SSNV241 - Law of behavior KIT_RGI : swelling prevented on test-tube

Summary:

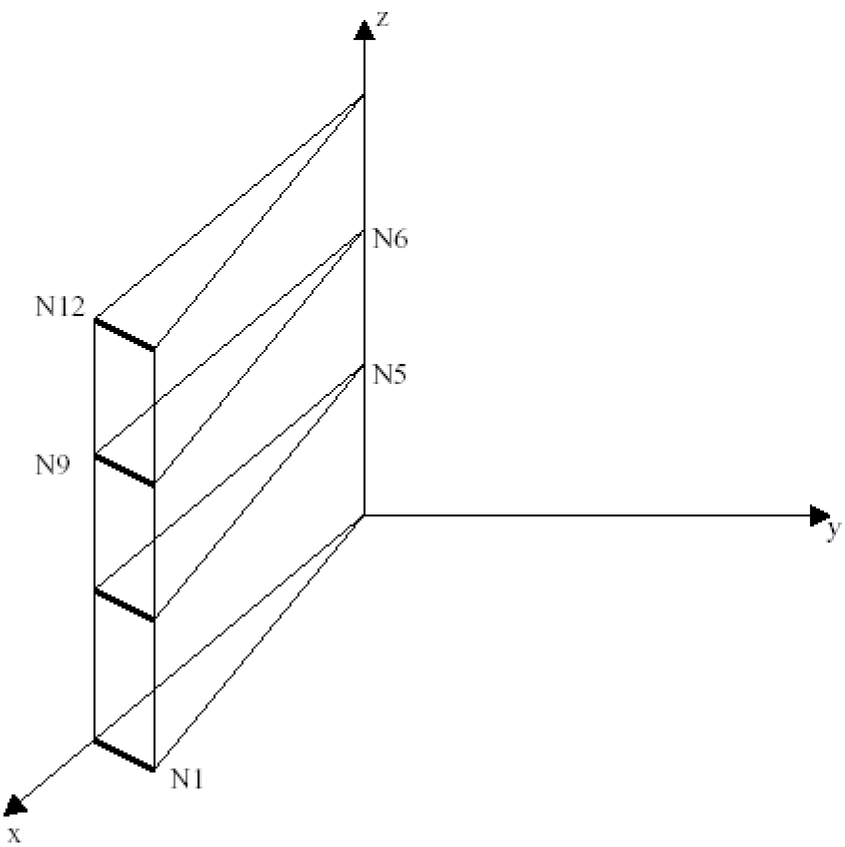
This document presents a test making it possible to validate the capacities of the model of behavior KIT_RGI and more precisely the module RGI_BETON. Let us specify that KIT_RGI is a set of three modules allowing to take into account the deformation differed from the concrete with FLUA_PORO_BETON, the damage of the concrete with ENDO_PORO_BETON and the reaction alkali-aggregate with RGI_BETON. A test of swelling under the effect of the reaction alkali-aggregate on a test-tube forced by steel rings is simulated.

1 Problem of reference

The digital simulations carried out here aim to check the capacity of the model to reproduce the evolution of swellings of a test-tube in prevented swelling.

1.1 Geometry

The test is based on the representation of a test-tube $13\times 24\,cm$.



1.2 Property of materials

Young modulus: $E=38000\,MPa$

Poisson's ratio: $\nu=0.13$

Tensile strength: $\sigma_{ft}=3.7\,MPa$

Compressive strength: $\sigma_{fc}=38.3\,MPa$

Deformation with the peak of compression: $\varepsilon_{fc}=2{,}0.10^{-3}$

Deformation with the peak of traction: $\varepsilon_{ft}=2{,}0.10^{-4}$

The properties materials of the RAG are the following ones:

- ALUC = $ALUC=500\,mol/(mm^3)$,
- SULC = $SULC=177\,mol/(mm^3)$,
- SILC = $SILC=1354\,mol/(mm^3)$,
- TDEF = $TDEF=20\,°C$,
- TAAR = $TAAR=120\,s^{-1}$¿ ,

- SSDE = $SSDE=0,95$,
- SSAR = $SAAR=0,2$,
- VAAR = $VAAR=0,0055\,mm^3$,
- VETT = $VETT=715\text{e-}6\,mm^3$,
- VVAR = $VVAR=0,15*VAAR\,mm^3$,
- VVDE = $VVDE=0,0001\,mm^3$,
- BAAR = $BAAR=0,23$,
- BDEF = $BDEF=1$,
- MAAR = $MAAR=27700.0\,MPa$,
- MDEF = $MDEF=0\,MPa$,
- COTH = $\coth=0$,
- CORG = $CORG=0$,
- ID0 = $ID0=0$,
- ID1 = $ID1=6,2$,
- ID2 = $ID2=11$,

Only asymptotic swellings are taken into account for the identification of the parameters " RAG ". For each test-tube, simulation takes into account the degree of saturation as well as stresses axial and radial .

The parameters of creep are identified in order to represent the following curves of creep:

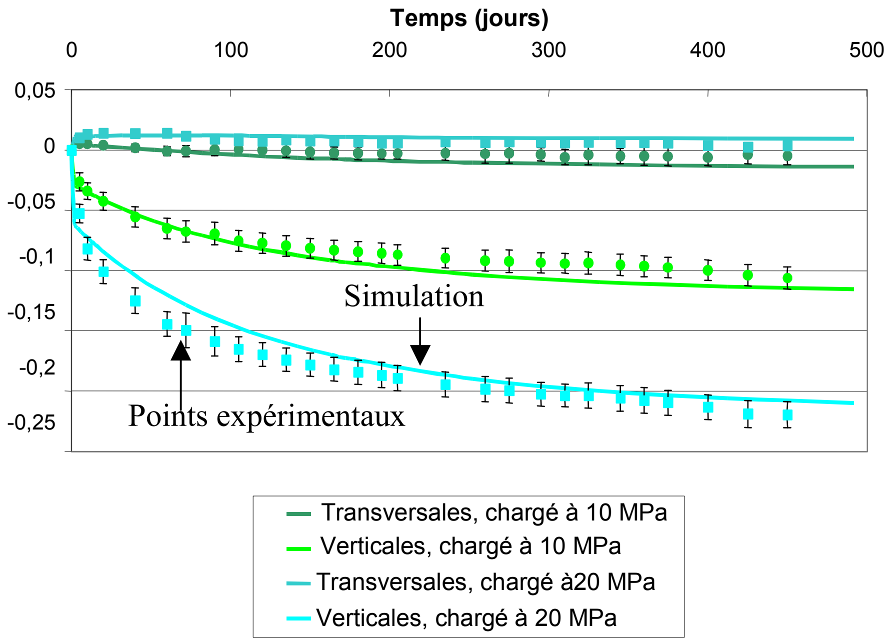


Figure 1.2-1 : Identification of the parameters of creep (FLUA_PORO_BETON) on a creep test

1.3 Boundary conditions and loadings

It is here about a test-tube charged axially (from $t=28.1\,jours$) by a pressure of $20\,MPa$ and confined radially by elastic steel rings ($E=190000\,MPa$, $\nu=0.3$) of a thickness of $3\,mm$. The boundary conditions indeed make it possible to compare this test-tube to a cylinder of ray $6,5\,cm$.

The loading is done by the variables of ordering of temperature and saturation:

- The coefficient of saturation is constant equal to 0.83 of $t=0\,jours$ with $t=28\,jours$.

- The coefficient of saturation varies linearly from 0.83 with $t=28\ jours$ to 0.63 with $t=500\ jours$.
- The temperature is constant equal to $20°C$ of $t=0\ jours$ with $t=28\ jours$.
- The temperature varies linearly $20°C$ with $t=28\ jours$ with $38°C$ with $t=29\ jours$.
- The temperature is constant equal to $38°C$ of $t=29\ jours$ with $t=500\ jours$.

Boundary conditions:
- $DY=0$ on the face included in the plan $(N6, N9, N12)$
- $DNOR=0$ on the face included in the plan $(N1, N5, N6)$
- $DZ=0$ on the lower face

1.4 Initial conditions

Nothing

2 Reference solution

2.1 Method of calculating

A calculation of nonregression east realizes.

2.2 Sizes and results of reference

The answer of model KIT_RGI is illustrated by the following figure:

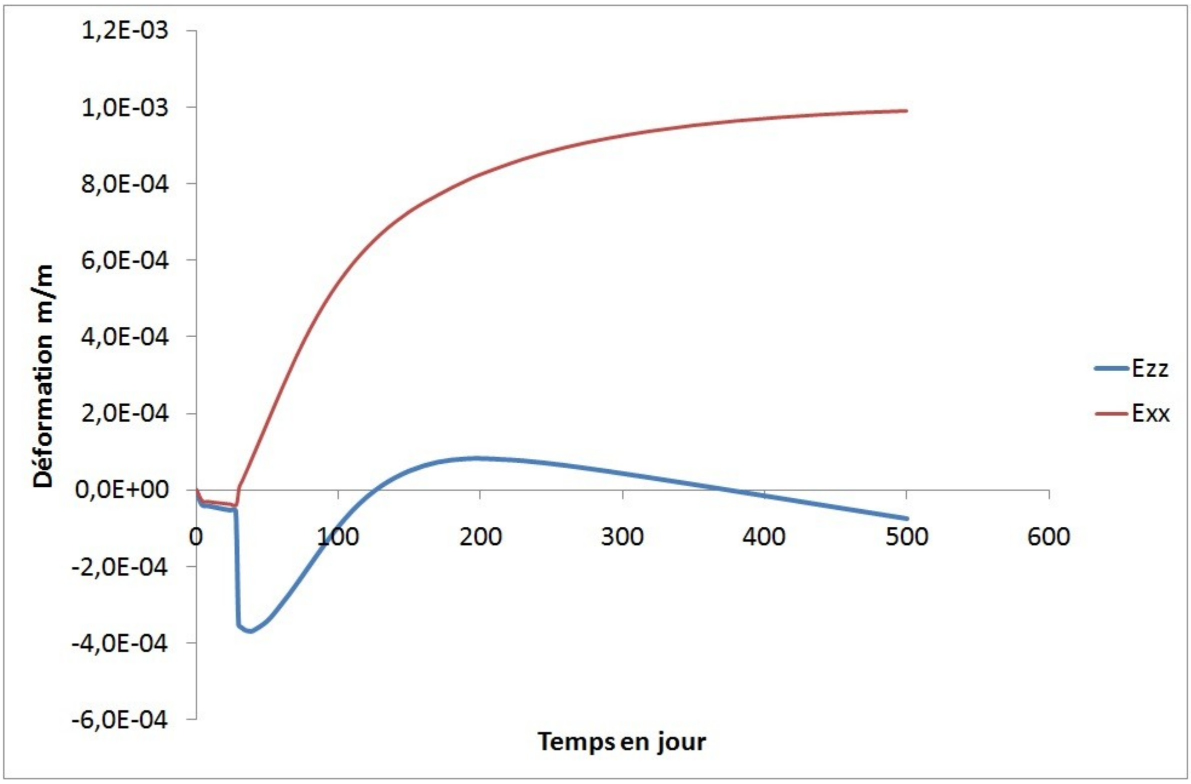


Figure 2.2-a : Deformations of the test-tubes with containment of $3\,mm$ and loading of $20\,MPa$

The curve obtained does not correspond to a real concrete. Only the evolution of the deformations is analyzed.
The values tested are displacements DZ , the volume of freezing induced by the RAG $V22$ and pressure of freezing $V18$ on the node $N5$ at several moments.

2.3 Uncertainties on the solution

Without object

2.4 Bibliographical references

Nothing

3 Modeling A

3.1 Characteristic of modeling

The problem is modelled in 3D.

3.2 Characteristic of the grid

1 mesh PENTA6

3.3 Sizes tested and results

Sizes tested with the node $N5$ afterwards the calculation of RGI_BETON are the volume of freezing of RAG $V22(N5)$ with the sequence number 8 and displacement $DZ(N5)$ with the sequence number 39. At the end of the calculation of KIT_RGI, displacements $DZ(N6)$ with the node $N6$ and $DZ(N5)$ with the node $N5$ are tested respectively with the sequence numbers 8 and 39. Displacement $DX(N12)$ with the node $N12$ and with the sequence number 39 is tested as well as the pressure of freezing $V18(N5)$ with the node $N5$ and with the sequence number 39.

4 Summary of the results

The results calculated by Code_Aster are in agreement with the values of reference. This model takes into account triaxial containment. On Figure 2.2-a three distinct zones are visible for the vertical deformation:

1) the first period corresponds to the loading (instantaneous strains),
2) the second period corresponds to the creep of the concrete under mechanical loading (up to 80 days),
3) the third period shows a return of creep, RAG product a pressure higher than the pressure applied ($20\,MPa$).

For the radial deformations, an increase in the kinetics is visible between 25 and 50 days. That corresponds to the moment when pressure induced by RAG exceed the constraint resulting from the mechanical loading and containment. The fact of modelling the anisotropic creep of manner, makes it possible to have a good correlation between experimentation and simulation for the tests with triaxial loadings. The kinetics of carryforward thus seems represented well, the assumption formulated on the modification of porosity accessible according to the loading seems to be checked.