SSNA121 - The model tube concrete subjected to an internal pressure with Summarized

UMLV_FP:

The purpose of this test consists in validating the good taking into account of the states of tension to treat the creep of the concrete, model `UMLV_FP`, under these stress states of tension. The test consists in applying an internal pressure to a concrete tube modelled in axisymmetric conditions.

1 Problem of reference

1.1 Geometry

One considers an infinite tube of interior radius of 20m and external radius 21m. The length of the tube does not intervene in the evaluating of the reference solution, but this length is fixed at 10m for the physical modelization of the problem (illustration 1.1.1).

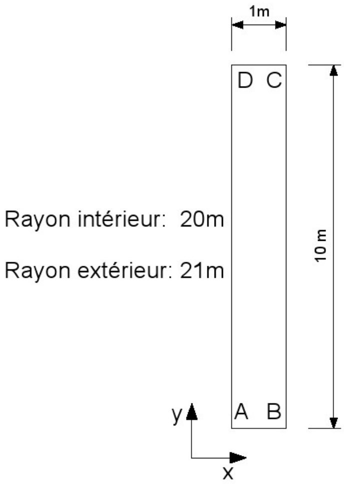


Illustration 1.1.1: Geometry of the concrete tube of thickness 1m and interior radius 20m

1.2 Properties of the material

concrete material is elastic isotropic whose properties are:

- $E = 31\,000\,MPa$
- $\nu = 0.2$

The properties of the concrete to clean creep (ULMV_FP `models`) are given below:

- `K_RS =` $2.0\text{e}11\,Pa$,
- `ETA_RS =` $4.0\text{e}16\,Pa.s$,
- `K_IS =` $5.0\text{e}10\,Pa$,
- `ETA_IS =` $1.0\text{e}17\,Pa.s$,
- `K_RD =` $5.0\text{e}11\,Pa$,
- `ETA_RD =` $1.0\text{e}16$,
- `ETA_ID =` $1.0\text{e}17$.

1.3 Boundary conditions and loadings

On edge AB, one blocks vertical displacements along the axis Y.
On edge AD, one imposes a confining pressure of 1MPa.
On edge BC, one imposes a uniform connection for all the nodes in the direction X.
On edge CD, one imposes a uniform connection for all the nodes in the direction Y.

The boundary conditions of type uniform connection ensures to model an infinite cylinder and not a cylinder with finished dimensions.

1.4 Initial conditions

nothing

2 Reference solution

2.1 elastic

2.1.1 Method of calculating Solution

the analytical solution is established on an infinite cylinder according to the direction Z, of interior radius R_{int}, of external radius R_{ext}, subjected to an interior pressure. In coordinates cylindrical and with the following boundary conditions:

$$\begin{cases} \sigma_{rr}(r=R_{\text{int}}) & = & -P \\ \sigma_{rr}(r=R_{\text{ext}}) & = & 0 \end{cases}$$

in plane stresses, the elastic solution is written:

$$\begin{cases} \sigma_{rr} & = & \dfrac{-R_{\text{int}}^2}{R_{\text{int}}^2-R_{\text{ext}}^2} P\left(1-\dfrac{R_{\text{ext}}}{r^2}\right) & \epsilon_{rr} & = & \left(\sigma_{rr}-\nu\,\sigma_{\theta\theta}\right)/E \\ \sigma_{\theta\theta} & = & \dfrac{-R_{\text{int}}^2}{R_{\text{int}}^2-R_{\text{ext}}^2} P\left(1+\dfrac{R_{\text{ext}}}{r^2}\right) & \epsilon_{\theta\theta} & = & \left(\sigma_{\theta\theta}-\nu\,\sigma_{rr}\right)/E \\ \sigma_{zz} & = & 0 & \epsilon_{zz} & = & -\nu\left(\sigma_{rr}+\sigma_{\theta\theta}\right)/E \end{cases}$$

This constitutes the reference solution of the elastic design which will be used as initial conditions with the clean computation of creep. This solution is applied with the following physical data: $R_{\text{int}}=20\,\mathrm{m}$ and $R_{\text{ext}}=21\,\mathrm{m}$.

2.1.2 Solution with clean creep

The model of clean creep of the concrete, `UMLV_FP`, is presented in details in [R7.01.06]. One briefly points out the partly spherical and deviatoric decomposition of the strains of clean creep. Each one of these parts is then itself separate out of components in reversible or irreversible matter.
One is interested here in a particular solution of this model of the strains differed for a constant loading and a relative humidity. The interest is especially related to the spherical part of the strains.
The model distinguishes the loadings leading to a positive strainrate (state of tension) or short-term behavior and the reverse, the long-term behavior for negative strainrates.

The interest of this benchmark aims at making sure only of the good behavior of the model for the loading in tension. The following equation specifies the evolutions to be respected compared to the model:

$$\begin{cases} \epsilon_r^{sph}(t) = \dfrac{h}{k_r^{sph}}\left[1-\exp\left(\dfrac{-t\,k_r^{sph}}{\eta_r^{sph}}\right)\right]\sigma^{sph} \\ \epsilon_i^{sph}(t) = 0 \end{cases}$$

with:
ϵ_r^{sph} : spherical voluminal strain known as in the short run
h : relative humidity of the continuum
t : time expressed in second
k_r^{sph} : reversible spherical apparent stiffness
η_r^{sph} : apparent viscosity
σ^{sph} : spherical part of the loading imposed

2.2 Quantities and results of reference

the only reference variable tested in this example is the irreversible voluminal strain of creep. The value of this quantity remains null for any stress state of tension.

2.3 Uncertainties on the solution

uncertainties are null, because it is about an analytical solution.

2.4 References

[1] BENBOUDJEMA, F.: Modelization of the strains differed from the concrete under biaxial requests. Application to the buildings engines of nuclear power plants, Memory of D.E.A. Advanced materials – Engineering of Structures and Envelopes, 38p. (+ additional), 1999. Documentation of reference

[2] of Code_aster [R7.01.06]: Behavior model UMLV for the clean creep of the concrete. Modelization

3 A Characteristic

3.1 of the modelization One uses

a modelization AXIS . `Characteristics`

3.2 of the mesh The mesh

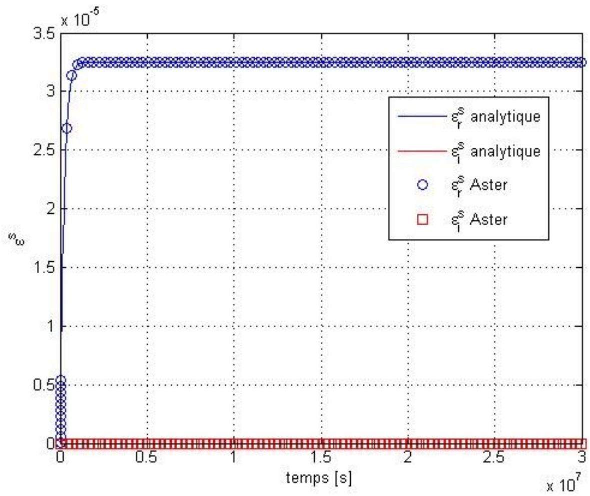
contains 50 elements of the type QUAD `8 and 30` SEG3 . `Quantities`

3.3 tested and results One tests

the irreversible voluminal strain, value carried by the local variable V2. `Identification`

NOM_CMP	Type	of reference Value of reference	Tolerance	Nets
- Gauss point $M1$ 1 V2 "	ANALYTIQUE	" the 0.0	10th	6

got results are in perfect agreement with the model analytical like presents it figure 3.3.1 3.3.1



3.3.1 3.3.1 of the strains differed under interior loading from Summary $1\mathrm{MPa}$

4 of the results the realization

from this test makes it possible to make sure of the good taking into account of creep under states of tension. The results got with Code_aster are in conformity with the analytical solution.