SSNV142 - Clean creep test: Granger model

Summary:

This case test of quasi-static mechanics nonlinear 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 linear viscoelastic model (grouping of rheological models of Kelvin in series) makes it possible to take into account the effects of the constraint, the temperature and the hygroscopy.

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

In modelings:

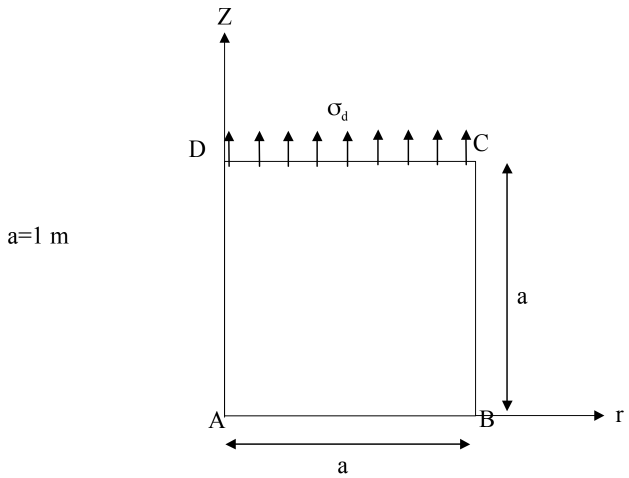
- A: the cylinder is modelled into axisymmetric by four elements quadrangles with 8 nodes.
- B: the structure is a bar,
- C: it is a multifibre beam POU_D_EM.
- D: draft the same problem on a cube $3D$.
- E: it is a multifibre beam POU_D_TGM.

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

1 Problem of reference

1.1 Geometry

Uniaxial state: cylindrical test-tube or ground volume $3D$ or bars, of dimension unit.



1.2 Material properties

Isotropic elasticity

$E=31000\,MPa$

$\nu=0.2$

Relation of clean behaviour of 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

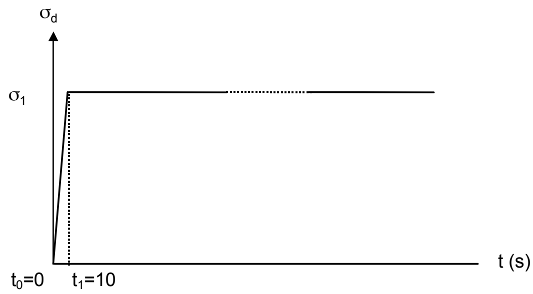
One takes account neither of the phenomenon of ageing, nor of the effect of the temperature in the relation of behavior of Granger.

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 $h=1$.

One charges in traction with 0 with $20\,MPa$ 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 the nature of the requests, the solution (forced σ , deformations 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 clean model of creep of Granger is such as the viscoelastic deformation corresponding to the case of a constant loading σ_0 applied to the moment 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 as h and $\frac{T-248}{45}$ are worth 1 respectively.

When the constraint 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 T_1. 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 deformation such as:

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

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

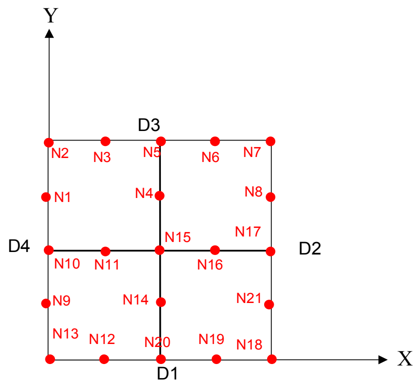
2.2 Results of reference

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

3 Modeling A

3.1 Characteristics of modeling

Modeling AXIS



The loading and the boundary conditions are modelled by:

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

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 grid

Many nodes:	21
Many meshs and types	4 QUAD4

Table 3.2-1

3.3 Sizes tested and results

One tests the values of ε_{xx}^{fl} and ε_{yy}^{fl} with the node $N5$, for the moments 45.245 and 365 days.

Variables	sequence number	Reference
ε_{xx}^{fl}	10	2,82E-004
ε_{yy}^{fl}	10	-1,41E-003
ε_{xx}^{fl}	50	3,85E-004
ε_{yy}^{fl}	50	– 1.925872 E-3
ε_{xx}^{fl}	74	$3.86922\,10^{-04}$
ε_{yy}^{fl}	74	$-1.9346\,10^{-03}$

Table 3.3-1

4 Modeling B

4.1 Characteristics of modeling

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 grid

Many nodes:	2
Many meshs and types	1 `SEG2`

Table 4.2-1

4.3 Sizes tested and results

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

Variables	sequence number	Reference
DX	74	-2.58 E-03

Table 4.3-1

5 Modeling C

5.1 Characteristics of modeling

A multifibre element of beam (POU_D_EM) of 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 grid

Many nodes:	2
Many meshs and types	1 SEG2

Table 5.2-1

5.3 Sizes tested and results

One tests the values with the sequence numbers corresponding to 365 days.

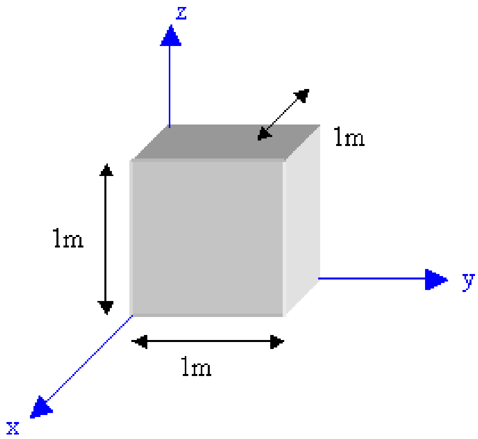
Variables	sequence number	Reference
DX	74	-2,58E-003

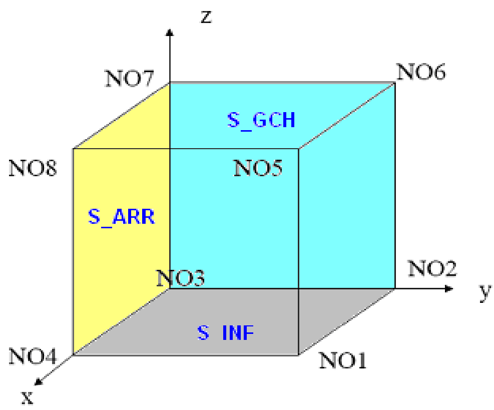
Table 5.3-1

6 Modeling D

6.1 Characteristics of modeling

Modeling 3D





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

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

The loading is made up 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 with $20\,MPa$ in $10\,s$. and one maintains the loading during 1 year.

6.2 Characteristics of the grid

Many nodes:	21
Many meshs and types	1 HEXA8 6 QUAD4

Table 6.2-1

6.3 Sizes tested and results

One tests the values of ε_{xx}^{fl} and ε_{zz}^{fl} with the node $NO6$, for the moments 45.245 and 365 days.

Variables	Day	Sequence number	Reference
ε_{xx}^{fl}	45	10	2.82160e-4
ε_{zz}^{fl}	45	10	-1.41079e-03
ε_{xx}^{fl}	245	50	3.8520e-04
ε_{zz}^{fl}	245	50	-1.92587e-03
ε_{xx}^{fl}	365	74	3.8692e-04
ε_{zz}^{fl}	365	74	-1.934608e-03

Table 6.3-1

7 Modeling E

7.1 Characteristics of modeling

A multifibre element of beam (POU_D_TGM) of length 1 and section unit, following Ox.
One imposes a 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.

7.2 Characteristics of the grid

Many nodes:	2
Many meshs and types	1 SEG2

Table 7.2-1

7.3 Sizes tested and results

One tests the values with the sequence numbers corresponding to 365 days.

Variables	sequence number	Reference
DX	74	-2,58E-003

Table 7.3-1

8 Summary of the results

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