WTNV122 - Triaxial compression test not drained with model CAM_CLAY

Summarized:

This test makes it possible to validate the mechanical model elastoplastic Cam_Clay specific to the normally consolidated soils. This model integrates an elastoplastic hydrostatic mechanism (of which the elastic part is not - linear and the flow threshold 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 modelizations are carried out in 3D. In each modelization, the test is carried out in hydro-mechanical coupling and it understands two ways of loading:

The modelization A is characterized by:

- a hydrostatic way of compression in condition drained until the pressure of consolidation,
- a way NON-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial stress state, and a plastic mode contracting.

The modelization B is characterized by:

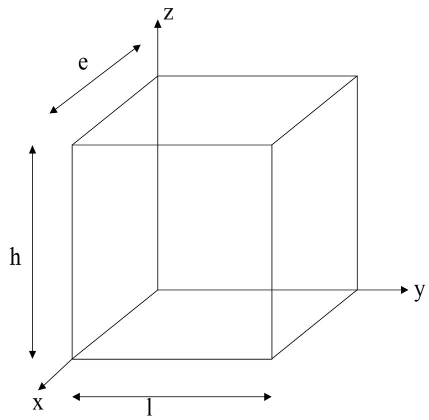
- a hydrostatic way of compression in condition drained until the pressure criticizes, equal to half of the pressure of consolidation,
- a way NON-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial stress state up to the critical point.

The modelization C is characterized by:

- a hydrostatic way of compression in condition drained until a pressure lower than the critical pressure,
- a way NON-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial stress state 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 the material

Parameters specific to CAM_CLAY :

$\mu=6.10^6$ PORO$=0.14$ $\lambda=0.25$ $\kappa=0.05$ $M=0.9$ 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 stress state hydrostatics: $\sigma_{xx}=\sigma_{yy}=\sigma_{zz}=P$. 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 maintained null $PRE1=0$ (drained condition). For the second way, one keeps the pressure P on the side sides and one imposes then a vertical displacement imposed in compression to model a triaxial compression test, computation is now not drained, which corresponds to a hydrostatic flux no one on all the sides.

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

For modelization b: $P_{\text{sup}}=P_{cr}$ (final state criticizes with voluminal variation null)

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

1.4 Initial conditions

the plastic compatibility condition requires that in an initial state the hydrostatic stress be strictly higher than zero. To initialize this stress, one chose to carry out at the beginning a purely elastic computation while making evolve the pressure of $0.$ with $1.\text{E}5\,Pa$. One extracts from this computation 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 stress necessary to the model Cam_Clay of following computation.

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 of results triaxial experimental tests allowing to compare them with computations.
This test is a test of NON-regression.

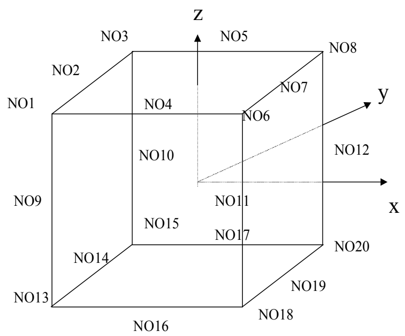
3 Modelization With

the modelization A is characterized by:

- a hydrostatic way of compression in condition drained until the pressure of consolidation,
- a way NON-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial stress state, and a plastic mode contracting.

3.1 Characteristics of the modelization

Modelization 3D



3.2 Characteristic of the mesh

Many nodes:	20
Number of meshes:	1 of type HEXA20
	6 of type QUAD 8

One defines the meshes following ones:

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 represent the 1/8ème of 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 the same distributed pressure in compression on the 3 meshes: $HAUT$, $DROITE$ and $DEVANT$ to simulate a hydrostatic test, and of a water pressure null to simulate the condition of drainage ($PRE1=0$). Then, the distributed pressure is kept constant on the side sides

$DROITE$ and $DEVANT$, a displacement DZ is imposed on the variable $HAUT$ face with time, and one changes the hydraulic loading (null flux) to simulate the not drained condition.

3.3 Quantities tested and results

the components σ_{xx}, σ_{yy} and σ_{zz} of the stress are tested at times 3. , 6. , 15. and 20. and the value of the pressure of water $PRE1$ at time 20 with the node $NO8$. The values of reference are values of NON-regression.

Values of σ_{xx} and σ_{yy} :

	Time	Reference	*Aster*
1st loading	3.	Non regression	– 3.000000+05
1st loading	6.	Non regression	– 6.000000+05
2nd loading	15.	Non regression	-2.42065+05
2nd loading	20.	Non regression	-2.413841+05

Values of σ_{zz} :

	Time	Reference	*Aster*
1st loading	3.	Non regression	– 3.000000+05
1st loading	6.	Non regression	– 6.000000+05
2nd loading	15.	Non regression	-5.520378+05
2nd loading	20.	Non regression	-5.514999+05

Values of $PRE1$:

	Time	Reference	*Aster*
2emechargement	20.	Non regression	3.586158+05

4 Modelization B

The modelization B is characterized by:

- a hydrostatic way of compression in condition drained until the pressure criticizes, equal to half of the pressure of consolidation,
- a way NON-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial stress state up to the critical point.

4.1 Characteristics of the modelization

Idem modelization A

4.2 Characteristic of the mesh

Idem modelization A

4.3 Quantities tested and results

the components σ_{xx} , σ_{yy} and σ_{zz} of the stress are tested at times 3. , 6. , 15. and 20. and the value of the pressure of water $PRE1$ at time 20 with the node $NO8$. The values of reference are values of NON-regression.

Values of σ_{xx} and σ_{yy} :

	Time	**Reference**	***Aster***
1st loading	3.	Non regression	– 2.000000+05
1st loading	6.	Non regression	– 3.000000+05
2nd loading	15.	Non regression	– 2.099999 +05
2nd loading	20.	Non regression	– 2.100000+05

Values of σ_{zz} :

	Time	**Reference**	***Aster***
1st loading	3.	Non regression	– 2.000000+05
1st loading	6.	Non regression	– 3.000000+05
2nd loading	15.	Non regression	– 4.799999+05
2nd loading	20.	Non regression	– 4.800000 +05

Values of $PRE1$:

	Time	**Reference**	***Aster***
2emechargement	20.	Non regression	9.00000+E4

5 Modelization C

The modelization C is characterized by:

- a hydrostatic way of compression in condition drained until a pressure lower than the critical pressure,
- a way NON-drained by maintaining the pressures lateral confining on the sample and by imposing a vertical displacement of compression which induces a triaxial stress state dilating plastic.

5.1 Characteristics of the modelization

Idem modelization A

5.2 Characteristic of the mesh

Idem modelization A

5.3 Quantities tested and results

the components σ_{xx}, σ_{yy} and σ_{zz} of the stress are tested at times 3. , 6. , 15. and 20. and the value of the pressure of water $PRE1$ at time 20 with the node $NO8$. The values of reference are values of NON-regression.

Values of σ_{xx} and σ_{yy} :

	Time	Reference	*Aster*
1st loading	3.	Non regression	– 2.000000+05
1st loading	6.	Non regression	– 2.200000+05
2nd loading	15.	Non regression	-1.800162+05
2nd loading	20.	Non regression	-1.958830+05

Values of σ_{zz} :

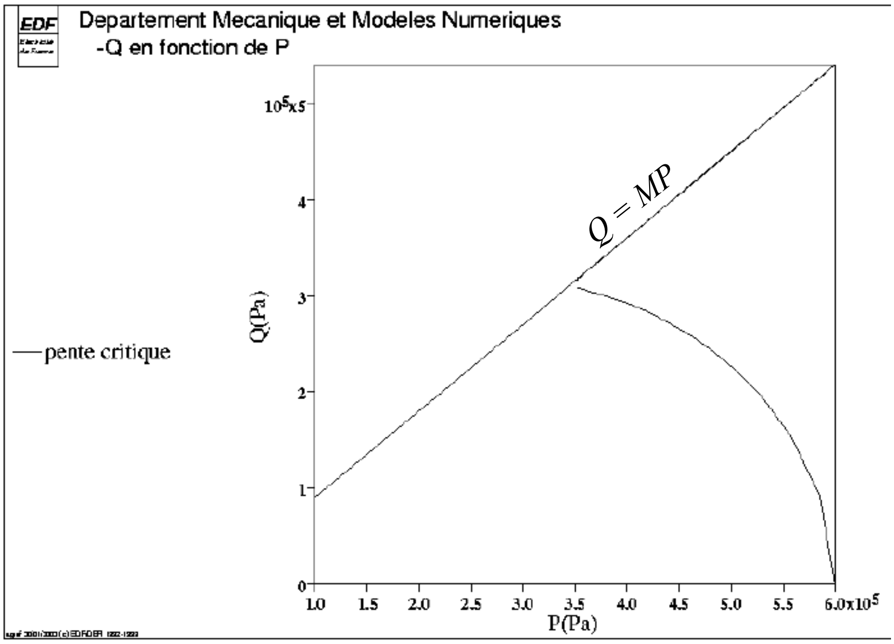
	Time	Reference	*Aster*
1st loading	3.	Non regression	– 2.000000+05
1st loading	6.	Non regression	– 2.200000+05
2nd loading	15.	Non regression	-4.369201+05
2nd loading	20.	Non regression	-4.499510+05

Values of $PRE1$:

	Time	Reference	*Aster*
2emechargement	20.	Non regression	2.411696+04

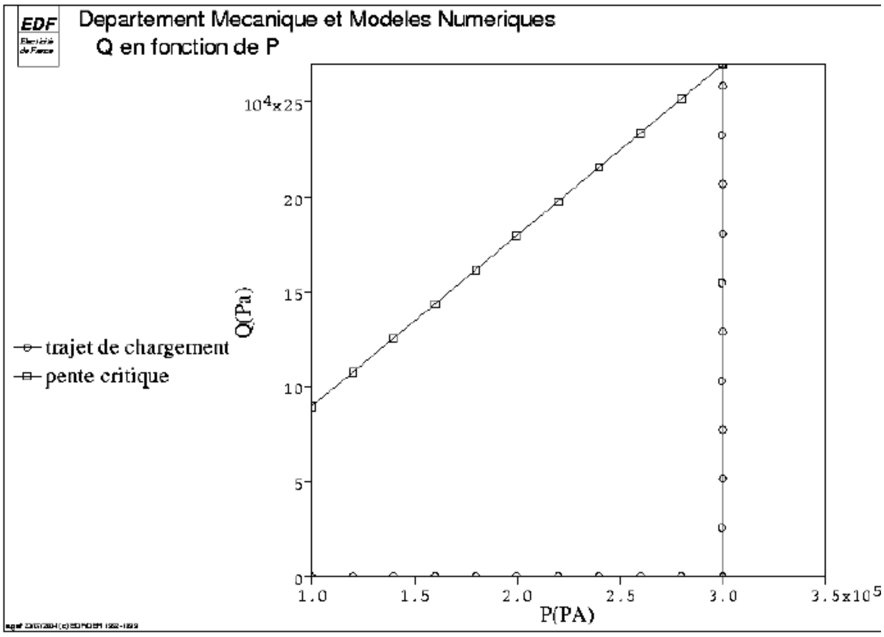
6 Summary of the results

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



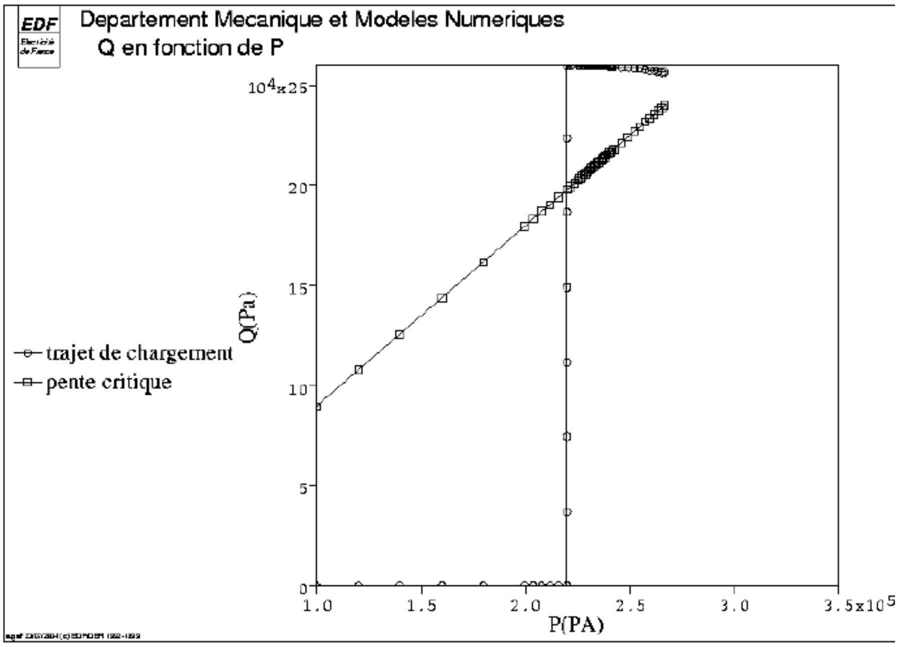
Appear 6-a: Q according to P (modelization A)

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



Appear 6-b: Q **according to** P **(modelization B)**

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



Appear 6-c: Q **according to** P **(modelization C)**