial total deflection is worth: $\varepsilon_{yy}=\varepsilon_{yy}^{fl}+\frac{\sigma_{yy}}{E}$

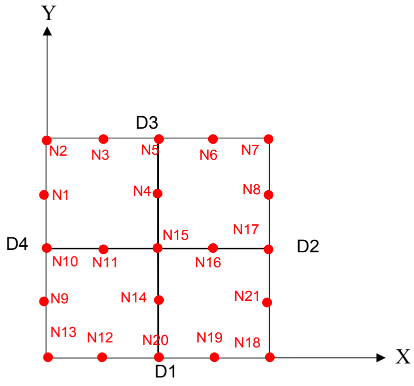
2.2 Results of reference

One will be interested in the values of the strains of creep to 45 days, 245 days and 365 days.

3 Modelization A

3.1 Characteristic of the modelization

Modelization `AXIS`



the loading and the boundary conditions are modelled by:

- On the face $D1$, displacement in Y no one
- On the face $D3$, imposed tension

One imposes moreover one uniform and constant temperature of $20°C$ and a field of uniform and constant drying of 1 on the structure. The curve of sorption - desorption (user datum) makes it possible to pass from variable drying to the hygroscopy.

3.2 Characteristics of the mesh

Many nodes:	21
Number of meshes and types	4 `QUAD4`

Table 3.2-1

3.3 Quantities tested and results

One test the values of ε_{xx}^{fl} and ε_{yy}^{fl} with the node $N5$, for times 45,245 and 365 days

Variable	sequence number	Reference	*Aster*	% difference
ε_{xx}^{fl}	10	2.82E-004	2.82E-004	0.
ε_{yy}^{fl}	10	-1.41E-003	-1.41E-003	0.
ε_{xx}^{fl}	50	3.85E-004	3.85E-004	0.
ε_{yy}^{fl}	50	– 1.925872 E-3	– 1.925872 E-3	0
ε_{xx}^{fl}	74	$3.86922\,10^{-04}$	$3.86922\,10^{-04}$	0.
ε_{yy}^{fl}	74	$-1.9346\,10^{-03}$	$-1.9346\,10^{-03}$	0.

Table 3.3-1

4 Modelization B

4.1 Characteristic of the modelization

an element of bar length 1 and section unit, following Ox .

One imposes moreover one uniform and constant temperature of $20°C$ and a field of uniform and constant drying of 1 on the structure. The curve of sorption - desorption (user datum) makes it possible to pass from variable drying to the hygroscopy.

4.2 Characteristics of the mesh

Many nodes:	2
Number of meshes and types	1 SEG2

Table 4.2-1

4.3 Quantities tested and results

One test the values of DX with the sequence numbers corresponding to 365 days

Variable	sequence number	Reference	*Aster*	% difference
DX	74	-2.58 E-03	-2.58 E-03	0.

Table 4.3-1

5 Modelization C

5.1 Characteristic of the modelization

a multifibre beam element (POU_D_EM) length 1 and section unit, following Ox .
One imposes moreover one uniform and constant temperature of $20°C$ and a field of uniform and constant drying of 1. The curve of sorption - desorption (user datum) makes it possible to pass from variable drying to the hygroscopy.

5.2 Characteristics of the mesh

Many nodes:	2
Number of meshes and types	1 SEG2

Table 5.2-1

5.3 Quantities tested and results

One test the values with the sequence numbers corresponding to 365 days

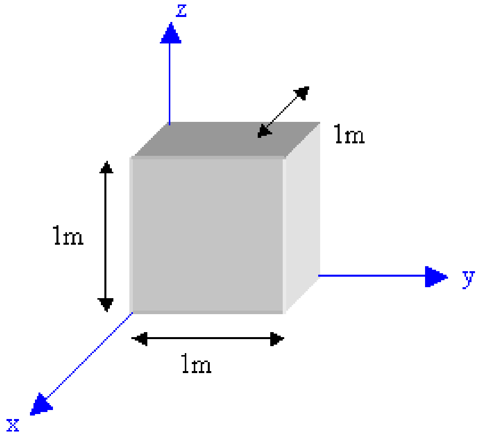
Variable	sequence number	Reference	*Aster*	% difference
DX	74	-2.58E-003	-2.58E-003	0.

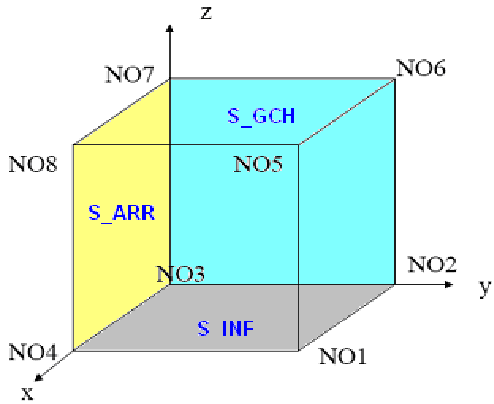
Table 5.3-1

6 Modelization D

6.1 Characteristic of the modelization

Modelization 3D





Height: $h=1.00\,m$ Width: $l=1.00\,m$ Thickness: $e=1.00\,m$

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 face S_INF : $DZ=0$
On the face S_ARR : $DY=0$
On the face S_GCH : $DX=0$

The loading is consisted by the same field of drying and same FORCE_FACE applied to S_SUP .
One uniformly imposes on the structure a constant temperature of $T=20°C$ and a constant hygroscopy $h=1$.
One charges in compression with 0 $20\,MPa$ in $10\,s$. and one maintains the loading during 1 year.

6.2 Characteristics of the mesh

Many nodes:	21
Number of meshes and types	1 HEXA8 6 QUAD4

Table 6.2-1

6.3 Quantities tested and results

One test the values of ε_{xx}^{fl} and ε_{zz}^{fl} with the node $NO6$, for times 45,245 and 365 days

Variable	Day	Sequence number	Reference	Aster	% difference
ε_{xx}^{fl}	45	10	**2.82160e-4**	**2.82160e-4**	0.
ε_{zz}^{fl}	45	10	**-1.41079e-03**	**-1.41079e-03**	0.
ε_{xx}^{fl}	245	50	**3.8520D-04**	**3.8520D-04**	0.
ε_{zz}^{fl}	245	50	**-1.92587e-03**	**-1.92587e-03**	0.
ε_{xx}^{fl}	365	74	**3.8692e-04**	**3.8692e-04**	0.
ε_{zz}^{fl}	365	74	**-1.934608e-03**	**-1.934608e-03**	0.

Table 6.3-1

7 Summary of the results

the results got with *Code_Aster* are close to those of the reference solution (variations $< 0.05\%$)