WTNV122 - Triaxial compression test not drained with the law CAM_CLAY

Summary:

This test makes it possible to validate the mechanical law elastoplastic Cam_Clay specific to the normally consolidated grounds. This law integrates an elastoplastic hydrostatic mechanism (of which the elastic part is not - linear and the threshold of flow corresponds to the pressure of consolidation) coupled to an elastoplastic mechanism deviatoric of which the elastic part is linear. The behavior is hardening or lenitive following the combination of the two mechanisms.

Three different modelings are realized in 3D. In each modeling, the test is carried out in hydro-mechanical coupling and it understands two ways of loading:

Modeling A is characterized by:

- a hydrostatic way of compression in condition drained until the pressure of consolidation,
- a way not-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial state of stresses, and a plastic mode contracting.

Modeling B is characterized by:

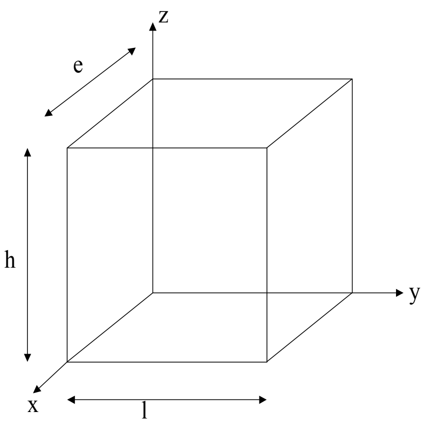
- a hydrostatic way of compression in condition drained until the critical pressure, equal to half of the pressure of consolidation,
- a way not-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial state of stresses up to the critical point.

Modeling C is characterized by:

- a hydrostatic way of compression in condition drained until a pressure lower than the critical pressure,
- a way not-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces state of stresses triaxial dilating plastic.

1 Problem of reference

1.1 Geometry



height: $h=1\text{m}$
width: $l=1\,m$
thickness: $e=1\,m$

1.2 Properties of material

Parameters specific to CAM_CLAY :

$\mu=6.10^6$, $\text{PORO}=0.14$, $\lambda=0.25$, $\kappa=0.05$, $M=0.9$, $\text{PRES\_CRIT}=3.10^5 Pa$, $K_{cam}=0$, $P_{trac}=0$

1.3 Boundary conditions and loadings

The first way of loading is carried out with a state of hydrostatic stresses: $\sigma_{xx}=\sigma_{yy}=\sigma_{zz}=P$. One does a first elastic design until $P=PA$ (to establish a plastically acceptable initial state). One increases then P until $P_{\sup}$, the pressure of water is kept worthless $PRE1=0$ (drained condition). For the second way, the pressure is kept P on the side faces and one imposes then a vertical displacement imposed in compression to model a triaxial compression test, calculation is now not drained, which corresponds to a hydrostatic flow no one on all the faces.

For modeling a: $P_{\sup}=P_{\text{consolidation}}=6.10^5 Pa=2\,P_{cr}$ (final state contracting)

For modeling b: $P_{\sup}=P_{cr}$ (final state criticizes with worthless voluminal variation)

For modeling C: $P_{\sup}=2.\,10^5 Pa<P_{cr}$ (final state dilating)

1.4 Initial conditions

The plastic condition of compatibility requires that in an initial state the hydrostatic constraint be strictly higher than zero. To initialize this constraint, one chose to carry out at the beginning a purely elastic calculation while making evolve the pressure of $0.$ with $1.\text{E}5\,Pa$. One extracts from this calculation only the stress field at the points of gauss. This stress field resulting from the elastic design is regarded as the initial state of the hydrostatic constraint necessary to the law Cam_Clay of following calculation.

2 Reference solution

An exact solution exists as much as the loading is hydrostatic (cf SSNV160). For the second triaxial way, an analytical solution is not obvious to find. In the same way, one does not have of the data and triaxial experimental test results allowing to compare them with calculations.
This test is a test of not-regression.

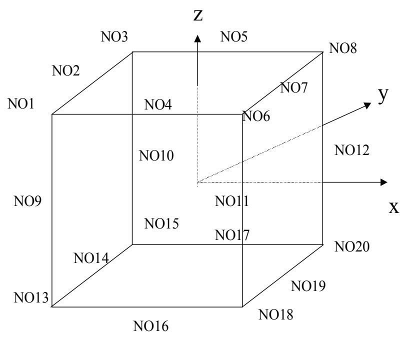
3 Modeling A

Modeling A is characterized by:

- a way of hydrostatic compression in condition drained until the pressure of consolidation,
- a way not-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial state of stresses, and a plastic mode contracting.

3.1 Characteristics of modeling

Modeling `3D`



3.2 Characteristics of the grid

Many nodes:	20
Many meshs:	1 of type `HEXA 20`
	6 of type `QUAD 8`

The following meshs are defined:

DROITE	*NO3 NO5 NO8 NO10 NO12 NO15 NO17 NO20*
GAUCHE	*NO1 NO4 NO6 NO9 NO11 NO13 NO16 NO18*
DEVANT	*NO6 NO7 NO8 NO11 NO12 NO18 NO19 NO20*
DERRIERE	*NO1 NO2 NO3 NO9 NO10 NO13 NO14 NO15*
BAS	*NO13 NO14 NO15 NO16 NO17 NO18 NO19 NO20*
HAUT	*NO1 NO2 NO3 NO4 NO5 NO6 NO7 NO8*

To account for the 1/8ème structure, the boundary conditions in displacement imposed are:

On the face BAS : $DZ=0$
On the face $GAUCHE$: $DY=0$
On the face $DERRIERE$: $DX=0$

The loading is made up by same pressure divided into compression on the 3 meshs: $HAUT$, $DROITE$ and $DEVANT$ to simulate a hydrostatic test, and of a worthless water pressure to simulate the condition of drainage ($PRE1=0$). Then, the pressure distributed is kept constant on the side faces $DROITE$ and $DEVANT$, a displacement DZ is imposed on the face $HAUT$

variable with time, and one changes the hydraulic loading (null flow) to simulate the not drained condition.

3.3 Sizes tested and results

Components σ_{xx} , σ_{yy} and σ_{zz} constraint are tested at moments 3. , 6. , 15. and 20. and the value of the pressure of water $PRE1$ at moment 20 with the node $NO8$. The values of reference are values of not-regression.

Values of σ_{xx} and σ_{yy} :

	Moment	Reference	*Aster*
1 er loading	3.	Not regression	–3.000000+05
1 er loading	6.	Not regression	–6.000000+05
2nd loading	15.	Not regression	-2.42065+05
2nd loading	20.	Not regression	-2.413841+05

Values of σ_{zz} :

	Moment	Reference	*Aster*
1 er loading	3.	Not regression	–3.000000+05
1 er loading	6.	Not regression	–6.000000+05
2nd loading	15.	Not regression	-5.520378+05
2nd loading	20.	Not regression	-5.514999+05

Values of $PRE1$:

	Moment	Reference	*Aster*
2emechargement	20.	Not regression	3.586158+05

4 Modeling B

Modeling B is characterized by:

- a hydrostatic way of compression in condition drained until the critical pressure, equal to half of the pressure of consolidation,
- a way not-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial state of stresses up to the critical point.

4.1 Characteristics of modeling

Idem modeling A

4.2 Characteristics of the grid

Idem modeling A

4.3 Sizes tested and results

Components σ_{xx}, σ_{yy} and σ_{zz} constraint are tested at moments 3. , 6. , 15. and 20. and the value of the pressure of water $PRE1$ at moment 20 with the node $NO8$. The values of reference are values of not-regression.

Values of σ_{xx} and σ_{yy} :

	Moment	**Reference**	***Aster***
1 er loading	3.	Not regression	–2.000000+05
1 er loading	6.	Not regression	–3.000000+05
2nd loading	15.	Not regression	–2.099999 +05
2nd loading	20.	Not regression	–2.100000+05

Values of σ_{zz} :

	Moment	**Reference**	***Aster***
1 er loading	3.	Not regression	–2.000000+05
1 er loading	6.	Not regression	–3.000000+05
2nd loading	15.	Not regression	–4.799999+05
2nd loading	20.	Not regression	–4.800000 +05

Values of $PRE1$:

	Moment	**Reference**	***Aster***
2emechargement	20.	Not regression	9.00000+E4

5 Modeling C

Modeling C is characterized by:

- a hydrostatic way of compression in condition drained until a pressure lower than the critical pressure,
- a way not-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces state of stresses triaxial dilating plastic.

5.1 Characteristics of modeling

Idem modeling A

5.2 Characteristics of the grid

Idem modeling A

5.3 Sizes tested and results

Components σ_{xx} , σ_{yy} and σ_{zz} constraint are tested at moments 3. , 6. , 15. and 20. and the value of the pressure of water $PRE1$ at moment 20 with the node $NO8$. The values of reference are values of not-regression.

Values of σ_{xx} and σ_{yy} :

	Moment	Reference	*Aster*
1 er loading	3.	Not regression	–2.000000+05
1 er loading	6.	Not regression	–2.200000+05
2nd loading	15.	Not regression	-1.800162+05
2nd loading	20.	Not regression	-1.958830+05

Values of σ_{zz} :

	Moment	Reference	*Aster*
1 er loading	3.	Not regression	–2.000000+05
1 er loading	6.	Not regression	–2.200000+05
2nd loading	15.	Not regression	-4.369201+05
2nd loading	20.	Not regression	-4.499510+05

Values of $PRE1$:

	Moment	Reference	*Aster*
2emechargement	20.	Not regression	2.411696+04

6 Summary of the results

By interpreting the diagram (P,Q), $P=\frac{-tr(\sigma)}{3}$ and $Q=-(\sigma_3-\sigma_1)$ for three modelings of this CAS-test, one notes well that in modeling A [Figure 6-a], the loading remains hydrostatic up to a value of $6.E^5\ Pa$. Once vertical displacement is imposed and varies with time, the pressures on the side faces being maintained constant, a diverter of constraints is induced and increases with time with a positive work hardening. When one approaches the point $Q=MP$, one tends towards perfect plasticity with plastic flow without work hardening and variation of constraints (see [§6] Doc. [R7.01.14]).

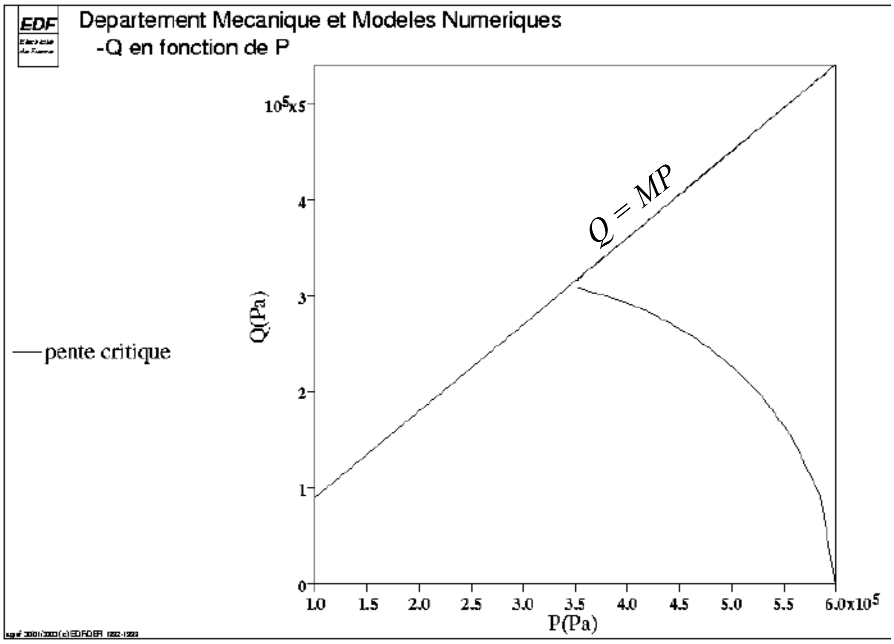


Figure 6-a: Q according to P (modeling A)

In modeling B [Figure 6-b], after a hydrostatic loading which reaches the pressure criticizes with $3.E^5\ Pa$, the second loading is only deviatoric with a hydrostatic pressure maintained with $3.E^5\ Pa$. When one reaches the point criticizes, one touches the critical slope, where plasticity is perfect with plastic flow without work hardening and variation of constraints.

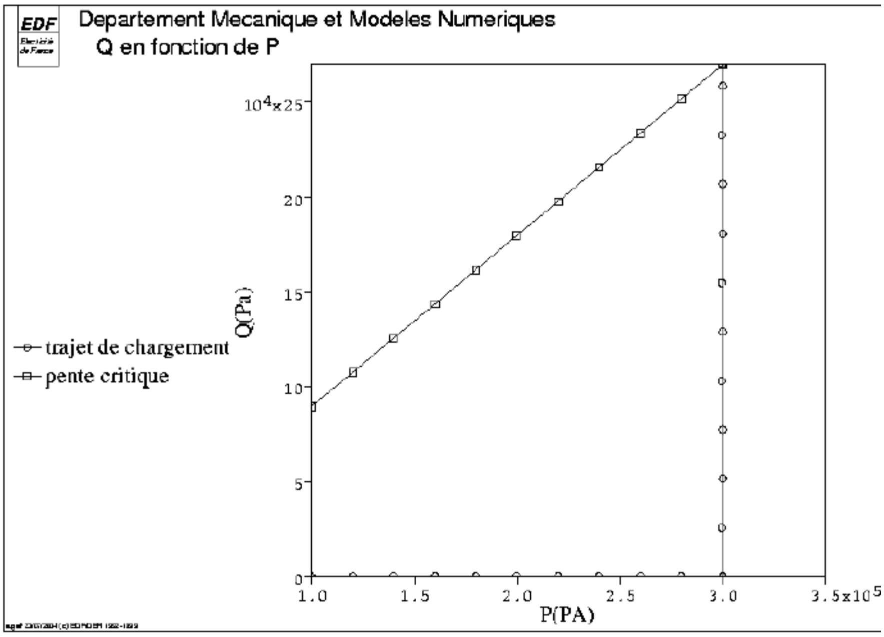


Figure 6-b: Q according to P (modeling B)

In modeling C [Figure 6-c], vertical displacement is imposed before the hydrostatic loading reached the critical pressure. The diverter of the constraints varies with time, while the pressures on the side faces are kept constant. As the criterion of plasticity is reached in the field of dilatancy, work hardening is negative and the diverter of the constraints decreases with time.

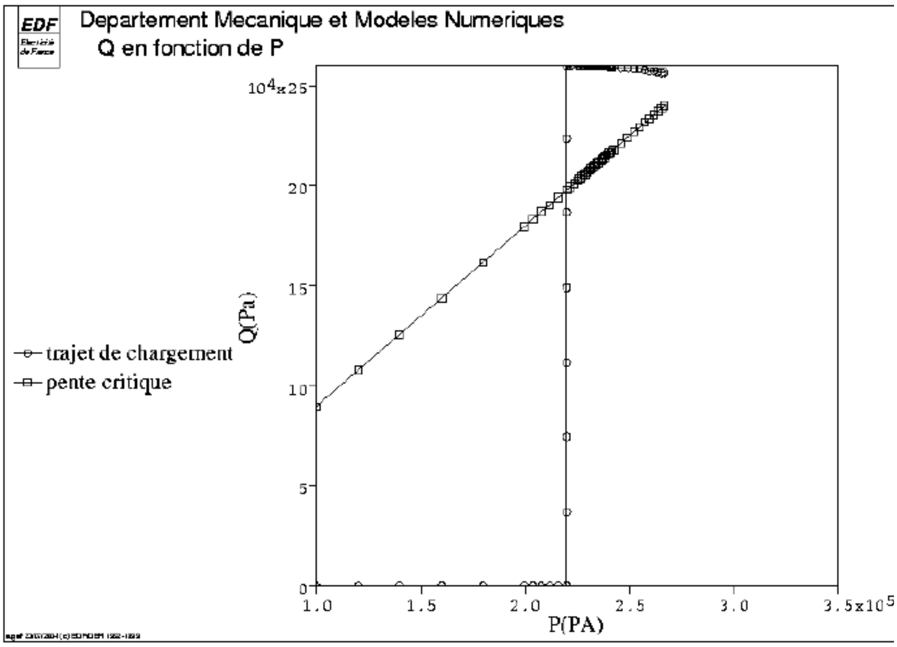


Figure 6-c: Q according to P (modeling C)