SSNV135 - Triaxial compression test drained with model CJS (level 1)

Summary

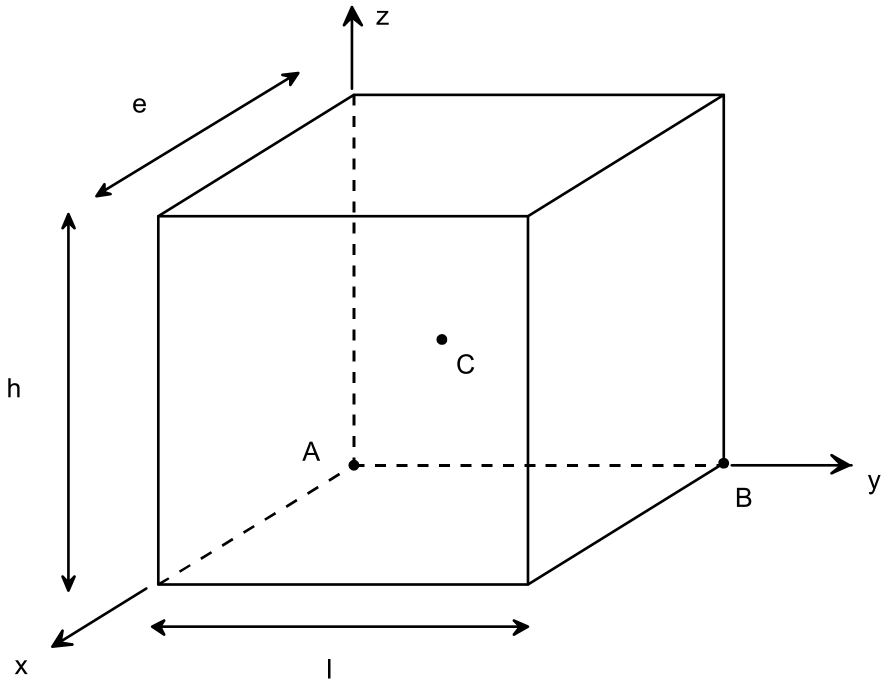
This test makes it possible to validate level 1 of model CJS. It is about a triaxial compression test in drained condition. Three levels of containment are simulated: 100 , 200 , then $400\,kPa$.

By reason of symmetry, one is interested only in the eighth of a sample subjected to a triaxial compression test.

The results got with model CJS1 are compared with the analytical solution.

1 Problem of reference

1.1 Geometry



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

Coordinates of the points (in meters):

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

1.2 Material property

$E=22{,}4\,10^3\,kPa$
$\nu=0{,}3$

Parameters CJS1: $\beta=-0{,}03$ $\gamma=0{,}82$ $R_m=0{,}289$ $P_a=-100\,kPa$

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 $\varepsilon_{zz}=-20\,\%$ (counted starting from the beginning of phase 2).

2 Reference solution

2.1 Development of the analytical solution for CJS1

One has permanently:

$$\sigma_{xx} = \sigma_{yy} = \sigma_{xx}^0$$

where $\sigma_{xx}^0 = \underline{C^{te}}$ represent the confining pressure.

Remain to determine σ_{zz}.

Elastic phase:

By writing the elastic law simply, one a:

$$\sigma_{xx}^0 = \sigma_{xx}^0 + \lambda \varepsilon_{zz} + (\lambda + 2\mu)\varepsilon_{xx} + \lambda \varepsilon_{xx}$$
$$\sigma_{zz} = \sigma_{zz}^0 + (\lambda + 2\mu)\varepsilon_{zz} + 2\lambda \varepsilon_{xx}$$

where here λ and μ are the coefficients of Lamé.

While eliminating ε_{xx} between these two equations, one finds:

$$\sigma_{zz} = \sigma_{zz}^0 + \frac{\mu(3\lambda + 2\mu)}{(\lambda + \mu)} \varepsilon_{zz}$$

Plastic phase:

One a:

$I_1 = \sigma_{zz} + 2\,\sigma_{xx}^0$ where $\sigma_{xx}^0 = \underline{C^{te}}$ represent the confining pressure.

One from of deduced for the components from the diverter $\underline{\underline{s}}$:

$s_{zz} = 2\left[\frac{1}{3} I_1 - \sigma_{xx}^0\right]$ and $s_{xx} = \sigma_{xx}^0 - \frac{1}{3} I_1$

that is to say: $s_{II} = \sqrt{6}\left[\sigma_{xx}^0 - \frac{1}{3} I_1\right]$ and $det(\underline{s}) = 2\left[\frac{1}{3} I_1 - \sigma_{xx}^0\right]^3$

Consequently: $h(\theta_S) = (1-\gamma)^{1/6}$

In addition, when one reaches the criterion of the mechanism déviatoire: $s_{II}\, h(\theta_S) + R_m I_1 = 0$ from where the relation:

$$I_1 = \frac{\sqrt{6}\,\sigma_{xx}^0}{\sqrt{\frac{2}{3} - \frac{R_m}{(1-\gamma)^{1/6}}}}$$

and finally, one has for the vertical constraint:

$$\sigma_{zz}=\frac{\sqrt{6}\,\sigma_{xx}^{0}}{\sqrt{\frac{2}{3}}-\frac{R_m}{(1-\gamma)^{1/6}}}-2\,\sigma_{xx}^{0}$$

Moreover, one can calculate that the transition enters the states rubber band and perfectly plastic is done for an axial deformation equalizes with:

$$\varepsilon_{zz}=\frac{\mu(3\lambda+2\mu)}{\lambda+\mu}\left[\frac{\sqrt{6}\sigma_{xx}^{0}}{\sqrt{\frac{2}{3}}-\frac{R_m}{(1-\gamma)^{1/6}}}-2\,\sigma_{xx}^{0}\right]$$

2.2 Results of reference

Constraints σ_{xx} , σ_{yy} and σ_{zz} at the points A , B and C .

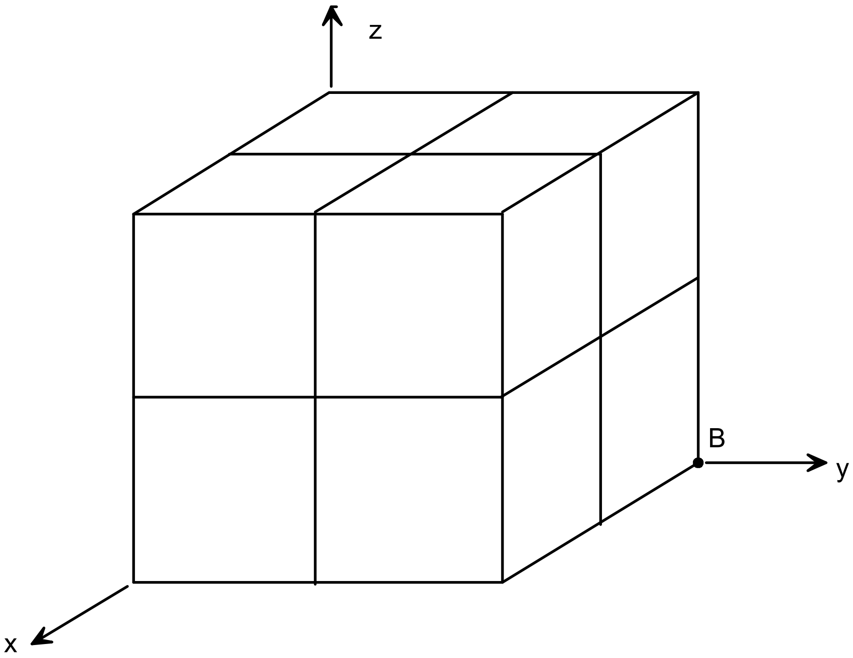
2.3 Uncertainty on the solution

Analytical solution for CJS1.

3 Modeling A

3.1 Characteristics of modeling

3D:



Cutting: 2 in height, in width and thickness.

Loading of phase 1:
Confining pressure: $\sigma_{xx}^0=\sigma_{yy}^0=\sigma_{zz}^0$: successively $-100\,kPa$, $-200\,kPa$ and $-400\,kPa$.
Level 1 of model CJS

3.2 Characteristic of the grid

Many nodes: 27
Many meshs and types: 8 HEXA8 and 24 QUA4

3.3 Values tested

For $\sigma_{xx}^0=\sigma_{yy}^0=\sigma_{zz}^0$: $-100\,kPa$

Localization	Sequence number	axial deformation ε_{zz} (%)	constraint (kPa)	Reference
Not A , B and C	10	– 0.8%	σ_{xx}	– 100.0
	100	– 20.0%	σ_{xx}	– 100.0
	10	– 0.8%	σ_{yy}	– 100.0
	100	– 20.0%	σ_{yy}	– 100.0
	10	– 0.8%	σ_{zz}	– 279.2
	20	– 1.6%	σ_{zz}	– 367,159
	40	– 3.2%	σ_{zz}	– 367,159

60	– 7.2%	σ_{zz}	– 367,159
100	– 20.0%	σ_{zz}	– 367,159

For $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0 : -200\,kPa$

Localization	Sequence number	axial deformation ε_{zz} (%)	constraint (kPa)	Reference
Not A , B and C	10	– 0.8%	σ_{xx}	– 200.0
	100	– 20.0%	σ_{xx}	– 200.0
	10	– 0.8%	σ_{yy}	– 200.0
	100	– 20.0%	σ_{yy}	– 200.0
	10	– 0.8%	σ_{zz}	– 379.2
	20	– 1.6%	σ_{zz}	– 558.4
	40	– 3.2%	σ_{zz}	– 734,317
	60	– 7.2%	σ_{zz}	– 734,317
	100	– 20.0%	σ_{zz}	– 734,317

For $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0 : -400\,kPa$

Localization	Sequence number	axial deformation ε_{zz} (%)	constraint (kPa)	Reference
Not A , B and C	10	– 0.8%	σ_{xx}	– 400.0
	100	– 20.0%	σ_{xx}	– 400.0
	10	– 0.8%	σ_{yy}	– 400.0
	100	– 20.0%	σ_{yy}	– 400.0
	10	– 0.8%	σ_{zz}	– 579.2
	20	– 1.6%	σ_{zz}	– 758.4
	40	– 3.2%	σ_{zz}	– 1116.8
	60	– 7.2%	σ_{zz}	– 1458.6348
	100	– 20.0%	σ_{zz}	– 1458.6348

4 Summary of the results

Values of *Code_Aster* are in triad with the values of the analytical solution of reference.