SSNV184 - Triaxial compression test with the model of Hoek-Brown modified

Summary

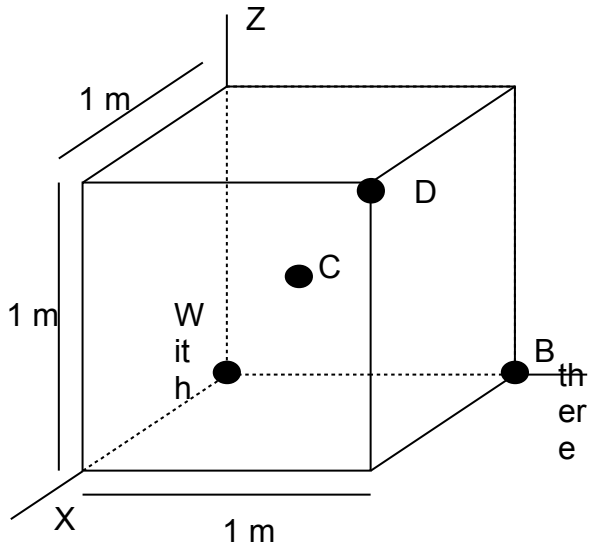
This test makes it possible to validate the elastoplastic law of behavior of Hoek-Brown modified in rock mechanics. It is about a triaxial compression test for which calculations are carried out in pure mechanics. Three levels of containment are applied: $5\,MPa$, $12\,MPa$ and $25\,MPa$. For reasons of symmetry, one is interested only in the eighth of a sample subjected to a triaxial compression test.

It is about a test of not-regression.

1 Problem of reference

1.1 Geometry

A cube of dimension here is considered $1\mathrm{m}\times 1\mathrm{m}\times 1\mathrm{m}$.



Coordinates of the points (in m):

	A	B	C	D
x	0	0	0.5	1
y	0	1	0.5	1
Z	0	0	0.5	1

1.2 Properties of material

Parameters of the elastic law of behavior:

$E=4500\ MPa$
$\nu=0.3$

Parameters of the law of Hoek-Brown modified:

$\gamma^{rup}=0.005$
$\gamma^{res}=0.017$
$(S\sigma_c^2)^{end}=225\ MPa^2$
$(S\sigma_c^2)^{rup}=482.5675\ MPa^2$
$(m\sigma_c)^{end}=13.5\ MPa$
$(m\sigma_c)^{rup}=83.75\ MPa$
$\beta=3\ MPa$
$\phi^{rup}=15°$
$\phi^{res}=30°$
$\alpha=3.3$

1.3 Initial conditions, with the limits and loading

The test breaks up into two phases:

1) Initially, one brings the sample in a homogeneous state $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0$. For that, the corresponding confining pressure is imposed on the front faces ($x = 1$), side right-hand side ($y = 1$) and higher ($z = 1$), while displacements are taken worthless on the faces postpones ($u_x\big|_{x=0} = 0$), side left ($u_y\big|_{y=0} = 0$) and lower ($u_z\big|_{z=0} = 0$).
2) Once the homogeneous state obtained, displacements are maintained blocked on the faces postpones, side left and lower and the confining pressure is always imposed on the front faces and side right-hand side. A displacement is imposed on the higher face ($u_z(t)$) in order to obtain a deformation ε_{zz} equalize with – 25% starting from the beginning of the second phase (with t=2). The increment of deformation is taken constant: $\Delta\varepsilon_{zz} = -2.5E-4$ for modelings A and B, and $\Delta\varepsilon_{zz} = -3.33E-4$ for modeling C.

2 Reference solution

2.1 Calculation of solution

The value of the major principal constraint can be calculated at the point of rupture (σ^{rup}) and with residual resistance (σ^{res}) starting from the form of the diverter of constraint:

$$|\sigma_1 - \sigma_3|^{rup} = \sqrt{(S\sigma_c^2)^{rup} - \sigma_3 (m\sigma_c)^{rup}}$$

$$|\sigma_1 - \sigma_3|^{res} = \sqrt{(S\sigma_c^2)^{res} - \sigma_3 (m\sigma_c)^{res}} - b^{res}\left[1 - \frac{\sigma_3}{\sigma_3^{b-d}}\right]$$

$$\text{avec } \sigma_3^{b-d} = \frac{-(m\sigma_c)^{rup} - \sqrt{((m\sigma_c)^{rup})^2 + 4(1-\alpha)^2 (S\sigma_c^2)^{rup}}}{2(1-\alpha)^2} \text{ et } b^{res} = \beta - \sqrt{(S\sigma_c^2)^{rup}}$$

2.2 Results of reference

Constraints $\sigma_{xx}(\sigma_3)$, $\sigma_{yy}(\sigma_1)$ and $\sigma_{zz}(\sigma_3)$ at the point D .

Displacements $\varepsilon_{xx}(\varepsilon_3)$ and $\varepsilon_{zz}(\varepsilon_1)$ at the point D .

3 Modeling A

3.1 Characteristics of modeling

Modeling 3D
Cutting: $1\mathrm{m}$ in height, $1\mathrm{m}$ in width
Loading of phase 1: $\sigma_{xx}^{0} = \sigma_{yy}^{0} = \sigma_{zz}^{0} = -5\ \mathrm{MPa}$ (confining pressure)
Boundary conditions: $u_x|_{x=0} = u_y|_{y=0} = u_z|_{z=0} = 0$

3.2 Characteristics of the grid

Many nodes: 20
Many meshs and types: 6 QUAD8 and 1 HEXA20

3.3 Sizes tested and results

Rupture:

Valeur de référence : $|\sigma_1 - \sigma_3|_{ref}^{rup} = 30.0219$

Valeur du *Code_Aster* : $|\sigma_1 - \sigma_3|^{rup} = 29.7520$ (numéro d'ordre : 43)

Ecart relatif réf - *Code_Aster* : 0.90 %

Residual resistance:

Valeur de référence : $|\sigma_1 - \sigma_3|_{ref}^{rup} = 15.7215$

Valeur du *Code_Aster* : $|\sigma_1 - \sigma_3|^{rup} = 15.7215$ (numéro d'ordre : 65)

Localization	Sequence number	Constraint (MPa)	*Code_Aster*
Not D	12	σ_{xx}	-5.00
	40	σ_{xx}	-5.00
	12	σ_{yy}	-5.00
	40	σ_{yy}	-5.00
	12	σ_{zz}	-18.5
	16	σ_{zz}	-22.4982
	30	σ_{zz}	-29.0442
	43	σ_{zz}	**-34.7520**
	45	σ_{zz}	-31.3756
	50	σ_{zz}	-24.4274
	55	σ_{zz}	-21.6325
	65	σ_{zz}	**-20.7215**

Localization	Sequence number	Deformation	*Code_Aster*

Not D	12	ε_{xx}	0.9 E-3
	16	ε_{xx}	1.22296 E-3
	30	ε_{xx}	2.82301 E-3
	43	ε_{xx}	4.59944 E-3
	45	ε_{xx}	5.39287 E-3
	50	ε_{xx}	7.41788 E-3
	55	ε_{xx}	9.07385 E-3
	65	ε_{xx}	11.9257 E-3
	12	ε_{zz}	-3 E-3
	65	ε_{zz}	-16.25 E-3

4 Modeling B

4.1 Characteristics of modeling

Modeling 3D
Cutting: $1\mathrm{m}$ in height, $1\mathrm{m}$ in width
Loading of phase 1: $\sigma_{xx}^{0} = \sigma_{yy}^{0} = \sigma_{zz}^{0} = -12\ \mathrm{MPa}$ (confining pressure)
Boundary conditions: $u_x|_{x=0} = u_y|_{y=0} = u_z|_{z=0} = 0$

4.2 Characteristics of the grid

Many nodes: 20
Many meshs and types: 6 QUAD8 and 1 HEXA20

4.3 Sizes tested and results

Rupture:

Valeur de référence : $|\sigma_1 - \sigma_3|_{ref}^{rup} = 38.5690$

Valeur du *Code_Aster* : $|\sigma_1 - \sigma_3|^{rup} = 38.4447$ (numéro d'ordre : 51)

Ecart réf - *Code_Aster* : 0.32 %

Residual resistance:

Valeur de référence : $|\sigma_1 - \sigma_3|_{ref}^{rup} = 30.8023$

Valeur du *Code_Aster* : $|\sigma_1 - \sigma_3|^{rup} = 30.8023$ (numéro d'ordre : 80)

Localization	Sequence number	Constraint (MPa)	*Code_Aster*
Not D	16	σ_{xx}	-12.00
	50	σ_{xx}	-12.00
	16	σ_{yy}	-12.00
	50	σ_{yy}	-12.00
	16	σ_{zz}	-30
	20	σ_{zz}	-33.2264
	40	σ_{zz}	-44.5889
	51	σ_{zz}	**-50.4447**
	55	σ_{zz}	-48.0512
	60	σ_{zz}	-45.5579
	70	σ_{zz}	-43.0472
	80	σ_{zz}	**-42.8023**

Localization	Sequence number	Deformation	*Code_Aster*

Not D	16	ε_{xx}	1.2 E-3
	20	ε_{xx}	1.56091 E-3
	40	ε_{xx}	3.78317 E-3
	51	ε_{xx}	5.22869 E-3
	55	ε_{xx}	6.32002 E-3
	60	ε_{xx}	7.74068 E-3
	70	ε_{xx}	10.5716 E-3
	80	ε_{xx}	13.3372 E-3
	16	ε_{zz}	-4 E-3
	80	ε_{zz}	2nd-2

5 Modeling C

5.1 Characteristics of modeling

Modeling 3D
Cutting: $1\mathrm{m}$ in height, $1\mathrm{m}$ in width
Loading of phase 1: $\sigma_{xx}^0 = \sigma_{yy}^0 = \sigma_{zz}^0 = -25\ \mathrm{MPa}$ (confining pressure)
Boundary conditions: $u_x|_{x=0} = u_y|_{y=0} = u_z|_{z=0} = 0$

5.2 Characteristics of the grid

Many nodes: 20
Many meshs and types: 6 QUAD8 and 1 HEXA20

5.3 Sizes tested and results

Rupture:

Valeur de référence : $|\sigma_1 - \sigma_3|_{ref}^{rup} = 50.7574$

Valeur du *Code_Aster* : $|\sigma_1 - \sigma_3|^{rup} = 50.3064$ (numéro d'ordre : 46)

Ecart réf - *Code_Aster* : 0.89 %

Residual resistance:

Valeur de référence : $|\sigma_1 - \sigma_3|_{ref}^{rup} = 55.1249$

Valeur du *Code_Aster* : $|\sigma_1 - \sigma_3|^{rup} = 55.1249$ (numéro d'ordre : 81)

Localization	Sequence number	Constraint (MPa)	*Code_Aster*
Not D	18	σ_{xx}	- 25.00
	81	σ_{xx}	- 25.00
	18	σ_{yy}	- 25.00
	81	σ_{yy}	- 25.00
	18	σ_{zz}	-50.8398
	24	σ_{zz}	-56.4340
	36	σ_{zz}	-66.9436
	46	σ_{zz}	**-75.3064**
	54	σ_{zz}	-77.6467
	66	σ_{zz}	-79.7633
	81	σ_{zz}	**-80.1249**

Localization	Sequence number	Deformation	*Code_Aster*
Not D	18	ε_{xx}	1.85408 E-3

24	ε_{xx}	2.63445 E-3
36	ε_{xx}	4.35497 E-3
46	ε_{xx}	5.98034 E-3
54	ε_{xx}	7.90516 E-3
66	ε_{xx}	11.3535 E-3
81	ε_{xx}	16.7102 E-3
18	ε_{zz}	-6 E-3
36	ε_{zz}	-12 E-3
81	ε_{zz}	-27 E-3

6 Synthesis of results

The got results show an agreement of the constraint σ_1 to the rupture and residual resistance enters the computed values and those obtained with *Code_Aster*.

This case test is a test of not-regression developed to validate the modified model of Hoek-Brown.