WTNV134 – Triaxial not drained cycliqueavec the model of Hujeux

Summarized

This test makes it possible to validate the cyclic mechanism déviatoires installation of and the cyclic mechanism of consolidation of the model of Hujeux. It is about a cyclic triaxial compression test carried out in not drained condition. The hydraulic coupling is taken into account, the sample is completely saturated, the squelette and the fluid is supposed to be incompressible.

The level of containment is of $30\,kPa$.

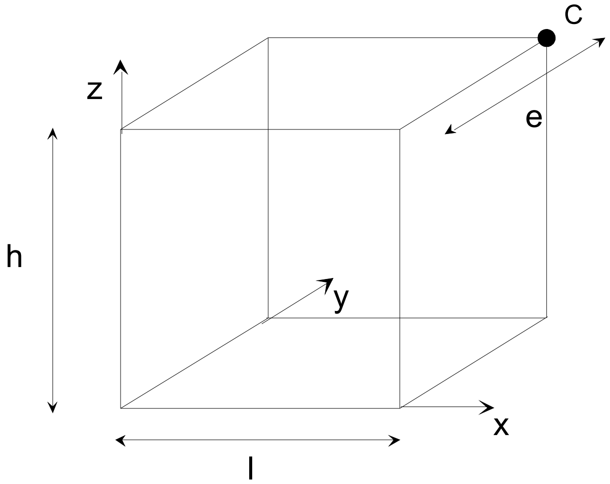
The results got with the model of Hujeux are compared with results resulting from the code finite elements GEFDYN of the Central School Paris (http://www.mssmat.ecp.fr/-GEFDYN,016-).

The modelization B allows to deal with the same problem with a simulation of type “material point”, without finite element.

1 Problem of reference

1.1 Geometry

It acts of a cubic sample of form of representation $1/8$ using an element $\mathrm{HEXA20}$.



hauteur : h = 1 m
largeur : l = 1 m
épaisseur : e = 1 m

1.2 Material properties

the elastic properties are:

- modulate isotropic compressibility: $K=516200\,kPa$;
- shear modulus: $\mu=238200\,kPa$;
- density [1] : $\rho_s=2500\,kg/m^3$.

The unelastic properties of the cyclic model of Hujeux result from the document referred with the following Internet address http://www.mssmat.ecp.fr/IMG/pdf/resp_loph40.pdf . They are the parameters relative to sand of Hostun:

- power of the nonlinear elastic model: $n_e=0.4$;
- $\beta=24$;
- $d=2.5$;
- $b=0.2$;
- friction angle: $\varphi=33°$;
- characteristic angle: $\psi=33°$;
- critical pressure: $P_{c0}=-1\,MPa$;
- pressure of reference: $P_{ref}=-1\,MPa$;
- elastic radius of the isotropic mechanisms: $r_{ela}^{s}=0.001$;
- elastic radius of the mechanisms déviatoires: $r_{ela}^{d}=0.005$;
- $a_{mon}=0.008$;
- $a_{cyc}=0.0001$;
- $c_{mon}=0.2$;
- $c_{cyc}=0.1$;
- $r_{hys}=0.05$;
- $r_{mob}=0.9$;
- $x_m=1$;
- $Dila=1$.

1 the absence of gravity, the densities of the soil and water does not intervene in the problem.

The hydraulic properties are:

- coefficient of Biot: $B=1$;
- density of water: $\rho_e=1000\,kg/m^3$;
- viscosity: $\nu=0.001$;
- the intrinsic permeability: $K^{\text{int}}=1.\text{E}^{-8}\,m^3/kg/s$;
- the modulus of compressibility of water: $K_e=1.\text{E}^{+12}\,Pa$.

1.3 Boundary conditions and loadings

1.3.1 Boundary conditions

They is the conditions of symmetry on the element, which represents $1/8$ sample. Displacements are blocked on the front sides ($u_y=0$), side left ($u_x=0$) and lower ($u_z=0$).

1.3.2 Loading

Phase 1: consolidation of the sample until the confining pressure p $_0$
One brings the sample in a homogeneous state of statically determinate effective stresses $\sigma_{xx}^0=\sigma_{yy}^0=\sigma_{zz}^0=\sigma^0=-30\,kPa$, by imposing the pressure σ_0 on the sides postpones, side right and higher of the element, while maintaining water pressures PRE1 null in the sample.

Phase 2: triaxial loading not drained
to obtain the not drained conditions, one imposes on all the sides of null hydraulic flux.
While maintaining on the sides back and side right a pressure equalizes with σ_0 , one applies an alternative loading in pressure of amplitude $\Delta\sigma$ equal to $15\,kPa$ the upper face, in order to obtain a variation of the vertical stress σ_{zz} in the sample understood in the interval $-45\,kPa\leq\sigma_{zz}\leq-15\,kPa$ (with sign convention less for compression).

1.4 Results

the solutions post-are treated with the point C, in terms of effective isotropic pressure P ($=\text{tr}(\sigma')/3$), plastic voluminal strain ε_v^p and coefficients of hardening isotropic $\left(r_{iso}^m+r_{ela}^{iso}\right)$ and $\left(r_{iso}^c+r_{ela}^{iso}\right)$ déviatoires $\left(r_d^m+r_{ela}^d\right)$ and $\left(r_d^c+r_{ela}^d\right)$.
The validation is carried out by comparison with solutions GEFDYN provided by the Central School Paris.

2 Modelization A

2.1 Characteristic of the modelization

The modelization is $3D$ with a hydro-mechanical coupling into quasi-static nonlinear.
In phase 1 of loading, one brings the sample to the pressure of consolidation $\sigma_{xx}^0=\sigma_{yy}^0=\sigma_{zz}^0=\sigma^0=-30\,kPa$
One uses the cyclic model of *Hujeux*.

2.2 Characteristics of the mesh

Many nodes: 20
Number of meshes and type: 1 HEXA20 and 6 QUAD8

2.3 Quantities tested and results

the solutions are calculated at the point C and are compared with the results got with GEFDYN. They are given in terms of isotropic pressure, plastic voluminal strain ε_v^p and factors of mobilization, and are recapitulated in the following tables:

$3\cdot P'=\sigma_{ij}\cdot\delta_{ij}\quad (kPa)$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster (kPa)	GEFDYN (kPa)	relative error
-15	-80.223	-80.194	0.038%
15	-73.988	-74.078	-0.122%
-15	-66.055	-66.250	-0.295%
15	-52.625	-52.999	-0.707%
-15	-45.539	-45.672	-0.292%

$\varepsilon_v^p=trace(\boldsymbol{\varepsilon}^p)$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster	GEFDYN	relative error
-15	-2.62e-5	-2.63e-5	-0.225%
$0\uparrow$	-2.80e-5	-2.78e-5	0.854%
$0\downarrow$	-4.48e-5	-4.43e-5	1.076%
$0\uparrow$	-7.11e-5	-7.05e-5	0.842%
$0\downarrow$	-1.13e-4	-1.11e-4	1.412%
$0\uparrow$	-1.85e-4	-1.85e-4	0.261%

$(r_{iso}^c+r_{ela}^s)$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster	GEFDYN	relative error
$0\uparrow$	0.00140	0.00138	1.329%
$0\downarrow$	0.00220	0.00217	1.406%
$0\uparrow$	0.00341	0.00337	1.246%
$0\downarrow$	0.00518	0.00510	1.663%
$0\uparrow$	0.00195	0.00189	2.947%

$(r_{dev}^m+r_{ela}^d)$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster	GEFDYN	relative error
15	0.326	0.326	-0.088%
-15	0.395	0.394	0.172%

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-15	0.579	0.578	0.255%

2.4 Remarks

the comparison between solutions Code_Aster and GEFDYN is relatively good. The differences are explained by the selected integration method for GEFDYN which is explicit. It would be necessary to increase the loading division to obtain values closer to those of Code_Aster.

3 Modelization B

3.1 Characteristic of the modelization

The modelization is of standard “material point” with linear relations on the components of the tensor of the strains simulating the incompressibility, into quasi-static nonlinear.
One considers here phase 2 of the loading, with a hydrostatic initial stress state $\sigma^0_{xx}=\sigma^0_{yy}=\sigma^0_{zz}=\sigma^0=-30\,kPa$
the data are identical to those of modelization A.

3.2 Caractéristiques of the mesh

No finite element

3.3 Quantities tested and results

the solutions are calculated at the point C and are compared with the results got with GEFDYN (same tests as the modelization A). They are given in terms of isotropic pressure, plastic voluminal strain ε^p_v and factors of mobilization, and are recapitulated in the following tables:

$3\cdot P'=\sigma_{ij}\cdot\delta_{ij}\quad (kPa)$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster (kPa)	GEFDYN (kPa)	relative error
-15	-80.223	-80.194	0.038%
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-15	-45.539	-45.672	-0.292%

$\varepsilon^p_v=trace(\boldsymbol{\varepsilon}^p)$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster	GEFDYN	relative error
-15	-2.62e-5	-2.63e-5	-0.225%
$0\uparrow$	-2.80e-5	-2.78e-5	0.854%
$0\downarrow$	-4.48e-5	-4.43e-5	1.076%
$0\uparrow$	-7.11e-5	-7.05e-5	0.842%
$0\downarrow$	-1.13e-4	-1.11e-4	1.412%
$0\uparrow$	-1.85e-4	-1.85e-4	0.261%

$(r^c_{iso}+r^s_{ela})$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster	GEFDYN	relative error
$0\uparrow$	0.00140	0.00138	1.329%
$0\downarrow$	0.00220	0.00217	1.406%
$0\uparrow$	0.00341	0.00337	1.246%
$0\downarrow$	0.00518	0.00510	1.663%
$0\uparrow$	0.00195	0.00189	2.947%

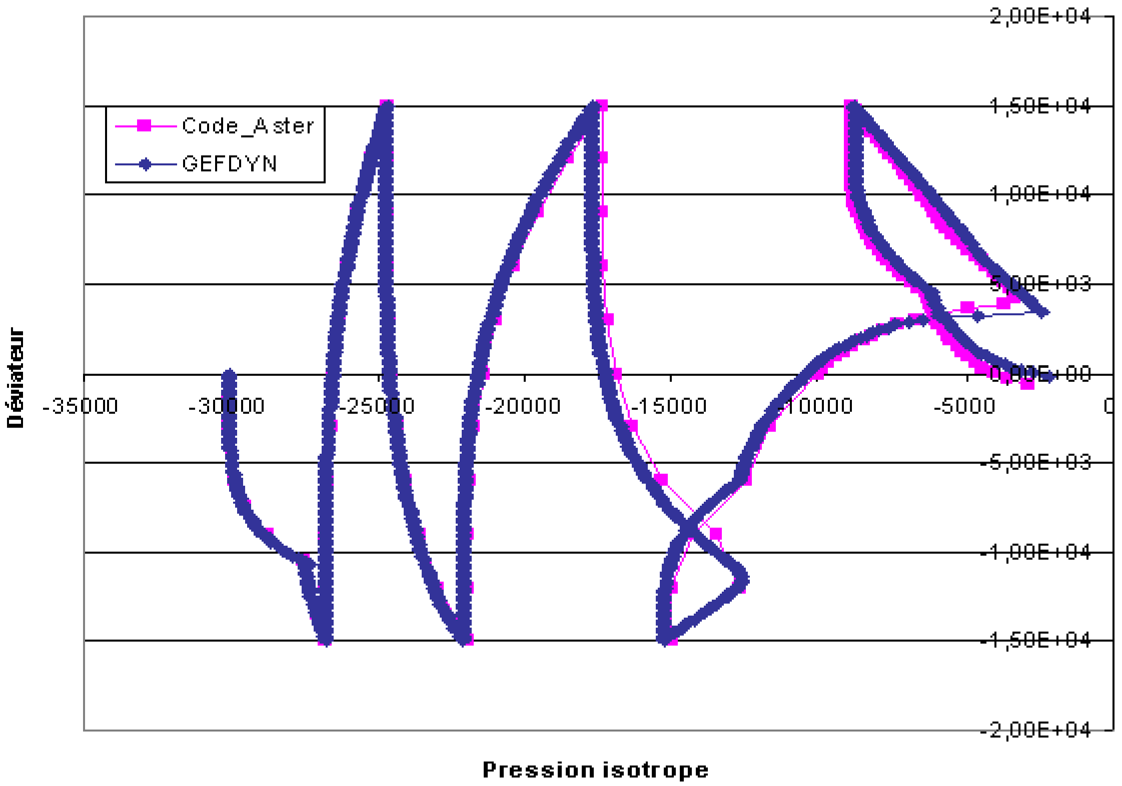
$(r^m_{dev}+r^d_{ela})$

$Q=\sigma_{zz}-\sigma_{xx}$ (kPa)	Code_Aster	GEFDYN	relative error
15	0.326	0.326	-0.088%
-15	0.395	0.394	0.172%

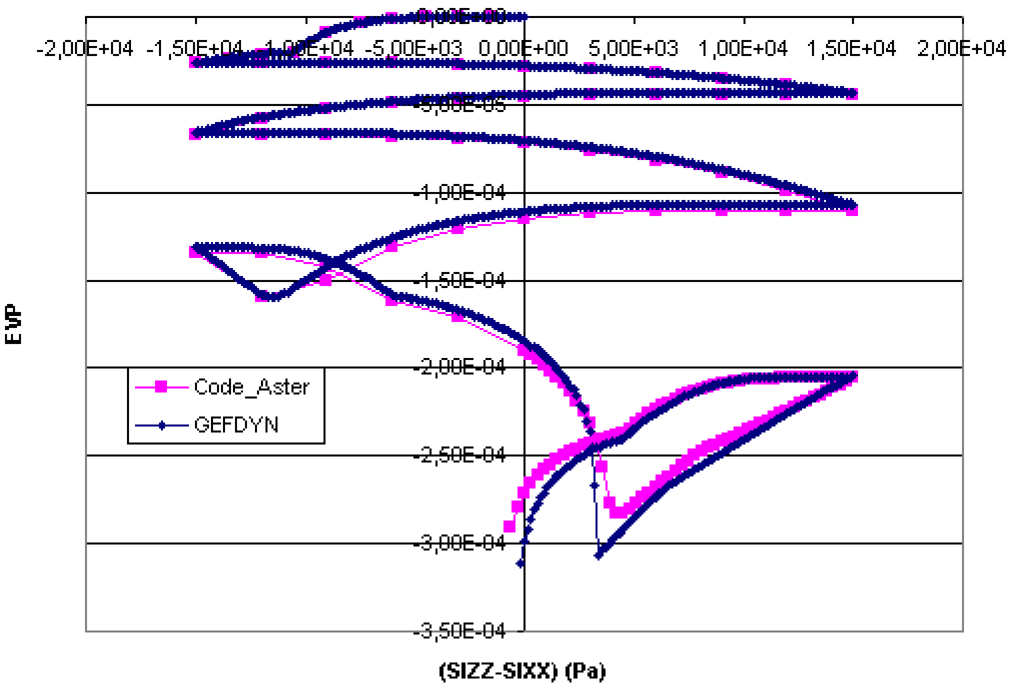
15	0.395	0.394	0.172%
-15	0.579	0.578	0.255%

4 Summary of the results

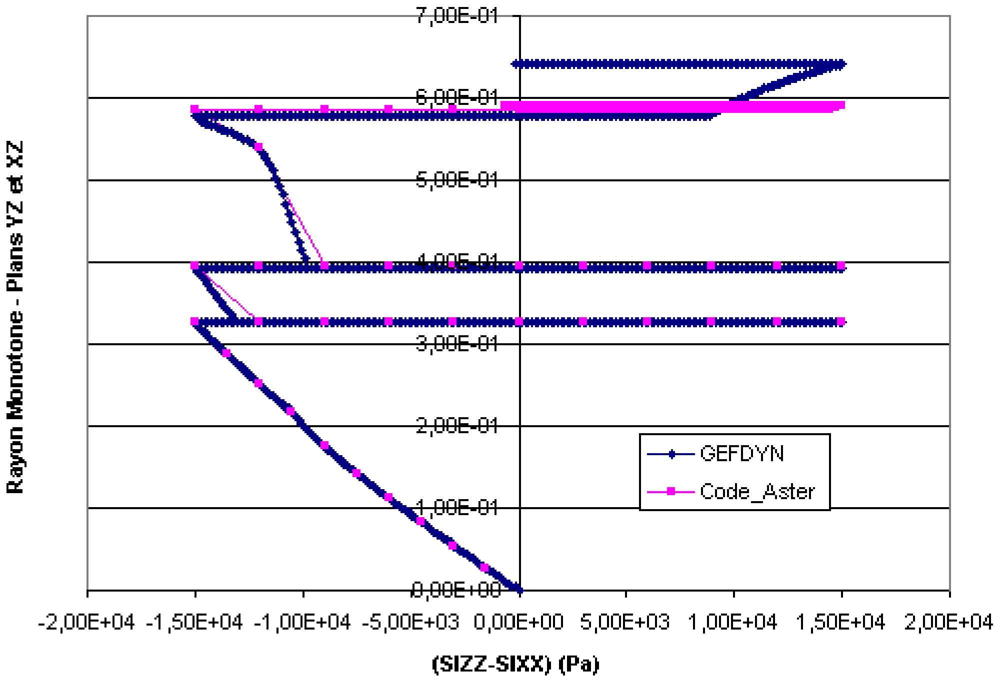
One represents in the following curves the various comparisons between *Code_Aster* and GEFDYN, in terms of isotropic pressure (Figure 4-a), of plastic voluminal strain (Figure 4-b) and of coefficients of hardening déviatoire (Figure 4-c).



Appear 4-a : ***Cyclic triaxial compression test not drained (Plane $P-Q$): comparison enters solutions Code_Aster and GEFDYN for a pressure of consolidation of $30\,kPa$.***



Appear 4-b: ***Plastic voluminal strain according to the deviator of the stresses: comparison enters the solutions Code_Aster and*** GEFDYN **.**



Appear 4-c: monotonous radius déviatoire according to the deviator of the stresses: comparison enters the results of Code_Aster and GEFDYN.