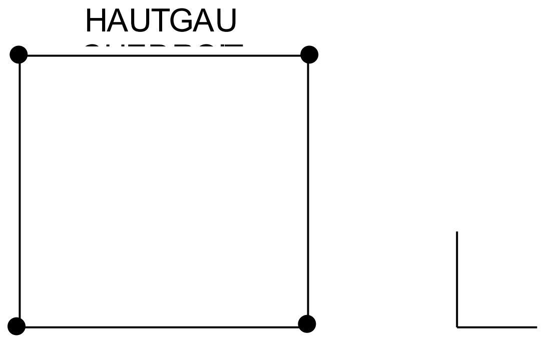
SSNV208 – Biaxial test drained with the model of Summarized

Hujeux

One carries out *a biaxial test in pure mechanics* (equivalent under drained hydraulic conditions) with *the model of Hujeux*. The calculated solutions are compared with results resulting from the code finite elements GEFDYN of the Central School Paris.

1 of reference

1.1 Geometry



the biaxial test is carried out on only one isoparametric finite element of square form `QUAD8`, named group of mesh $BLOC$. The length of each edge is worth $1\mathrm{m}$. The various sides of this square are named groups of mesh $HAUT$ BAS , $DROIT$ and $GAUCHE$. The mesh group $COTE$ contains the groups of mesh in addition $DROIT$ and $GAUCHE$; the group of mesh $APPUI$ the group of mesh BAS .

1.2 Material properties of the sand of Hostun

the elastic properties are:

- modulate isotropic compressibility: $K=148\,MPa$
- shear modulus: $\mu=68\,MPa$

The unelastic properties (models of Hujeux) result from the report of thesis of K.Hamadi **[2]** and correspond to sand of not very dense Hostun:

- power of the nonlinear elastic model: $n_e=0.$ (linear elastic)
- $\beta=30.$
- $d=2.5$
- $b=0.2$
- friction angle: $\phi=33°$
- characteristic angle: $\Psi=33°$
- critical pressure: $P_{CO}=-400\,kPa$
- pressure of reference: $P_{ref}=-1000\,kPa$
- elastic radius of the isotropic mechanism: $r^s_{ela}=10^{-4}$
- elastic radius of the mechanism déviatoire: $r^d_{ela}=0.01$
- $a_{mon}=0.017$
- $a_{cyc}=0.0001$
- $c_{mon}=0.08$
- $c_{cyc}=0.04$
- $r_{hys}=0.05$
- $r_{mob}=0.9$
- $x_m=1.$
- $dila=1.$

1.3 Boundary conditions and loadings

the biaxial test presented here is carried out in modelization D_PLAN. Normal displacements with the study plan are thus null. One imposes on the test-tube a vertical displacement all while keeping the side pressure constant in the study plan. It can be drained (the pore fluid water pressure does not vary during the test) or NON-drained (one turns off the tap: the pore fluid water pressure evolves in the sample). One is interested here in the drained case, simpler, because not utilizing the influence of the pore water pressure of the fluid. One chooses a modelization in pure mechanics then.

In the model considered, the square element represents a quarter of the sample. The boundary conditions are thus the following ones:
Conditions of symmetry:
- $u_y = 0.$ on the group of mesh BAS
- $u_x = 0.$ on the group of mesh $GAUCHE$

conditions of side pressure:
- $P_n = 1.$ on the group of mesh $COTE$

conditions of loading:
- $P_n = 1.$ on the group of mesh $HAUT$
- $u_z = -1.$ on the group of mesh $HAUT$

the loading is carried out in two phases:
- An isotropic stress state $P_o = 100\, kPa$, is affected initially on the mesh $BLOC$;
- A vertical displacement is imposed on the mesh group $HAUT$ and varies between $t=0.$ and $t=10.$ from $u_y = 0.$ and $u_y = -0.2$ (total vertical strain of 20%).

1.4 Results

the solutions post-are treated with the point C, in terms of stress σ_{yy}, total voluminal strain ε_v and coefficients of isotropic hardening $\left(r_{ela}^{iso,m} + r_{iso}^{m}\right)$ and déviatoire $\left(r_{ela}^{d,m} + r_{dev}^{m}\right)$.

The validation is carried out by comparison with solutions GEFDYN provided by the Central School Paris (http://www.mssmat.ecp.fr/-GEFDYN,016-).

One also carries out the elementary computation of option PDIL_ELGA for this problem of softening. This computation option makes it possible to consider the value maximum A1 to allocate with the parameter of regularization mediums of second gradient of thermal expansion [R5.04.03]. This value is a function of the material parameters, stress state and values of the local variables at the time of computation [1].

1.5 Bibliographical references

[1] Foucault A. " *Modelization of the cyclic behavior of the ground works integrating of the techniques of regularization ".* Thesis of Doctor, Central School Paris, Châtenay Malabry, France, 2010.
[2] Hamadi K. "*Modelization of the bifurcations and instabilities in the géomatériaux ones*". Thesis of Doctor, Central School Paris, Châtenay Malabry, France, 2006

2 Modelization A

2.1 Characteristic of the modelization

The modelization is two-dimensional with plane strains D_PLAN and nonlinear static.
The vertical displacement imposed on the higher facet varies between 0 and $-0.2\mathrm{m}$ in 280 time step enters $t=0.$ and $t=10$. The automatic subdivision of the time step is activated to manage the situations of nonconvergence of local integration.

Computation option INDL_ELGA, making it possible to calculate the directions of the tensor of Rice, is also activated. The results provided by this option are tested in mode of NON-regression.

Computation option PDIL_ELGA, making it possible to calculate the values of parameter A1_LC2, is also activated. The results provided by this option are tested in mode of NON-regression.

2.2 Quantities tested and results

the solutions are calculated at the point C and are compared with references GEFDYN. They are given in terms of stress σ_{yy} , total voluminal strain ε_v and coefficients of hardening isotropic $\left(r_{ela}^{iso,m}+r_{iso}^{m}\right)$ and déviatoire $\left(r_{ela}^{d,m}+r_{dev}^{m}\right)$, and recapitulated in the following tables:

$\sigma_{yy}(kPa)$

ε_{zz}	TYPE	GEFDYN	Tolerance (%)
-1%	"SOURCE_EXTERNE"	-243.1	1.0.-2%
	"SOURCE_EXTERNE"	-287.8	1.0.-5%
	"SOURCE_EXTERNE"	-345.1	1.0
-10%	"SOURCE_EXTERNE"	-372.9	1.0
-20%	"SOURCE_EXTERNE"	-377.2	1.0

$\varepsilon_V=trace(\varepsilon)$

ε_{zz}	TYPE	GEFDYN	Tolerance (%)
-1%	"SOURCE_EXTERNE"	-4.07E-3	1.0.-2%
	"SOURCE_EXTERNE"	-6.04E-3	1.0.-5%
	"SOURCE_EXTERNE"	-8.18E-3	2.0
-10%	"SOURCE_EXTERNE"	-7.19E-3	6.0
-20%	"SOURCE_EXTERNE"	-1.87E-3	4.0

$\left(r_{ela}^{d,m}+r_{dev}^{m}\right)$ (Plane YZ)

ε_{zz}	TYPE	GEFDYN	Tolerance (%)
-1%	"SOURCE_EXTERNE"	0.398	2.0.-2%
	"SOURCE_EXTERNE"	0.455	1.0.-5%
	"SOURCE_EXTERNE"	0.517	2.0
-10%	"SOURCE_EXTERNE"	0.553	6.0
-20%	"SOURCE_EXTERNE"	0.582	1.0

$\left(r_{ela}^{d,m}+r_{dev}^{m}\right)$ (Plane XY)

ε_{zz}	TYPE	GEFDYN	Tolerance (%)
-1%	"SOURCE_EXTERNE"	0.643	2.0.-2%
	"SOURCE_EXTERNE"	0.755	1.0.-5%

	"SOURCE_EXTERNE"	0.870	1.0
-10%	"SOURCE_EXTERNE"	0.926	1.0
-20%	"SOURCE_EXTERNE"	0.961	1.0

$$\left(r_{ela}^{iso,m}+r_{iso}^{m}\right)$$

ε_{zz}	TYPE	GEFDYN	Tolerance (%)
-1%	"SOURCE_EXTERNE"	0.146	1.0.-2%
	"SOURCE_EXTERNE"	0.155	1.0.-5%
	"SOURCE_EXTERNE"	0.166	1.0
-10%	"SOURCE_EXTERNE"	0.181	2.0
-20%	"SOURCE_EXTERNE"	0.214	1.0

2.3 Comments

the comparison between solutions *Code_Aster* and GEFDYN is particularly good, with generally less ded' 1% error. The relative errors higher than 1% appear for levels of lower values tested.

3 Summary of the results

One represents in the following curves the various comparisons between *Code_Aster* and GEFDYN in terms of stress σ_{yy} (Figure 1), total voluminal strain (Figure 2 and of coefficients of hardening déviatoire (Figure 3) and isotropic (Figure 4).

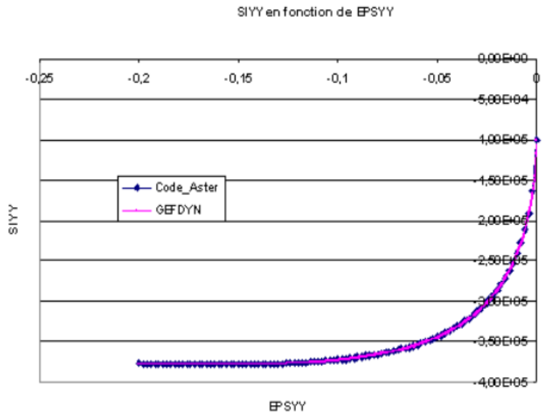


Figure **1** : σyy *according to the axial strain: comparison enters solutions Code_Aster and GEFDYN.*

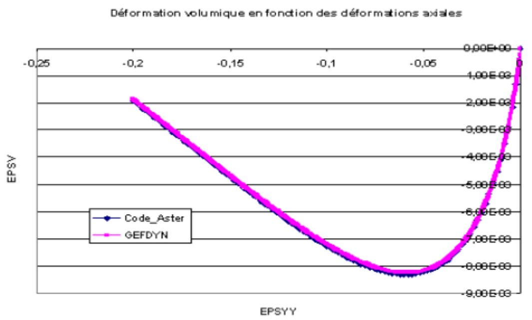


Figure **2** : *Total voluminal strain according to the axial strain: comparison enters solutions Code_Aster and GEFDYN (noted "EPSv").*

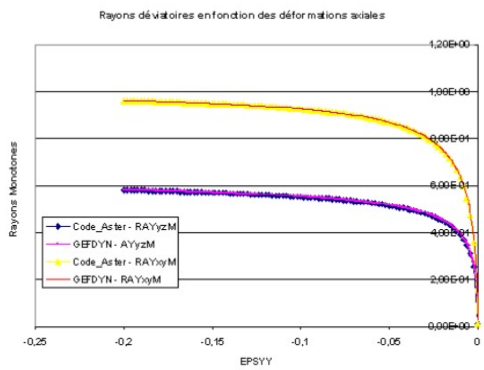


Figure **3** : *radius déviatoires according to the axial strain: comparison enters solutions Code_Aster and GEFDYN.*

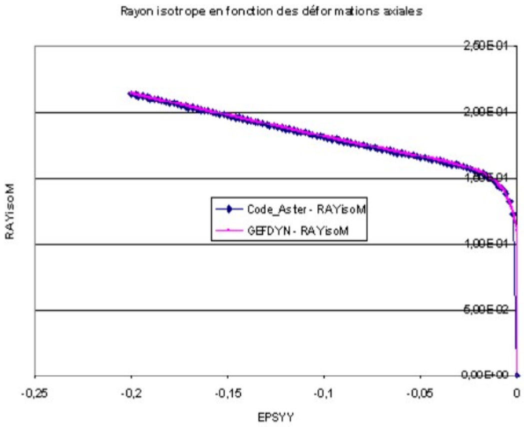


Figure **4** : *isotropic radius according to the axial strain: comparison enters solutions Code_Aster and GEFDYN.*