SSLA103 - Calculation of the withdrawal of desiccation and the endogenous withdrawal on a cylinder

Summary:

The purpose of this CAS-test is to validate the calculation of the withdrawal of desiccation and the endogenous withdrawal. It also tests the possibility of making depend 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 modelings A , C, E and F and by an element HEXA20 for modelings B and D. For modelings A and B, the behavior is supposed to be elastic, which makes it possible to validate the calculation of withdrawal at the same time with STAT_NON_LINE and with MECA_STATIQUE. Modelings C and D allow to validate the calculation of withdrawal with the law of MAZARS local and not-local (without activation of the damage). Modeling E validate the calculation of withdrawal with the law ENDO_ISOT_BETON (with method of NEWTON and method IMPLEX) and modeling F coupling ENDO_ISOT_BETON/BETON_UMLV_FP

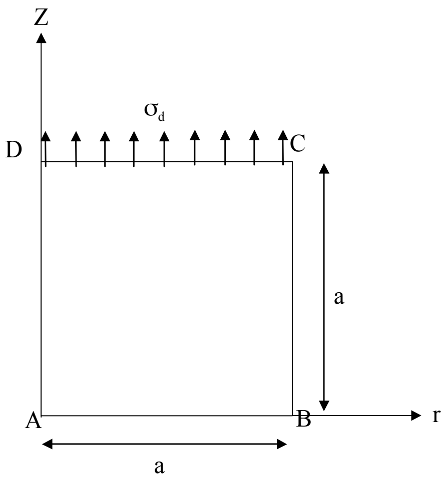
Results got by *Code_Aster* are identical to the analytical solution of reference.

1 Problem of reference

1.1 Geometry

Cylindrical test-tube.

a=1 m



1.2 Material properties

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

Modeling A and B : Isotropic elasticity

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

Modeling C and D : `MAZARS`

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

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

Modeling E : `ENDO_ISOT_BETON`

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

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

Modeling F : `ENDO_ISOT_BETON/BETON_UMLV_FP`

See modeling $E+$
k_r^s $=10^{19}$ MPa
k_i^s $=10^{19}$ MPa
k_r^d $=10^{19}$ MPa
η_r^s $=10^{19}$ MPa.j
η_i^s $=10^{19}$ MPa.j
η_r^d $=10^{19}$ MPa.j
η_i^d $=10^{19}$ MPa.j

1.3 Boundary conditions and loadings

On the side AB : $u_z=0$

One varies uniformly on the structure:

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

2 Reference solution

2.1 Method of calculating used for the reference solution

Being given the nature of the requests, the total deflection is only due to the withdrawal and thermal dilation. Consequently, one a:

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

with:

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

The elastic strain being worthless in this problem, the constraints are worthless, as well as the damage in the case of modelings with the law of MAZARS and ENDO_ISOT_BETON.

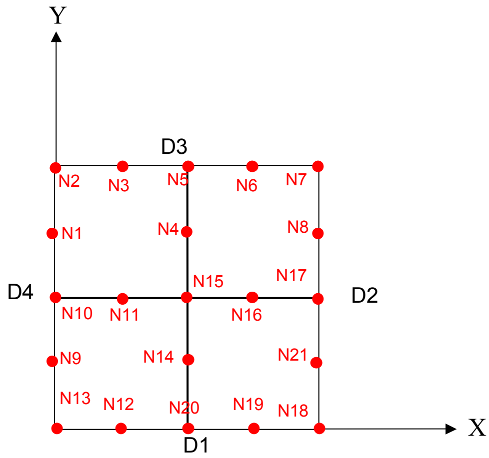
2.2 Results of reference

One checks the value of the deformation after 3600 days, as well as the constraint. One also checks that the plastic deformation is worthless, as well as the damage for modelings concerned. The results are tested with STAT_NON_LINE like with MECA_STATIQUE (for modelings A and B).

3 Modeling A

3.1 Characteristics of modeling

Modeling is of type AXIS.



The loading and the boundary conditions are modelled by:

```
FACE_IMPO =_F (GROUP_MA = D1, DY= 0.)
```

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

3.2 Characteristics of the grid

Many nodes:	21
Many meshs and types:	4 QUAD8

3.3 Sizes tested and results

For calculation with STAT_NON_LINE (with BEHAVIOR), one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIEF_NOEU are worthless as well as the plastic deformation (EPSP_NOEU).
For calculation with MECA_STATIQUE, one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIGM_NOEU are worthless.

Calculation STAT_NON_LINE

Variables	Moment	Type of Reference	Reference	tolerance
ε_{xx}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{yy}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{xx}^{p}	3600	ANALYTICAL	0.	1,00E-006
ε_{yy}^{p}	3600	ANALYTICAL	0.	1,00E-006
σ_{xx}	3600	ANALYTICAL	0.	1,00E-006

σ_{yy}	3600	ANALYTICAL	0.	1,00E-006

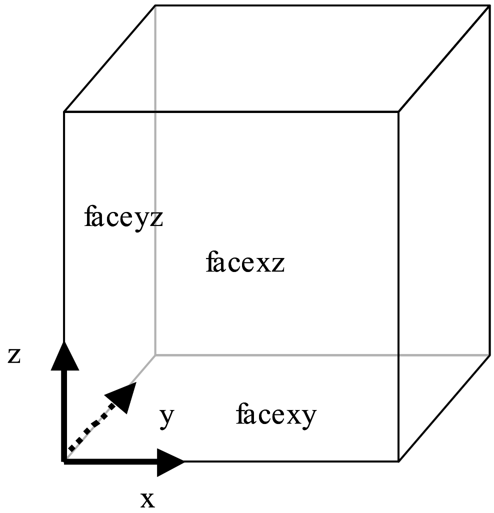
Calculation `MECA_STATIQUE`

Variables	Moment	Type of Reference	Reference	tolerance
ε_{xx}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{yy}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
σ_{xx}	3600	ANALYTICAL	0.	1,00E-006
σ_{yy}	3600	ANALYTICAL	0.	1,00E-006

4 Modeling B

4.1 Characteristics of modeling

Modeling 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.))
```

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

4.2 Characteristics of the grid

Many nodes:	20
Many meshs and types:	1 HEXA20

4.3 Sizes tested and results

For calculation with STAT_NON_LINE (with BEHAVIOR), one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIEF_NOEU are worthless as well as the plastic deformation (EPSP_NOEU).

For calculation with MECA_STATIQUE, one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIGM_NOEU are worthless.

Calculation `STAT_NON_LINE`

Variables	Moment	Type of Reference	Reference	tolerance
ε_{xx}	3600	`ANALYTICAL`	6.53 10^{-4}	0.50%
ε_{yy}	3600	`ANALYTICAL`	6.53 10^{-4}	0.50%
ε_{xx}^{p}	3600	`ANALYTICAL`	0.	1,00E-006
ε_{yy}^{p}	3600	`ANALYTICAL`	0.	1,00E-006
σ_{xx}	3600	`ANALYTICAL`	0.	1,00E-006
σ_{yy}	3600	`ANALYTICAL`	0.	1,00E-006

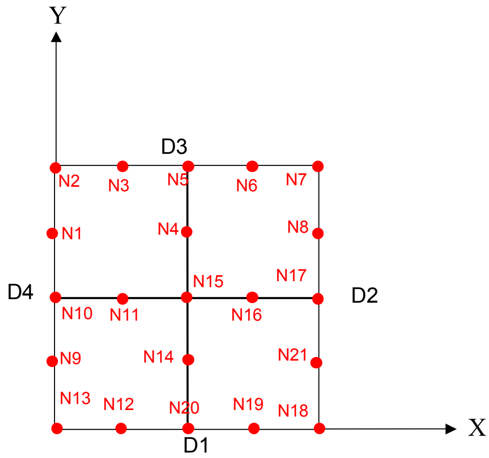
Calculation `MECA_STATIQUE`

Variables	Moment	Type of Reference	Reference	tolerance
ε_{xx}	3600	`ANALYTICAL`	6.53 10^{-4}	0.50%
ε_{yy}	3600	`ANALYTICAL`	6.53 10^{-4}	0.50%
σ_{xx}	3600	`ANALYTICAL`	0.	1,00E-006
σ_{yy}	3600	`ANALYTICAL`	0.	1,00E-006

5 Modeling C

5.1 Characteristics of modeling

Modeling is of type `AXIS`.



The loading and the boundary conditions are modelled by:

```
FACE_IMP O =_F (GROUP_MA = D1, DY= 0.)
```

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

5.2 Characteristics of the grid

Many nodes:	21
Many meshs and types:	4 `QUAD8`

5.3 Sizes tested and results

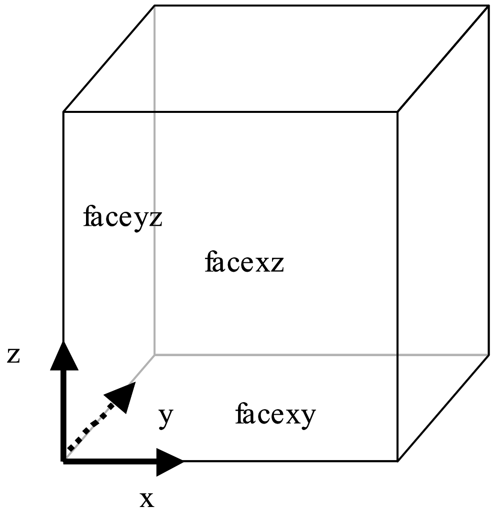
For calculation with `STAT_NON_LINE`, one tests the components of the tensor of the deformations `EPSI_NOEU` after 3600 days. It is also checked that the constraints `SIEF_NOEU` are worthless as well as the plastic deformation (`EPSP_NOEU`) and the variable of damage (`VARI_NOEU, V1`).

Variables	Moment	Type of Reference	Reference	Tolerance
ε_{xx}	3600	`ANALYTICAL`	6.53 10^{-4}	0.50%
ε_{yy}	3600	`ANALYTICAL`	6.53 10^{-4}	0.50%
ε^p_{xx}	3600	`ANALYTICAL`	0.	1,00E-006
ε^p_{yy}	3600	`ANALYTICAL`	0.	1,00E-006
σ_{xx}	3600	`ANALYTICAL`	0.	1,00E-006
σ_{yy}	3600	`ANALYTICAL`	0.	1,00E-006
D	3600	`ANALYTICAL`	0.	1,00E-006

6 Modeling D

6.1 Characteristics of modeling

Modeling 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.

6.2 Characteristics of the grid

Many nodes:	20
Many meshs and types:	1 HEXA20

6.3 Sizes tested and results

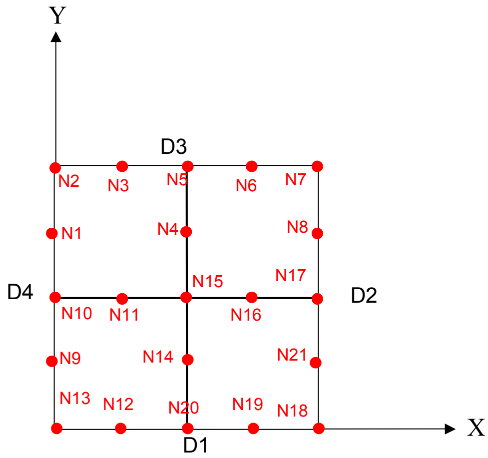
For calculation with STAT_NON_LINE, one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIEF_NOEU are worthless as well as the plastic deformation (EPSP_NOEU) and the variable of damage VARI_NOEU, V1.

Variables	Moment	Type of Reference	Reference	Tolerance
ε_{xx}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{yy}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{xx}^{p}	3600	ANALYTICAL	0.	1,00E-006
ε_{yy}^{p}	3600	ANALYTICAL	0.	1,00E-006
σ_{xx}	3600	ANALYTICAL	0.	1,00E-006
σ_{yy}	3600	ANALYTICAL	0.	1,00E-006
D	3600	ANALYTICAL	0.	1,00E-006

7 Modeling E

7.1 Characteristics of modeling

Modeling is of type AXIS.



The loading and the boundary conditions are modelled by:

```
FACE_IMPO =_F (GROUP_MA = D1, DY= 0.)
```

Fields of temperature TEMP1, of drying SECH1 and of hydration HYDR1 are applied to all the model. One uses the method of resolution of NEWTON and IMPLEX with 2 pas de charges.

7.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 4 QUAD8

7.3 Sizes tested and results

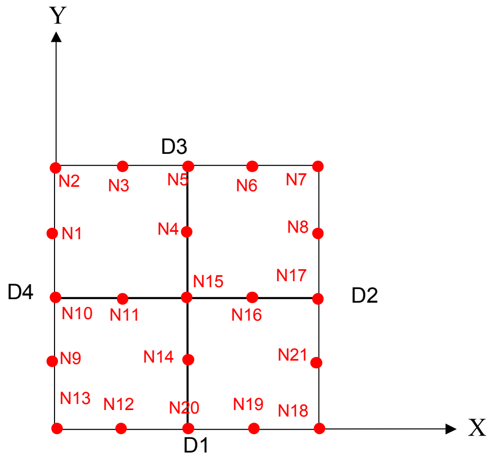
For calculation with STAT_NON_LINE, one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIEF_NOEU are worthless as well as the plastic deformation (EPSP_NOEU) and the variable of damage (VARI_NOEU, V1).

Variables	Moment	Type of Reference	Reference	Tolerance
ε_{xx}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{yy}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{xx}^{p}	3600	ANALYTICAL	0.	1,00E-006
ε_{yy}^{p}	3600	ANALYTICAL	0.	1,00E-006
σ_{xx}	3600	ANALYTICAL	0.	1,00E-006
σ_{yy}	3600	ANALYTICAL	0.	1,00E-006
D	3600	ANALYTICAL	0.	1,00E-006

8 Modeling F

8.1 Characteristics of modeling

Modeling is of type AXIS.



The loading and the boundary conditions are modelled by:

```
FACE_IMPO =_F (GROUP_MA = D1, DY= 0.)
```

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

8.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 4 QUAD8

8.3 Sizes tested and results

For calculation with STAT_NON_LINE, one tests the components of the tensor of the deformations EPSI_NOEU after 3600 days. It is also checked that the constraints SIEF_NOEU are worthless as well as the plastic deformation (EPSP_NOEU) and the variable of damage (VARI_NOEU, V1).

Variables	Moment	Type of Reference	Reference	Tolerance
ε_{xx}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{yy}	3600	ANALYTICAL	6.53 10^{-4}	0.50%
ε_{xx}^{p}	3600	ANALYTICAL	0.	1,00E-006
ε_{yy}^{p}	3600	ANALYTICAL	0.	1,00E-006
σ_{xx}	3600	ANALYTICAL	0.	1,00E-006
σ_{yy}	3600	ANALYTICAL	0.	1,00E-006
D	3600	ANALYTICAL	0.	1,00E-006

9 Summary of the results

Results got with *Code_Aster* are identical to the analytical solution. One thus validated the calculation of thermal dilation and the withdrawals endogenous and desiccation for the elastic model, that it is with STAT_NON_LINE or MECA_STATIQUE, like for the law of Mazars, local or not-local version, for the law ENDO_ISOT_BETON and for the case of the coupling BETON_UMLV_FP/ENDO_ISOT_BETON. Let us announce that modelings A and B also allow to validate the calculation of the withdrawals for the laws VMIS_ISOT_TRAC and VMIS_ISOT_LINE who uses the same routine as ELAS.