SSNV206 - Triaxial compression test with model LETK of the CIH

Summary

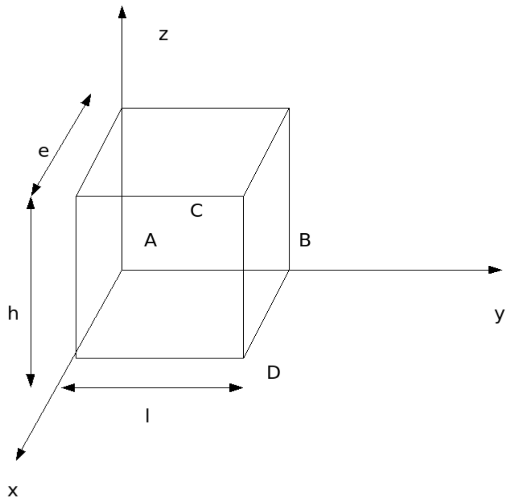
This test makes it possible to validate the model LETK in rock mechanics. It is about a triaxial compression test in pure mechanics or drained condition. Calculations are carried out only on the solid part of the ground without hydraulic coupling. One applies a level of containment of $5\,MPa$. By reason of symmetry, one is interested only in the eighth of a sample subjected to a triaxial compression test. Modeling is axisymmetric.

- Modeling a: the local algorithm of integration of the model explicit, is classified like specific thereafter.
- Modeling b: the local algorithm of integration of the model is implicit with the local matrix jacobienne obtained by disturbance.
- Modeling C: The local algorithm of integration of the model is implicit with the local matrix jacobienne obtained analytically.
- Modeling D: The local algorithm of integration of the model explicit, is classified like specific thereafter. The loading is applied 100 times more slowly to propose the role of viscosity in the model
- Modeling E: The local algorithm of integration of the model is implicit with the local matrix jacobienne obtained analytically. The loading is applied 100 times more slowly to propose the role of viscosity in the model

They are tests of nonregression. The five modeling converge towards concordant solutions for fine discretizations of the loading applied.

1 Problem of reference

1.1 Geometry



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

Coordinates of the points (in meters):

	A	B	C	D
x	0.	0.	0.5	1.
y	0.	1.	0.5	1.
z	0.	0.	0.5	0.

1.2 Material property

$E=5000\,MPa$
$\nu=0,12$
$\alpha=0.$
$Pa\quad=0,1\,MPa$
$n_{elas}\quad=0.$
$\sigma_c=12.\,MPa$
$H_0^{ext}=1,10292$
$\gamma_{cjs}=0,8$
$x_{ams}=0,1$
$\eta=0,04$
$a_0=0,25$
$a_e\quad=0,60$
$a_{pic}\quad=0,40$
$s_0=0,0005$
$m_0\quad=0,01$
$m_e\quad=2.$
$m_{pic}=6.$
$m_{ult}=0,61$
$\xi_{ult}=0,365$
$\xi_e=0,028$
$\xi_{pic}=0,015$
$m_{v-\max}=3.$
$\xi_{v-\max}=0,0039$
$A^v=1,510^{-12}\,Pa$
$n^v=4,5$
$\sigma_{p1}\quad=57,8\,MPa\,;$
$\mu_{0,v}=0,1$
$\xi_{0,v}=0,3$
$\mu_1=0,1$
$\xi_1=0,3$

1.3 Initial conditions, boundary conditions, and loading

Phase 1:
One brings the sample in a homogeneous state: $\sigma_{xx}^{0}=\sigma_{yy}^{0}=\sigma_{zz}^{0}$, by imposing the corresponding confining pressure on the front, side right-hand side and higher faces. Displacements are blocked on the faces postpones ($u_x=0$), side left ($u_y=0$) and lower ($u_z=0$).

Phase 2:
One maintains displacements blocked on the faces postpones ($u_x=0$), side left ($u_y=0$) and lower ($u_z=0$), as well as the confining pressure on the front faces and side right-hand side. One applies a displacement imposed to the higher face: $u_z(t)$, in order to obtain a deformation $\varepsilon_{zz}=-6$ over one duration of 6e3 seconds for modelings A, B and C and a duration of 6e5 seconds for modelings D and E.

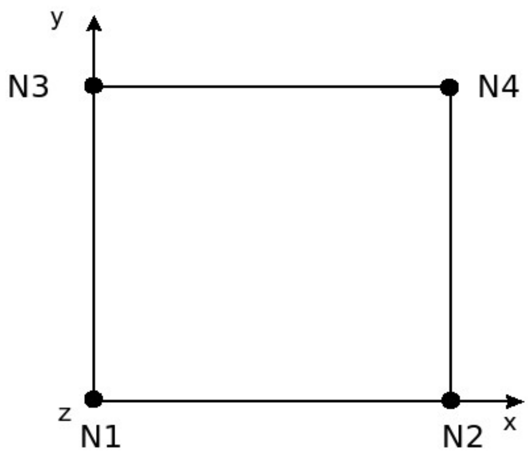
2 Reference solutions

The reference solutions are obtained by fine discretization of the loading. There does not exist a priori of known analytical solutions for the integration of the model LETK according to a triaxial compression test of compression.

3 Modeling A

3.1 Characteristic of modeling

AXIS :



Cutting: 1 in height, 1 in width.

Loading of phase 1:
Confining pressure: $\sigma_{xx}^0 = \sigma_{zz}^0 = -5\ MPa$.

3.2 Characteristic of the grid

Many nodes: 4
Many meshs and types: 1 QUAD4 and 4 SEG2

3.3 Sizes tested and results

The values are tested in nonregression with a tolerance given of $0,1\%$.

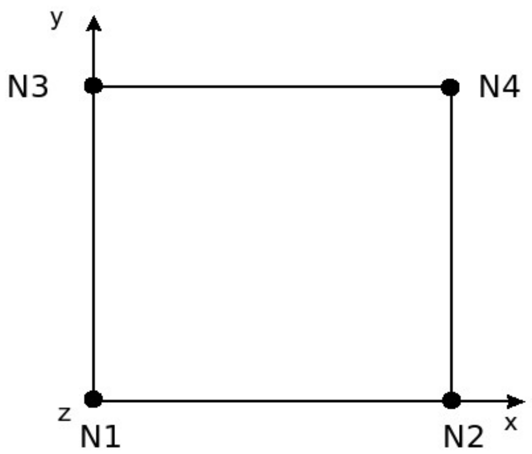
Localization	Moment	Constraint (MPa)	Aster
Not $N4$	7000.	σ_{yy}	– 5,000
	13000.	σ_{yy}	– 11,941

Localization	Moment	Displacement	Aster
Not $N4$	7000.	DX	-7.6 10^{-4}
	13000.	DX	3,020 10^{-2}

4 Modeling B

4.1 Characteristic of modeling

AXIS :



Cutting: 1 in height, 1 in width.

Loading of phase 1:
Confining pressure: $\sigma_{xx}^{0}=\sigma_{zz}^{0}=-5\,MPa$.

4.2 Characteristic of the grid

Many nodes: 4
Many meshs and types: 1 QUAD4 and 4 SEG2

4.3 Sizes tested and results

The values are tested in nonregression with a tolerance given of $0,1\%$.

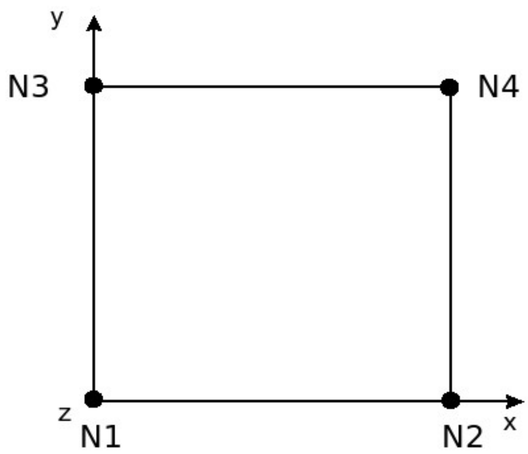
Localization	Moment	Constraint (MPa)	Aster
Not $N4$	7000.	σ_{yy}	– 5,000
	13000.	σ_{yy}	– 11,945

Localization	Moment	Displacement	Aster
Not $N4$	7000.	DX	$-7.6\ 10^{-4}$
	13000.	DX	$3,026\ 10^{-2}$

5 Modeling C

5.1 Characteristic of modeling

AXIS :



Cutting: 1 in height, 1 in width.

Loading of phase 1:
Confining pressure: $\sigma_{xx}^{0}=\sigma_{zz}^{0}=-5\,MPa$.

5.2 Characteristic of the grid

Many nodes: 4
Many meshs and types: 1 QUAD4 and 4 SEG2

5.3 Sizes tested and results

The values are tested in nonregression with a tolerance given of $0{,}1\%$.

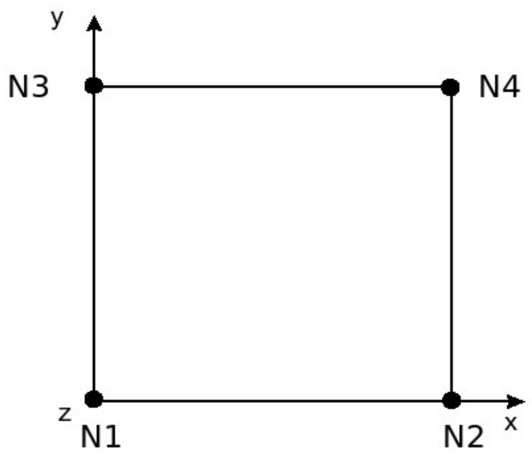
Localization	Moment	Constraint (MPa)	Aster
Not $N4$	7000.	σ_{yy}	– 5,000
	13000.	σ_{yy}	– 11,945

Localization	Moment	Displacement	Aster
Not $N4$	7000.	DX	-7.6 10^{-4}
	13000.	DX	3,026 10^{-2}

6 Modeling D

6.1 Characteristic of modeling

AXIS :



Cutting: 1 in height, 1 in width.

Loading of phase 1:
Confining pressure: $\sigma_{xx}^{0}=\sigma_{zz}^{0}=-5\,MPa$.
The loading is applied 100 times less quickly than for modelings A, B and C.

6.2 Characteristic of the grid

Many nodes: 4
Many meshs and types: 1 QUAD4 and 4 SEG2

6.3 Sizes tested and results

The values are tested in nonregression with a tolerance given of $0{,}1\,\%$.

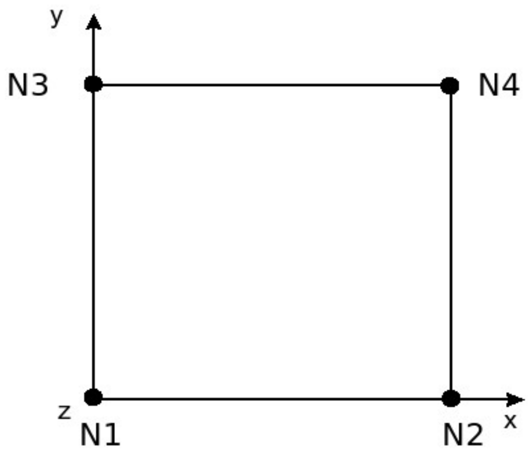
Localization	Moment	Constraint (MPa)	Aster
Not $N4$	7000.	σ_{yy}	– 5,000
	13000.	σ_{yy}	– 12.01

Localization	Moment	Displacement	Aster
Not $N4$	7000.	DX	-7.6 10^{-4}
	13000.	DX	2.98 10^{-2}

7 Modeling E

7.1 Characteristic of modeling

`AXIS` :



Cutting: 1 in height, 1 in width.

Loading of phase 1:
Confining pressure: $\sigma_{xx}^{0}=\sigma_{zz}^{0}=-5\,MPa$.
The loading is applied 100 times less quickly than for modelings A, B and C. the loading is identical to that applied for modeling D

7.2 Characteristic of the grid

Many nodes: 4
Many meshs and types: 1 `QUAD4` and 4 `SEG2`

7.3 Sizes tested and results

The values are tested in nonregression with a tolerance given of $0,1\%$.

Localization	Moment	Constraint (MPa)	Aster
Not $N4$	7000.	σ_{yy}	– 5,000
	13000.	σ_{yy}	– 12.01

Localization	Moment	Displacement	Aster
Not $N4$	7000.	DX	$-7.6\ 10^{-4}$
	13000.	DX	$3.00\ 10^{-2}$

8 Summary of the results

They are tests of nonregression developed to validate the model LETK in pure mechanics. The comparison between the two diagrams of integration makes it possible to identify certain tendencies on the profiles of convergence.

An explicit diagram of integration makes it possible for a fine discretization of the loading to guarantee converged results and an execution time machine less than the implicit scheme. It is on the other hand difficult to quantify the level of smoothness of the loading to be applied to guarantee the convergence of the studies with a diagram of explicit integration.
The implicit diagram of integration guarantees a level of precision higher than the explicit diagram for the same discretization of loading. It also makes it possible to have a local tangent operator consist. These advantages thus ensure on a broad range of discretizations of the loading a convergence on the results got with the implicit scheme.

The following figures illustrate the preceding sales leaflet.

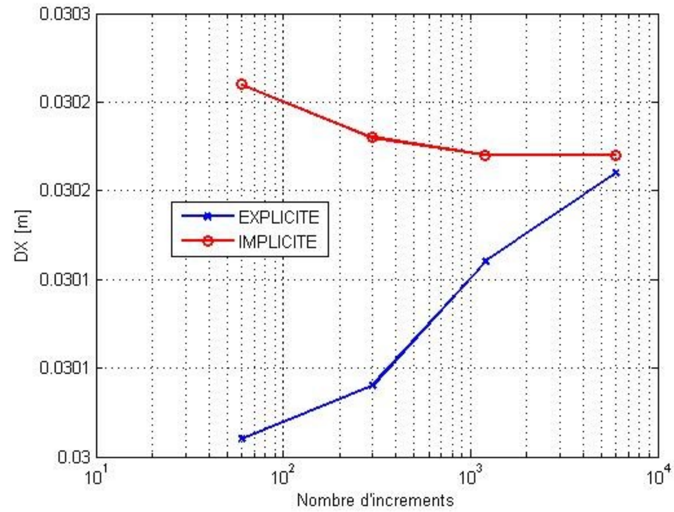


Illustration 1: Maximum side displacement of the sample of laboratory during a triaxial compression test of compression according to the level of discretization of the loading

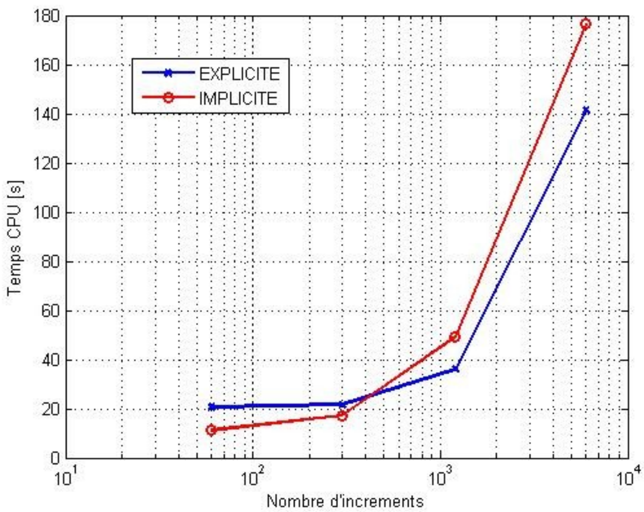


Illustration 2: Time CPU cumulated for the triaxial compression test of compression according to the level of discretization of the loading