SSNV207 – Cyclic shear test including of the microphone-discharges with the model of Summarized

Hujeux

One carries out a cyclic shear test, controlled in force, in pure mechanics (equivalent under drained hydraulic conditions) with *the model of Hujeux*. During the cycles of load-discharge, microphone-discharges are carried out to test the capacity of the model of Hujeux to find the shear modulus hammer-hardened before this microphone-discharge. The calculated solutions are compared with results resulting from Code_Aster for a way of identical cyclic loading without the microphone-discharges.

1 Problem of reference

1.1 Geometry

the cyclic shear test is carried out on a single Gauss point. The test is thus controlled completely in imposed stresses and strains.

1.2 Material properties of the sand of Hostun

the elastic properties are:
- modulate isotropic compressibility: $K=516\,MPa$
- shear modulus: $\mu=238\,MPa$

The unelastic properties (models of Hujeux) were established by F.Lopez-Caballero **[1]** :
- power of the nonlinear elastic model: $n_e=0.4$ (– > elastic linear)
- $\beta=24.$
- $d=2.5$
- $b=0.2$
- friction angle: $\phi=33°$
- characteristic angle: $\Psi=33°$
- critical pressure: $P_{CO}=-1000\,kPa$
- pressure of reference: $P_{ref}=-1000\,kPa$
- elastic radius of the isotropic mechanism: $r_i^{ela}=10^{-3}$
- elastic radius of the mechanism déviatoire: $r_d^{ela}=0.005$
- $a_{mon}=0.008$
- $a_{cyc}=0.0001$
- $c_{mon}=0.18$
- $c_{cyc}=0.09$
- $r_{hys}=0.05$
- $r_{mob}=0.9$
- $x_m=1.$
- $dila=1.$

1.3 Boundary conditions and loadings

the cyclic shear test presented here is carried out in pure mechanical conditions, via command `SIMU_POINT_MAT`. One imposes at the local level on the Gauss point considered a shearing stress σ_{xy} , variable during the test. The components σ_{xx} σ_{yy} , σ_{zz} are constant during the test and equal to the value of confining pressure of $P_0=-50\,kPa$. The test carried out corresponds to a direct shear test.

In the model considered, the imposed stresses are thus the following ones:
- Constant confining pressure:

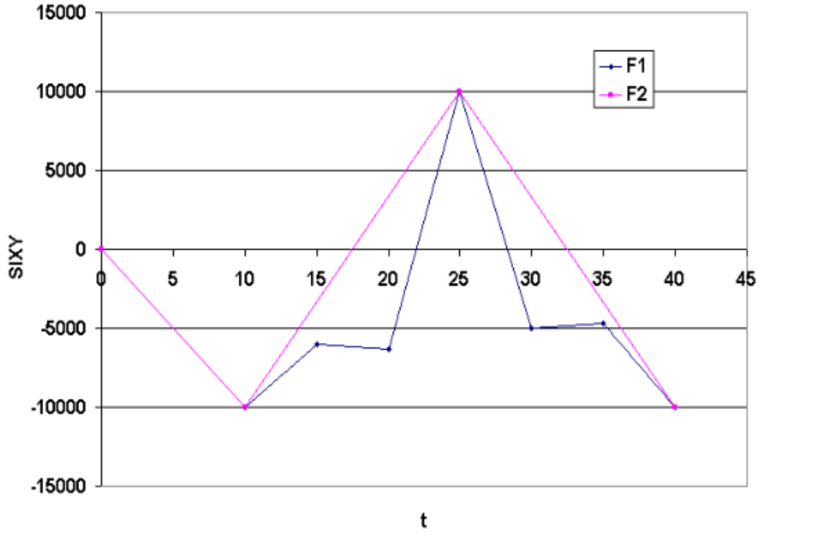
$$P_0=\sigma_{xx}=\sigma_{yy}=\sigma_{zz}=-50\,kPa$$

- Conditions of loading:

$$\sigma_{xy}=F1(t)$$, t corresponding to the fictitious time of the modelization.

The loading is carried out in two phases:
- An isotropic stress state $P_o=-50\,kPa$, is affected initially at the Gauss point considered;
- A shearing stress σ_{xy} , is imposed and varies between $t=0.$ and $t=40$ according to the function $F1(t)$.

A test of non regression is carried out with Code_Aster where one also carries out a cyclic direct shear test but microphone-discharge. Shearing stresses following the function then $F2(t)$.



Appear 1.3-a: Evolution of $F1$ and $F2$ according to t

1.4 Results

the solutions post-are treated with the Gauss point, in terms of distortion ε_{xy} , cumulated plastic voluminal strain $\varepsilon_v^p\,\%$, and of coefficients of cyclic hardening déviatoire r_d^c .

The validation is carried out by comparison with the solution obtained for the way of loading without the microphone-discharges via Code_Aster.

2 Modelization A

2.1 Characteristic of the modelization

The modelization is three-dimensional $3D$ and static nonlinear.

The cyclic shear test with microphone-discharges is controlled in stresses, via σ_{xy}, while imposing a constant confining pressure $P_0 = -50\,kPa$. The automatic subdivision of the time step is only activated to manage the situations of nonconvergence of local integration.
In the integration of the balance equations, one asks for a reactualization of the tangent matrix, which is provided by the routines of the model of Hujeux and accelerates convergence considerably. One also asks for the subdivision of time step (command DEFI_LIST_INST) to treat the situations of failure of local integration due to increments of too large loading. This functionality *is largely recommended*.

2.2 Quantities tested and results

the solutions are calculated at the Gauss point and are compared with references Code_Aster for a way of identical loading without the microphone-discharges. They are given in terms of strains ε_{xy}, cumulated plastic voluminal strain ε_v^p and coefficients of hardening déviatoire cyclic $\left(r_{ela}^{d,c} + r_{dev}^{c}\right)$, and are recapitulated in the following tables:

ε_{xy}

σ_{xy} [Pa]	Standard of Reference	Value of reference	Tolerance ($\%$)
$-1E4$	AUTRE_ASTER	$-1.95E-4$	1.0
$1E4$	AUTRE_ASTER	$1.94E-4$	1.0
$-1E4$	AUTRE_ASTER	$1.95E-4$	1.0

ε_v^p

σ_{xy} [Pa]	Standard of Reference	Value of reference	Tolerance ($\%$)
$-1E4$	AUTRE_ASTER	$-1.35E-5$	2.0
$1E4$	AUTRE_ASTER	$-4.28E-5$	1.0
$-1E4$	AUTRE_ASTER	$-7.21E-5$	1.0

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

σ_{xy} [Pa]	Standard of Reference	Value of reference	Tolerance ($\%$)
$1E4$	AUTRE_ASTER	0.23	1.0
$-1E4$	AUTRE_ASTER	0.23	1.0

2.3 Comments

the comparison between the solutions with or without microphone-discharge are particularly good, with generally less 1% of error.

3 Summary of the results

One represents as information in the following curves the various comparisons between Code_Aster for the two types of loading stated in the document (AD : With discharge; SD : Without discharge) and GEFDYN, the software finite elements developed at the MSSMat laboratory of the Central School Paris. The curves take again the quantities tested beforehand in the preceding section, namely ε_{xy} (figure 3-a), ε_v^p (figure 3-b) and $\left(r_{ela}^{d,c}+r_{dev}^{c}\right)$ (figure 3-c).

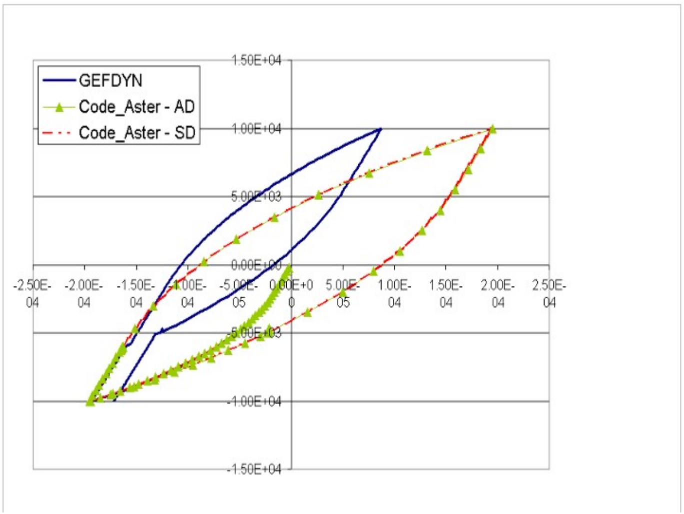
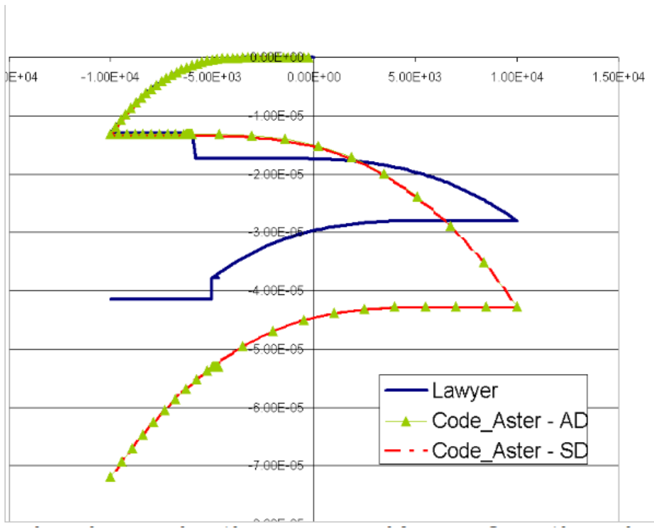
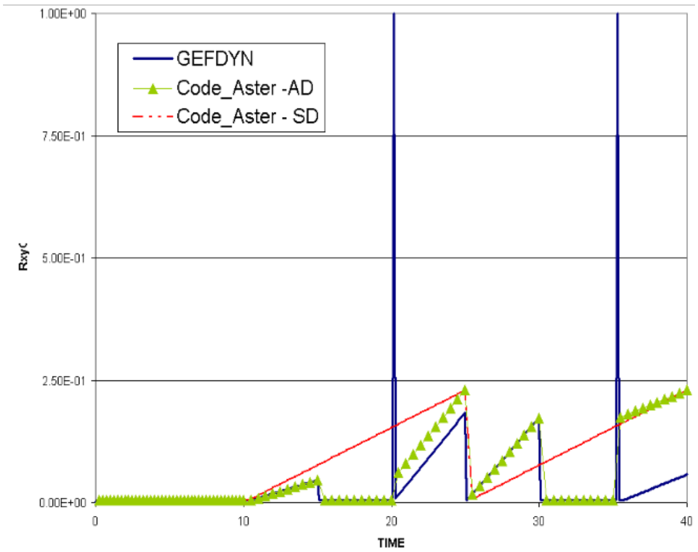


Figure 3-a : **3-a** *Stress déviatoire according to the distortion: comparison of the solutions of Code_Aster and GEFDYN*



Appears **3-b** : *plastic voluminal strain cumulated according to the stress déviatoire: comparison enters the solutions of Code_Aster and GEFDYN.*



Appear **3-c**: *cyclic radius déviatoire according to fictitious time: comparison enters the solutions of Code_Aster and GEFDYN.*

The differences observed between GEFDYN and Code_Aster propose a suspect management by GEFDYN of the hardening of the cyclic circles déviatoires in the plane of imposed shears. Whereas the model predicted an elastic microphone-discharge, GEFDYN proposes a complete hardening of the cyclic circle déviatoire until perfect plasticity, before defining a cyclic circle déviatoire in elastic radius. The behavior of the Code_Aster respects the elastic character of this discharge and takes again in output of this microphone-discharge a slope of hardening identical to that obtained before.

The development team of GEFDYN is advised divergences noted between the two computer codes.

[1] Lopez Caballero F. "Influence of Behavior Nonlinear of the Soil on the Seismic Motions Induced in Géo-Structures". Thesis of Doctor, Central School Paris, Châtenay Malabry, France, 2003