SSLA103 - Computation of the shrinkage of desiccation and the endogenous shrinkage on a Summarized

cylinder:

The purpose of this benchmark is validating the computation of the shrinkage of desiccation and the endogenous shrinkage. It also tests the possibility of making depend the characteristic materials on the hydration and drying (in the case of the model of Mazars). It is about a cylinder which undergoes a drying and a uniform hydration. The temperature also varies.

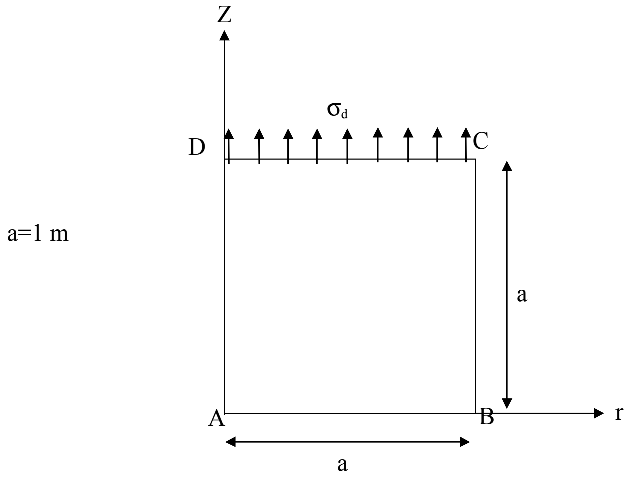
The cylinder is modelled by four elements quadrangles with 8 nodes for the modelizations A C, E and F by an element HEXA20 for the modelizations B and D. For the modelizations A and B, the behavior is supposed to be elastic, which makes it possible to validate the computation of shrinkage at the same time with STAT_NON_LINE and MECA_STATIQUE. The modelizations C and D make it possible to validate the computation of shrinkage with the model of MAZARS local and NON-local (without activation of the damage). The modelization E validates the computation of shrinkage with the model ENDO_ISOT_BETON (with method of NEWTON and method IMPLEX) and the modelization F coupling ENDO_ISOT_BETON/BETON_UMLV_FP

the results got by *Code_Aster* are identical to the analytical solution of reference.

1 Problem of reference

1.1 cylindrical

Geometry Test-tube.



1.2 Material properties

For the modelizations A and B, the material is supposed to be elastic and the characteristic materials are constant to be able to validate computation with MECA_STATIQUE,
For the modelizations C and D, the model of MAZARS is used and certain parameters depend on the hydration and drying.
The modelization E allows to test model ENDO_ISOT_BETON, with method of NEWTON and IMPLEX, and the modelization F coupling ENDO_ISOT_BETON / BETON_UMLV_FP, knowing that materials parameters model BETON_UMLV_FP are selected so that one does not have creep and thus which one finds the behavior of model ENDO_ISOT_BETON. In both cases, the characteristic materials are constant.
Let us announce that being given the loading (thermal expansion, hydration and free drying), no damage develops: one thus finds in all the cases, the elastic solution.

Modelization A and B : Isotropic elasticity

$E=30000\,MPa$
$\nu=0.2$
$\kappa=1.66\,10^{-5}(l/m^3)^{-1}$
$\beta_{endo}=1.5\,10^{-5}$
$\alpha=1.0\,10^{-5}\circ C^{-1}$

Modelization C and D : MAZARS

$E=10000\,MPa$ for $C=100l/m^3$
$30000\,MPa$ $C=80l/m^3$
$\nu=0.25$ for $h=0$
0.15 for $h=1$
$\kappa=1.66\,10^{-5}(l/m^3)^{-1}$
$\beta_{endo}=1.5\,10^{-5}$
$\alpha=1.0\,10^{-5}\circ C^{-1}$

$A_c=1.4$
$A_t=1.0$ $C=100l/m^3$
0.8 for $C=80l/m^3$
$B_c=2000$
$Bt=10000$ $h=0$
11000 for $h=1$
$\varepsilon_{d0}=10^{-4}$
$k=0.7$

Modelization E : ENDO_ISOT_BETON

$E=30000\,MPa$
$\nu=0.2$
$\kappa=1.66\,10-5(l/m^3)^{-1}$
$\beta_{endo}=1.5\,10^{-5}$
$\alpha=1.0\,10^{-5}\circ C^{-1}$

$\sigma^t_y=4.0\,MPa$
$\sigma^c_y=53.4\,MPa$
$E_t=-1.0\,10^3\,MPa$

Modelization F : ENDO_ISOT_BETON/BETON_UMLV_FP

See modelization $E+$
$k_r^s=10^{19}$ MPa
$k_i^s=10^{19}$ MPa
$k_r^d=10^{19}$ MPa
$\eta_r^s=10^{19}$ MPa.j MPa.j
$\eta_i^s=10^{19}$ MPa.j MPa.j
$\eta_r^d=10^{19}$ Boundary conditions
$\eta_i^d=10^{19}$

1.3 and loadings On the side

: One varies AB $u_z=0$

uniformly on the structure: the temperature

1) of at initial time $T=20\circ C$ until at final time $T=120\circ C$ the water content
2) of at initial time $100\,l/m^3$ until at final time $80\,l/m^3$ the hydration
3) varies from 0. at initial time with 1. at final time. Reference solution

2 Method of calculating

2.1 used for the reference solution being given

nature of the requests, the total deflection is only due to the shrinkage and thermal thermal expansion. Consequently, one a: with: ,

$$\boldsymbol{\varepsilon} = \varepsilon^{th} + \boldsymbol{\varepsilon}^{rd} + \boldsymbol{\varepsilon}^{re} = \alpha\left(T - T_{ref}\right)\mathbf{I}_d - \kappa\left(C_0 - C\right)\mathbf{I}_d - \beta\, h\,\mathbf{I}_d$$

the temperature

- T at time, the reference temperature t
- T_{ref} , water content
- C_0 initial (water content). , the water content $\mathrm{HR}=100\%$
- C at time, the degree t
- h of hydration at time, the coefficient of thermal expansion t
- α , the coefficient
- κ of shrinkage of desiccation, the endogenous
- β coefficient of shrinkage the elastic strain

being null in this problem, the stresses are null, as well as the damage in the case of the modelizations with the model of MAZARS and ENDO_ISOT_BETON . Results

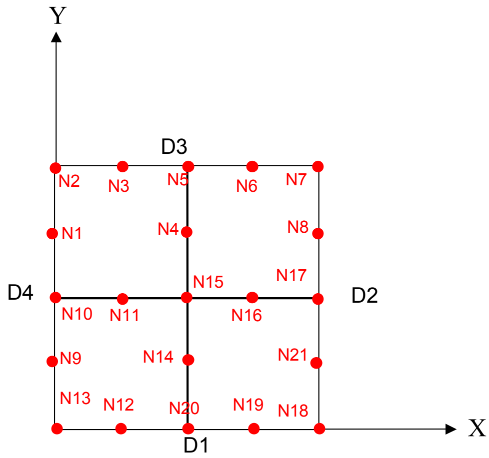
2.2 of reference One checks

the value of the strain after 3600 days, as well as the stress. One also checks that the plastic strain is null, as well as the damage for the modelizations concerned. The results are tested with STAT_NON_LINE as well as with MECA_STATIQUE (for the modelizations and). Modelization A B

3 A Characteristic

3.1 of the modelization The modelization

is of type AXIS. The loading



and the boundary conditions are modelled by: FACE_IMPO =

`_F (GROUP_MA = D1, DY= 0.) The fields`

of temperature TEMP1, drying SECH1 and `hydration` HYDR1 `are applied` to all the model. Characteristics

3.2 of the mesh Many nodes

: 21 Number of meshes
and types: 4 QUAD8 `tested`
Quantities

3.3 and results For computation

with STAT_NON_LINE `(with COMP_ELAS` and `COMP_INCR`), `one tests` the components of the tensor of strains EPSI_NOEU after `3600` days. It is also checked that stresses SIEF_NOEU are `null` as well as plastic strain (EPSP_NOEU). `For computation`
with MECA_STATIQUE , `one tests` the components of the tensor of strains EPSI_NOEU after `3600` days. It is also checked that stresses SIGM_NOEU are `null` . STAT_NON_LINE computation

`Variables Standard`

Time	of Reference	Reference	tolerance	3600 ANALYTIQUE
ε_{xx}		`6.53 10-4 0.50%`	3600	ANALYTIQUE
ε_{yy}		`6.53 10-4 0.50%`	3600	ANALYTIQUE
ε_{xx}^{p}		`0. 1,00E-006`	3600	1.00E-006
ε_{yy}^{p}		`0. 1,00E-006`	3600	1.00E-006

σ_{xx}		0. 1,00E-006	3600	1.00E-006
σ_{yy}		0. 1,00E-006	Standard	1.00E-006

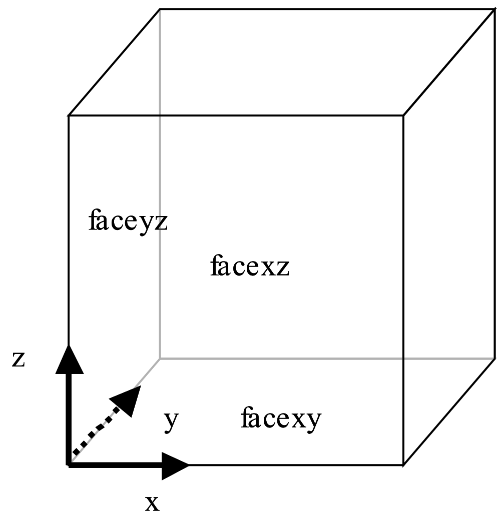
MECA_STATIQUE Variables

Urgent	of Reference	Reference	tolerance	3600 ANALYTIQUE
ε_{xx}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{yy}		6.53 10-4 0.50%	3600	ANALYTIQUE
σ_{xx}		0. 1,00E-006	3600	1.00E-006
σ_{yy}		0. 1,00E-006	Modelization	1.00E-006

4 B Characteristic

4.1 of the modelization The modelization

is of type 3D. The loading



and the boundary conditions are modelled by: FACE_IMPO =

```
(_F (GROUP_MA        = "facexy", DZ= 0.), _F (GROUP_MA
                   = "facexz", DY= 0.), _F (GROUP_MA
                   = "faceyz", DX= 0.)) The fields
```

of temperature TEMP1, drying SECH1 and hydration HYDR1 are applied to all the model. Characteristics

4.2 of the mesh Many nodes

: 20 Number of meshes
and types: 1 tested
HEXA20 Quantities

4.3 and results For computation

with STAT_NON_LINE (with COMP_ELAS and COMP_INCR), one tests the components of the tensor of strains EPSI_NOEU after 3600 days. It is also checked that stresses SIEF_NOEU are null as well as plastic strain (EPSP_NOEU). For computation

with MECA_STATIQUE , one tests the components of the tensor of strains EPSI_NOEU after 3600 days. It is also checked that stresses SIGM_NOEU are null . STAT_NON_LINE computation

Variables Standard

Time	of Reference	Reference	tolerance	3600 ANALYTIQUE
ε_{xx}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{yy}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{xx}^{p}		0. 1,00E-006	3600	1.00E-006
ε_{yy}^{p}		0. 1,00E-006	3600	1.00E-006
σ_{xx}		0. 1,00E-006	3600	1.00E-006
σ_{yy}		0. 1,00E-006	Standard	1.00E-006

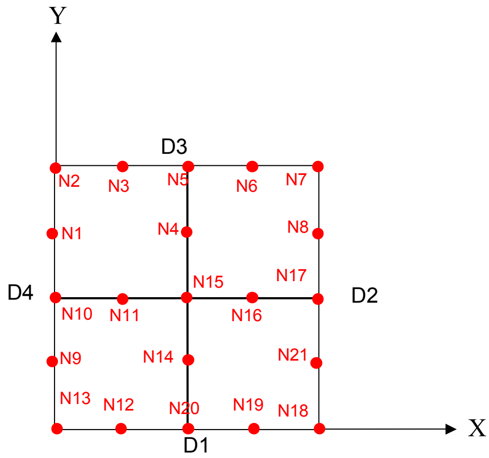
MECA_STATIQUE Variables

Urgent	of Reference	Reference	tolerance	3600 ANALYTIQUE
ε_{xx}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{yy}		6.53 10-4 0.50%	3600	ANALYTIQUE
σ_{xx}		0. 1,00E-006	3600	1.00E-006
σ_{yy}		0. 1,00E-006	Modelization	1.00E-006

5 C Characteristic

5.1 of the modelization The modelization

is of type AXIS. The loading



and the boundary conditions are modelled by: FACE_IMP O

`=_F (GROUP_MA = D1, DY= 0.) The fields`

of temperature TEMP1, drying SECH1 and `hydration` HYDR1 `are applied` to all the model. Characteristics

5.2 of the mesh Many nodes

: 21 Number of meshes
and types: 4 QUAD8 `tested`
Quantities

5.3 and results For computation

with STAT_NON_LINE , `one tests` the components of the tensor of strains EPSI_NOEU after `3600` days. It is also checked that stresses SIEF_NOEU are `null` as well as the plastic strain (EPSP_NOEU) and `the variable` of damage (VARI_NOEU, V1). `Variables` Standard

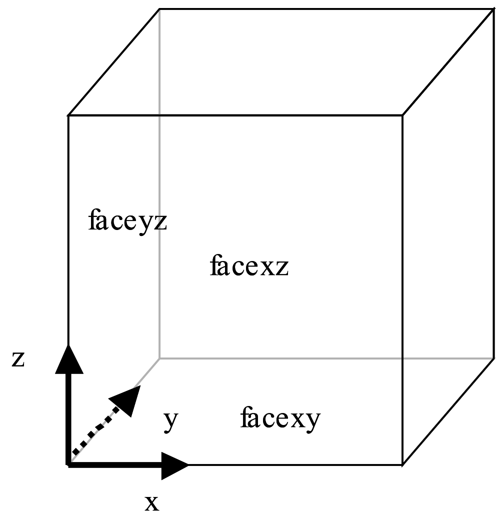
Time	of Reference	Reference	Tolerance	3600 ANALYTIQUE
ε_{xx}		`6.53 10-4 0.50%`	3600	ANALYTIQUE
ε_{yy}		`6.53 10-4 0.50%`	3600	ANALYTIQUE
ε_{xx}^{p}		`0. 1,00E-006`	3600	1.00E-006
ε_{yy}^{p}		`0. 1,00E-006`	3600	1.00E-006
σ_{xx}		`0. 1,00E-006`	3600	1.00E-006

σ_{yy}	0. 1,00E-006	3600	1.00E-006
D	0. 1,00E-006	Modelization	1.00E-006

6 D Characteristic

6.1 of the modelization The modelization

is of type 3D_GRAD_EPSI . The loading



and the boundary conditions are modelled by: FACE_IMPO =

```
(_F (GROUP_MA       = "facexy", DZ= 0. ), _F (GROUP_MA
                   = "facexz", DY= 0. ), _F (GROUP_MA
                   = "faceyz", DX= 0.)) The fields
```

of temperature TEMP1, drying SECH1 and hydration HYDR1 are applied to all the model. Characteristics

6.2 of the mesh Many nodes

: 20 Number of meshes
and types: 1 tested
HEXA20 Quantities

6.3 and results For computation

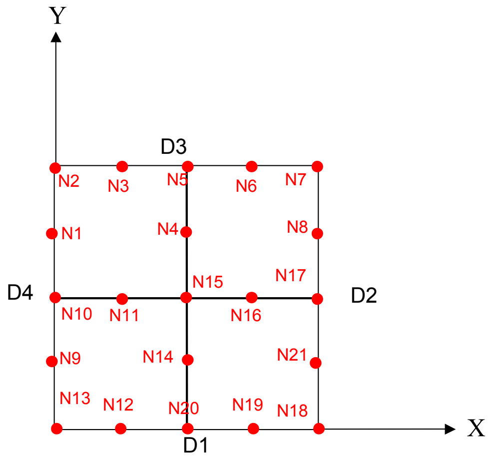
with STAT_NON_LINE , one tests the components of the tensor of strains EPSI_NOEU after 3600 days. One also checks that stresses SIEF_NOEU are null as well as the plastic strain (EPSP_NOEU) and the variable of damage VARI_NOEU, V1. Variables Standard

Time	of Reference	Reference	Tolerance	3600 ANALYTIQUE
ε_{xx}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{yy}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{xx}^{p}		0. 1,00E-006	3600	1.00E-006
ε_{yy}^{p}		0. 1,00E-006	3600	1.00E-006
σ_{xx}		0. 1,00E-006	3600	1.00E-006
σ_{yy}		0. 1,00E-006	3600	1.00E-006
D		0. 1,00E-006	Modelization	

7 E Characteristic

7.1 of the modelization The modelization

is of type AXIS. The loading



and the boundary conditions are modelled by: FACE_IMPO =

`_F (GROUP_MA = D1, DY= 0.) The fields`

of temperature TEMP1, drying SECH1 and hydration HYDR1 are applied to all the model. One uses
the method of resolution of NEWTON and IMPLEX with 2 steps of load. Characteristics

7.2 of the mesh Many nodes

: 21 Number of meshes
and types: 4 QUAD8 tested
Quantities

7.3 and results For computation

with STAT_NON_LINE , one tests the components of the tensor of strains EPSI_NOEU after 3600 days. It is also checked that stresses SIEF_NOEU are null as well as the plastic strain (EPSP_NOEU) and the variable of damage (VARI_NOEU, V1) . Variables Standard

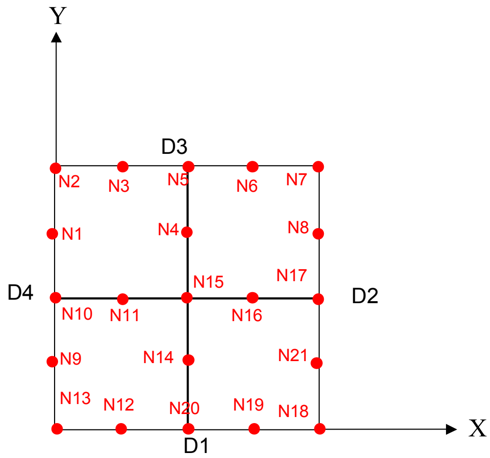
Time	of Reference	Reference	Tolerance	3600 ANALYTIQUE
ε_{xx}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{yy}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{xx}^{p}		0. 1,00E-006	3600	1.00E-006
ε_{yy}^{p}		0. 1,00E-006	3600	1.00E-006
σ_{xx}		0. 1,00E-006	3600	1.00E-006

σ_{yy}	0. 1,00E-006	3600	1.00E-006
D	0. 1,00E-006	Modelization	

8 F Characteristic

8.1 of the modelization The modelization

is of type AXIS. The loading



and the boundary conditions are modelled by: FACE_IMPO =
_F (GROUP_MA = D1, DY= 0.) The fields

of temperature TEMP1, drying SECH1 and hydration HYDR1 are applied to all the model. Characteristics

8.2 of the mesh Many nodes

: 21 Number of meshes
and types: 4 QUAD8 tested
Quantities

8.3 and results For computation

with STAT_NON_LINE , one tests the components of the tensor of strains EPSI_NOEU after 3600 days. It is also checked that stresses SIEF_NOEU are null as well as the plastic strain (EPSP_NOEU) and the variable of damage (VARI_NOEU, V1). Variables Standard

Time	of Reference	Reference	Tolerance	3600 ANALYTIQUE
ε_{xx}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε_{yy}		6.53 10-4 0.50%	3600	ANALYTIQUE
ε^p_{xx}		0. 1,00E-006	3600	1.00E-006
ε^p_{yy}		0. 1,00E-006	3600	1.00E-006

σ_{xx}	0.	1,00E-006	3600	1.00E-006
σ_{yy}	0.	1,00E-006	3600	1.00E-006
D	0.	1,00E-006	Summary	of

9 the results the results

got with the Code_Aster *are identical* to the analytical solution. One thus validated the computation of thermal thermal expansion and the shrinkages endogenous and desiccation for the model elastic, that it is with STAT_NON_LINE or MECA_STATIQUE , like for the model of Mazars, local or NON-local version, for model ENDO_ISOT_BETON and the case of coupling BETON_UMLV_ FP/ENDO_ISOT_BETON. Let us announce that the modelizations and also A B allow to validate the computation of the shrinkages for models VMIS_ISOT_TRAC and VMIS_ISOT_LINE which uses the same routine as ELAS.