# SSNV151 - Tension/Compression with constitutive law BETON_DOUBLE_DP

**Summarized**

This case of validation is intended to the model check behavior 3D BETON_DOUBLE_DP formulated in the frame of thermoplasticity, for the description of the nonlinear behavior of the concrete in tension and compression, with the taking into account of the irreversible variations of the thermal and mechanical characteristics of the concrete, particularly sensitive at high temperature.
The description of cracking is treated in the frame of plasticity, using an energy equivalence, by identifying the density of energy of cracking in mode $I$, with the plastic work of a homogeneous medium are equivalent, where the plastic strain is uniformly distributed in an "elementary" zone. This approach preserves the continuity of the formulation of the model, on the group of its behavior, and contributes to avoid the possible numerical difficulties during the change of state of the material.
The pathological sensitivity of the numerical solution to the spatial discretization (mesh), generated by the introduction of a softening behavior of the concrete in tension and compression, is partially solved by introducing an energy of cracking or fracture, dependant a characteristic length $l_c$, bound in keeping with elements.
The resolution of the constitutive equations of the model is carried out by an implicit scheme.

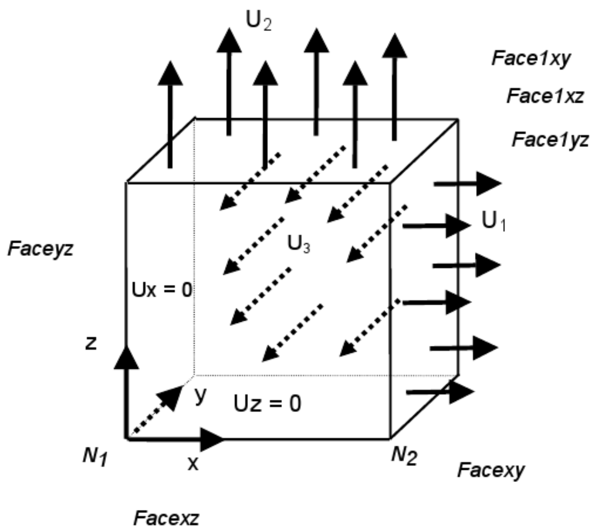
It is about a cube with 8 nodes subjected to a uniaxial pressing, in imposed displacement to which is added a biaxial tension when one reached an important hardening in tension. This loading led to the typical case of a hydrostatic stress state, solved by projection at the top of the cone of tension, when one places oneself in a hydrostatic diagram forced equivalent stress/. It is about a case test of NON-regression.

# 1 Problem of reference

## 1.1 Geometry

It acts of a cube with 8 nodes, whose three sides have a normal displacement no one, and the three opposite sides have an imposed and identical normal displacement.
The made cube $1\,mm$ on side. In the modelization A, the cube is directed according to the reference $Oxyz$ .

**Modelization A**




## 1.2 Material properties

to test the establishment of thermal thermal expansion and the shrinkage of desiccation, one imposes a field of temperature and a field of drying variables so that the strains generated by the two phenomena are compensated, while considering that the coefficients of thermal expansion thermal and of shrinkage of desiccation are equal. The values related to drying do not have any physical meaning, the test is from this point of view, purely data-processing.

**For the usual linear mechanical characteristics:**

| | |
|---|---|
| Young modulus: | $E=32\,000\,MPa$ |
| Poisson's ratio: | $\nu=0.18$ |
| Thermal coefficient of thermal expansion: | $\alpha=10^{-5}/°C$ |
| Coefficient of shrinkage of desiccation: | $\kappa=10^{-5}$ |
| Reference temperature | $T_{ref}=0°C$ |
| Drying of reference | $C_{ref}=20$ |

**For the nonlinear mechanical characteristics of model `BETON_DOUBLE_DP` :**

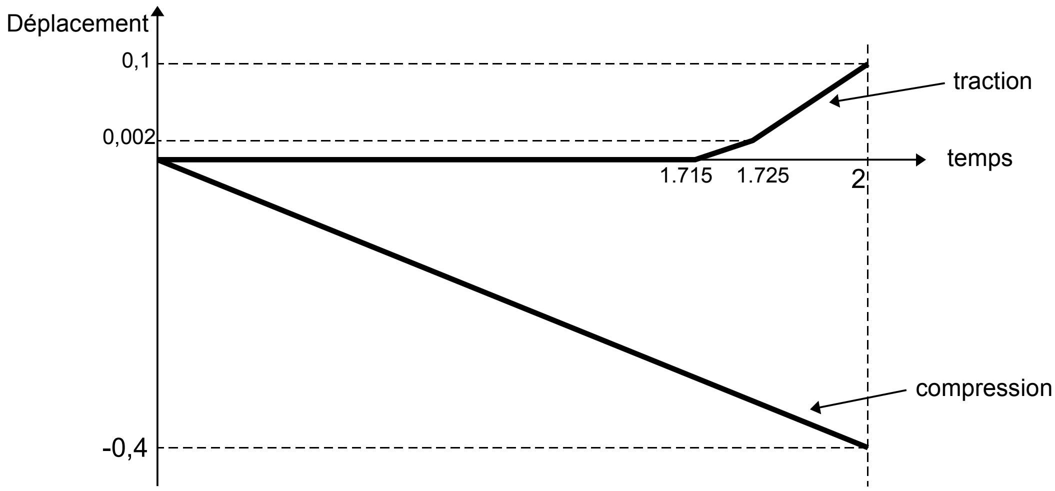
| | |
|---|---|
| Strength in uniaxial pressing: | $f'c=40\,N/mm^2$ |
| Strength in uniaxial tension: | $f't=4\,N/mm^2$ |
| Ratio of strength in biaxial compression/uniaxial pressing: | $\beta=1.16$ |
| Energy of fracture in compression: | $\mathrm{Gc}=10\,Nmm/mm^2$ |
| Energy of fracture in tension: | $\mathrm{Gt}=0.1\,Nmm/mm^2$ |
| Ratio of the elastic limit to strength in uniaxial pressing: | 30% |

## 1.3 Boundary conditions and mechanical loadings

increasing Field of temperature of $0°C$ with $20°C$.
Field of drying decreasing from 20 to 0.

| | |
|---|---|
| Lower face of the cube ( $facexy$ ): | blocked according to $oz$ . |
| Upper face of the cube ( $face1xy$ ): | variable displacement imposed opposite $mm$ |
| left the cube ( $faceyz$ ): | blocked according to $ox$ . |
| Right face of the cube ( $face1yz$ ): | variable displacement imposed opposite $mm$ |
| before cube ( $facexz$ ): | blocked according to $oy$ . |
| Face postpones cube ( $face1xz$ ): | variable displacement imposed in $mm$ |

the mechanical loading is applied in displacement imposed to the various sides of the cube. One applies a compression to the face $face1xz$ , affected by a first multiplying coefficient and a tension according to the sides $face1xy$ and $face1yz$ , affected by a second multiplying coefficient, no one during the first part at the beginning of loading, according to the following diagram:

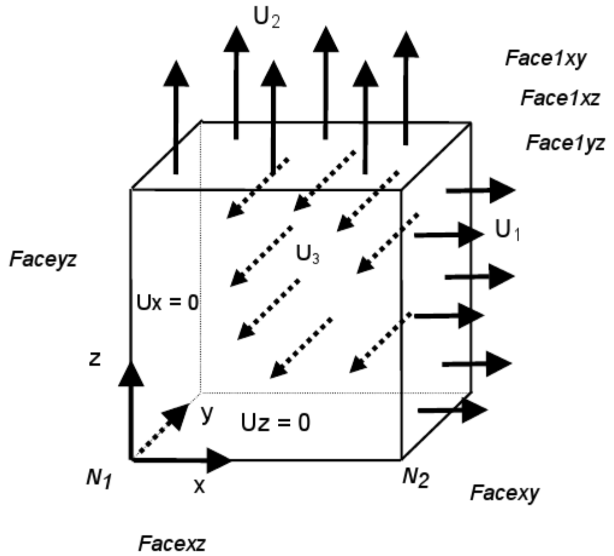


# 2 Modelization A

## 2.1 Characteristic of the modelization

**3D (HEXA8)**

1 element, stress field and uniform strain.




## 2.2 Characteristics of the mesh

Many nodes: 8
Number of meshes and type: 1 HEXA8

## 2.3 Quantities tested and results

were tested the components $xx$ and $yy$ of stress field SIGM_ELNO, the plastic strain cumulated in compression, the plastic strain cumulated in tension (first and second local variable, second component of field VARI_ELNO) and the plastic state (the fourth variable of field VARI_ELNO). The plastic state is worth 1 in compression, 11 after projection at the top of the cone of compression, 2 in tension, 22 after projection at the top of the criterion of tension, 3 in compression and tension together, and 33 after projection out of the two tops of the two cones. Displacement being imposed, field EPSI_ELNO is not tested.
The values given here correspond to version 7.2.25.

**Field SIGM_ELNO component SIXX**

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| For a displacement imposed in $U_3=-1.$ and $U_1=U_2=0.$ | – | – | – |
| For a displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.010$ | – | 2.5737449 | – |
| For a displacement imposed in $U_3=-1.8$ and $U_1=U_2=0.02872$ | – | 0.6767446 | – |
| For a displacement imposed in $U_3=-2.$ and $U_1=U_2=0.1$ | – | 2.666667 10-6 | – |

**Field SIGM_ELNO component SIYY**

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| For a displacement imposed in $U_3=-1.$ and $U_1=U_2=0.$ | – | – 17.4575632 | – |
| For a displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.010$ | – | 2.5737449 | – |
| For a displacement imposed in $U_3=-1.8$ and $U_1=U_2=0.02872$ | – | 0.6767446 | – |
| For a displacement imposed in $U_3=-2.$ and $U_1=U_2=0.1$ | – | -3.622988 10-5 | – |

**Field VARI_ELNO component V1 (plastic strain cumulated in compression)**

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| For a displacement imposed in $U_3=-1.$ and $U_1=U_2=0.$ | - | 0.1995285 | - |
| For one displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.010$ | - | 0.3429299 | - |
| For a displacement imposed in $U_3=-1.8$ and $U_1=U_2=0.02872$ | - | 0.3449657 | - |
| For a displacement imposed in $U_3=-2.$ and U_1 = U_2 = 0.1 | - | 0.3849539 | - |

**Field VARI_ELNO component $V2$ (plastic strain cumulated in tension)**

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| For a displacement imposed in $U_3=-1.$ and $U_1=U_2=0.$ | - | - | - |
| For a displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.010$ | - | 1.231450e-03 | - |
| For a displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.02872$ | - | 2.638289e-02 | - |
| For a displacement imposed in $U_3=-2.$ and $U_1=U_2=0.1$ | - | 8.373868e-02 | - |

**Field VARI_ELNO component $V4$ (plastic state)**

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| For a displacement imposed in $U_3=-1.$ and $U_1=U_2=0.$ | - | 1. | - |
| For a displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.010$ | - | 22. | - |
| For a displacement imposed in $U_3=-1.725$ and $U_1=U_2=0.02872$ | - | 22. | - |
| For a displacement imposed in $U_3=-2.$ and $U_1=U_2=0.1$ | - | 3. | - |