

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

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### 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 Lhas modeling  $B$ . 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. Lhas modeling  $C$  allows to validate the calculation of withdrawal with the law of MAZARS (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

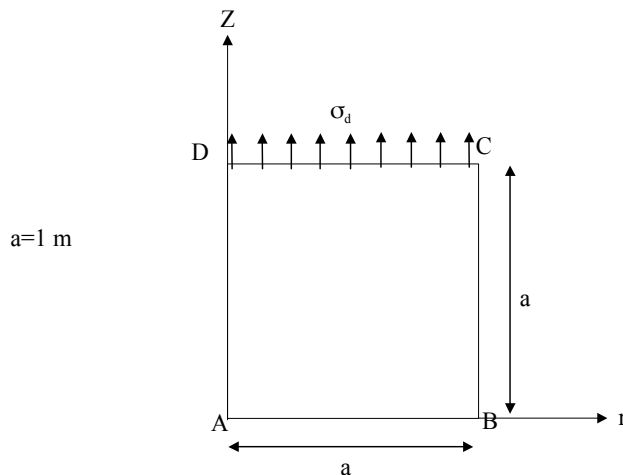
Results got by Code\_hasster are identical to the analytical solution of reference.

## 1 Problem of reference

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### 1.1 Geometry

Cylindrical test-tube.



### 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 Lhas modeling  $C$ , 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

$$E = 30000 \text{ MPa}$$

$$\nu = 0.2$$

$$\kappa = 1.66 \cdot 10^{-5} (\text{l/m}^3)^{-1}$$

$$\beta_{endo} = 1.5 \cdot 10^{-5}$$

$$\alpha = 1.0 \cdot 10^{-5} \text{ } ^\circ\text{C}^{-1}$$

## Modeling C : MAZARS

$$E = 10000 \text{ MPa for } C = 100 \text{ l/m}^3$$

$$30000 \text{ MPa for } C = 80 \text{ l/m}^3$$

$$\nu = 0.25 \text{ for } h = 0$$

$$0.15 \text{ for } h = 1$$

$$\kappa = 1.66 \cdot 10^{-5} (\text{l/m}^3)^{-1}$$

$$\beta_{endo} = 1.5 \cdot 10^{-5}$$

$$\alpha = 1.0 \cdot 10^{-5} \text{ } ^\circ\text{C}^{-1}$$

$$A_c = 1.4$$

$$A_t = 1.0 \text{ for } C = 100 \text{ l/m}^3$$

$$0.8 \text{ for } C = 80 \text{ l/m}^3$$

$$B_c = 2000$$

$$B_t = 10000 \text{ for } h = 0$$

$$11000 \text{ for } h = 1$$

$$\varepsilon_{d0} = 10^{-4}$$

$$k = 0.7$$

## Modeling E : ENDO\_ISOT\_BETON

$$E = 30000 \text{ MPa}$$

$$\nu = 0.2$$

$$\kappa = 1.66 \cdot 10^{-5} (\text{l/m}^3)^{-1}$$

$$\beta_{endo} = 1.5 \cdot 10^{-5}$$

$$\alpha = 1.0 \cdot 10^{-5} \text{ } ^\circ\text{C}^{-1}$$

$$\sigma_y^t = 4.0 \text{ MPa}$$

$$\sigma_y^c = 53.4 \text{ MPa}$$

$$E_t = -1.0 \cdot 10^3 \text{ MPa}$$

## Modeling F :

ENDO\_ISOT\_BETON/BETON\_UMLV\_FP

See modeling E +

$$k_r^s = 10^{19} \text{ MPa}$$

$$k_i^s = 10^{19} \text{ MPa}$$

$$k_r^d = 10^{19} \text{ MPa}$$

$$\eta_r^s = 10^{19} \text{ MPa.j}$$

$$\eta_i^s = 10^{19} \text{ MPa.j}$$

$$\eta_r^d = 10^{19} \text{ MPa.j}$$

$$\eta_i^d = 10^{19} \text{ MPa.j}$$

## 1.3 Boundary conditions and loadings

On the side AB :  $u_z = 0$

One varies uniformly on the structure:

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

## 2 Reference solution

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### 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:

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

with:

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

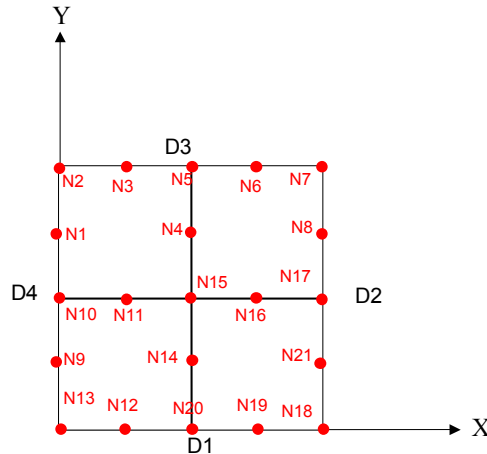
### 2.2 Results of reference

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 meshes 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
$\epsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\epsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\epsilon_{xx}^P$	3600	ANALYTICAL	0.	1,00E-006
$\epsilon_{yy}^P$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{xx}$	3600	ANALYTICAL	0.	1,00E-006

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$\sigma_{yy}$	3600	ANALYTICAL	0.	1,00E-006
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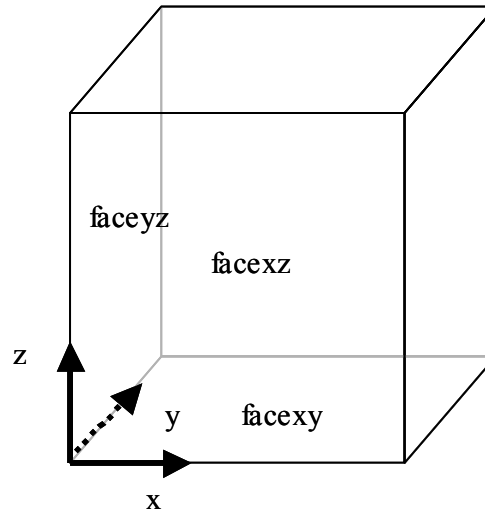
## Calculations MECA\_STATIQUE

Variables	Moment	Type of Reference	Reference	tolerance
$\varepsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\sigma_{xx}$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{yy}$	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 meshes 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
$\varepsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{xx}^p$	3600	ANALYTICAL	0.	1,00E-006
$\varepsilon_{yy}^p$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{xx}$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{yy}$	3600	ANALYTICAL	0.	1,00E-006

**Calculation MECA\_STATIQUE**

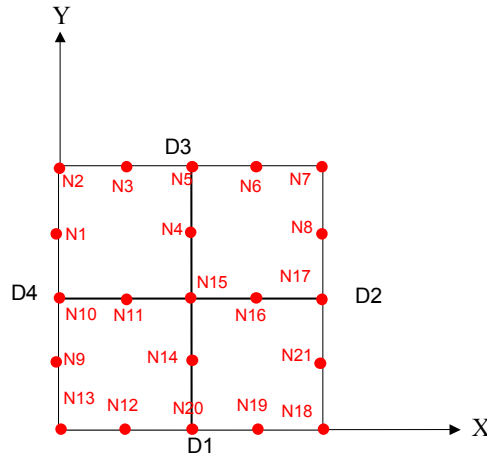
Variables	Moment	Type of Reference	Reference	tolerance
$\varepsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\sigma_{xx}$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{yy}$	3600	ANALYTICAL	0.	1,00E-006



## 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 meshes 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`).

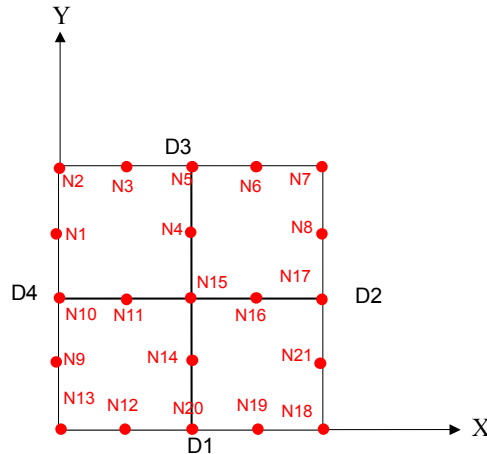
Variables	Moment	Type of Reference	Reference	Tolerance
$\varepsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{xx}^p$	3600	ANALYTICAL	0.	1,00E-006
$\varepsilon_{yy}^p$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{xx}$	3600	ANALYTICAL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



## 6 Modeling E

### 6.1 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.

### 6.2 Characteristics of the grid

Many nodes: 21  
Many meshes and types: 4 QUAD8

### 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
$\epsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\epsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\epsilon_{xx}^p$	3600	ANALYTICAL	0.	1,00E-006
$\epsilon_{yy}^p$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{xx}$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{yy}$	3600	ANALYTICAL	0.	1,00E-006
$D$	3600	ANALYTICAL	0.	1,00E-006

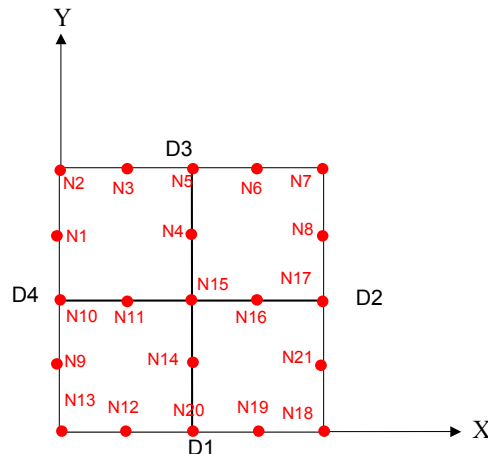
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## 7 Modeling F

### 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.

### 7.2 Characteristics of the grid

Many nodes: 21  
Many meshes 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
$\varepsilon_{xx}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{yy}$	3600	ANALYTICAL	$6.53 \cdot 10^{-4}$	0.50%
$\varepsilon_{xx}^p$	3600	ANALYTICAL	0.	1,00E-006
$\varepsilon_{yy}^p$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{xx}$	3600	ANALYTICAL	0.	1,00E-006
$\sigma_{yy}$	3600	ANALYTICAL	0.	1,00E-006
$D$	3600	ANALYTICAL	0.	1,00E-006

## 8 Summary of the results

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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, 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`.