Barodesy

A Constitutive Model based on two Rules by Goldscheider

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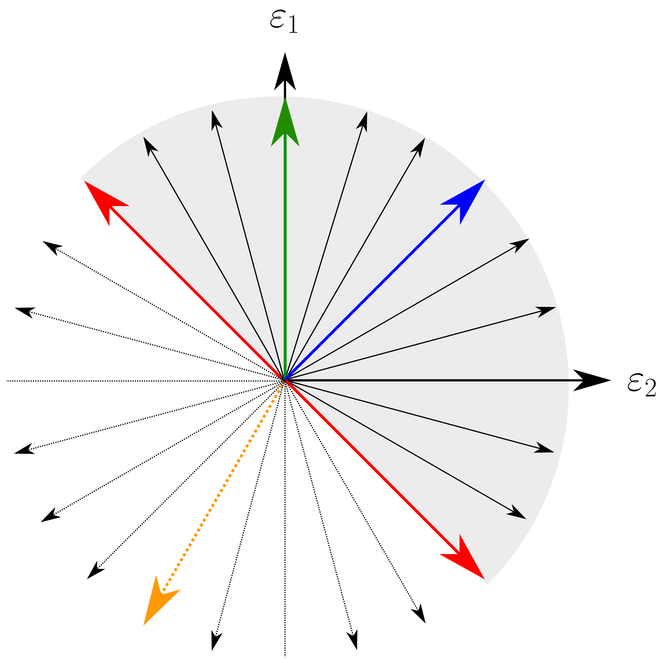
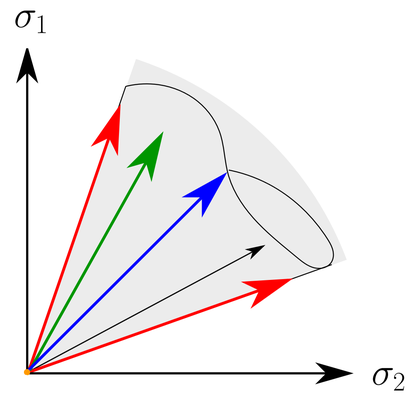
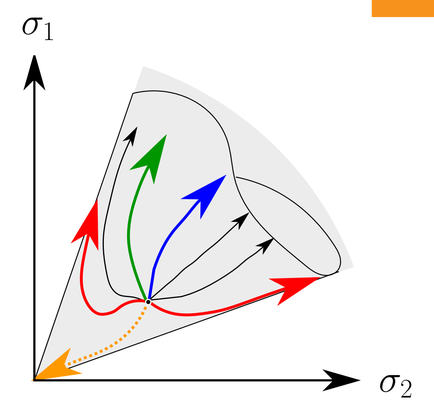


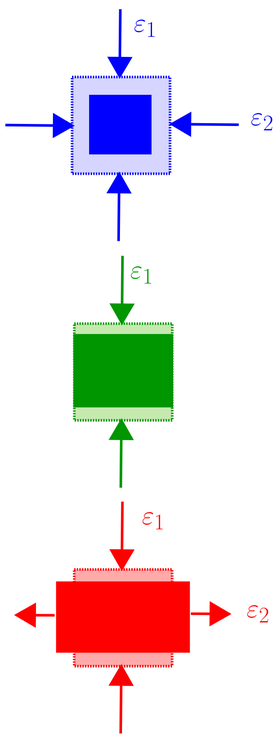


Goldscheiders 1. rule: Starting from $\mathbf{T} = \mathbf{0}$, proportional strain paths (i.e. $\varepsilon_1 : \varepsilon_2 : \varepsilon_3 = \text{const}$) lead to proportional stress paths (i.e. $\sigma_1 : \sigma_2 : \sigma_3 = \text{const}$).



Goldscheiders 2. rule: Starting from $\mathbf{T} \neq \mathbf{0}$, proportional strain paths lead asymptotically to the respective proportional stess paths for $\mathbf{D}$ starting from $\mathbf{T} = \mathbf{0}$. This means that proportional stress paths act as attractors.

$\mathbf{D}$	$\mathbf{R}(\mathbf{D}) = (\operatorname{tr}\mathbf{D}^0)\,\mathbf{1} + c_1 \exp(c_2\mathbf{D}^0)$	$\dot{\mathbf{T}} = h(\sigma)\cdot(f\mathbf{R}^0 + g\mathbf{T}^0)\cdot\lvert\mathbf{D}\rvert$
$\mathbf{D} = \frac{1}{2}[\operatorname{grad}\mathbf{v} + (\operatorname{grad}\mathbf{v})^{\mathsf{T}}]$, $\mathbf{D}^0 = \mathbf{D}/\lvert\mathbf{D}\rvert$ with $\lvert\mathbf{D}\rvert = \sqrt{\operatorname{tr}\mathbf{D}^2}$	$\mathbf{R}(\mathbf{D})$: directions of proportional stress paths	$\mathbf{T}$: Cauchy stress (effective), $\sigma := \lvert\mathbf{T}\rvert$



Isotropic Compression

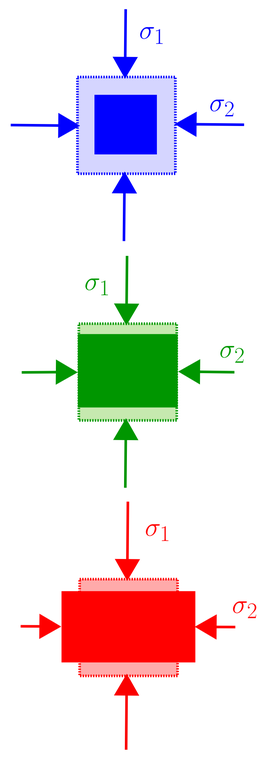
$$\mathbf{D} = \begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

Oedometric Compression

$$\mathbf{D} = \begin{pmatrix} -1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

CU

$$\mathbf{D} = \begin{pmatrix} -1 & 0 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 0.5 \end{pmatrix}$$



Isotropic Compression

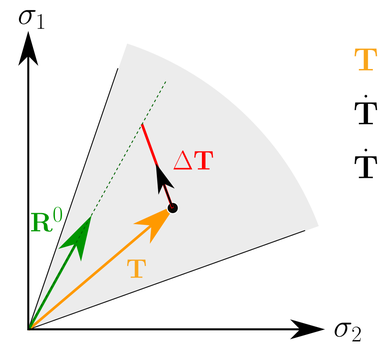
$$\mathbf{R}(\mathbf{D}) \propto \begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

Oedometric Compression

$$\mathbf{R}(\mathbf{D}) \propto \begin{pmatrix} -1 & 0 & 0 \\ 0 & -K_0 & 0 \\ 0 & 0 & -K_0 \end{pmatrix}$$

CU

$$\mathbf{R}(\mathbf{D}) \propto \begin{pmatrix} -1 & 0 & 0 \\ 0 & -\frac{1-\sin\varphi_c}{1+\sin\varphi_c} & 0 \\ 0 & 0 & -\frac{1-\sin\varphi_c}{1+\sin\varphi_c} \end{pmatrix}$$



$$\mathbf{T} + \dot{\mathbf{T}}\Delta t = \mu\mathbf{R}^0$$
$$\dot{\mathbf{T}} = \hat{f}\mathbf{R}^0 + \hat{g}\mathbf{T}$$
$$\dot{\mathbf{T}} = h(\sigma)\cdot(f\mathbf{R}^0 + g\mathbf{T}^0)\cdot\lvert\mathbf{D}\rvert$$

Barodesy for Clay

$h = c_3\sigma$

$f = c_5 \operatorname{tr}\mathbf{D}^0 - \ln(1+e_c)$

$g = \ln(1+e)$

Barodesy for Sand

$h = c_3\sigma^{c_4}$

$f = c_5 \operatorname{tr}\mathbf{D}^0 - e_c$

$g = e$

Links to traditional concepts of Soil Mechanics

Yield: $\boxed{f\mathbf{R}^0 + g\mathbf{T}^0 = \mathbf{0}}$

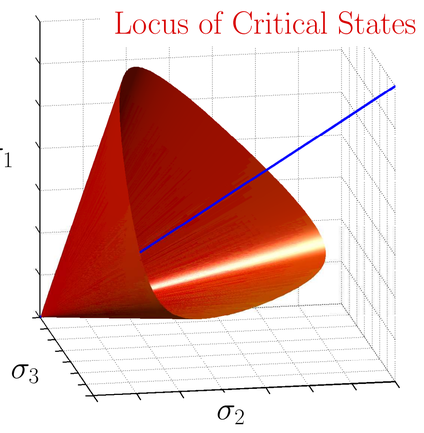
$\rightsquigarrow \quad \mathbf{R}^0 = \mathbf{T}^0$

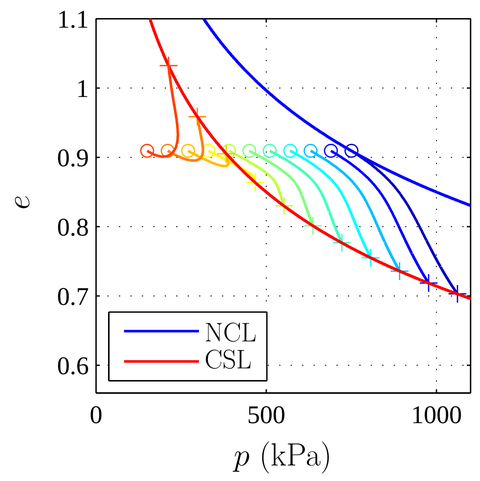
$\rightsquigarrow \quad f + g = 0$

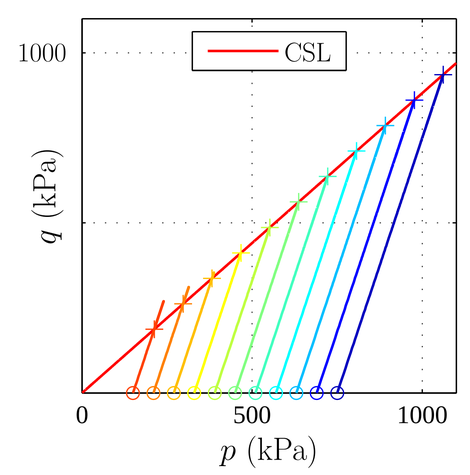
Critical States, CSL: $e = e_c \quad \text{and} \quad \operatorname{tr}\mathbf{D}^0 = 0$

Stress dependency of stiffness: $E_s \propto \sigma^{c_4}$

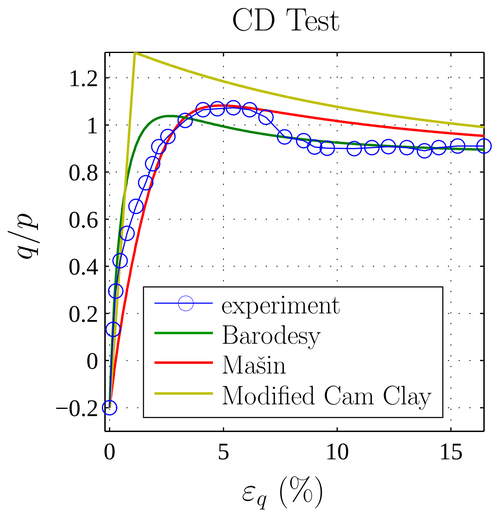
Pyknotropy + Barotropy

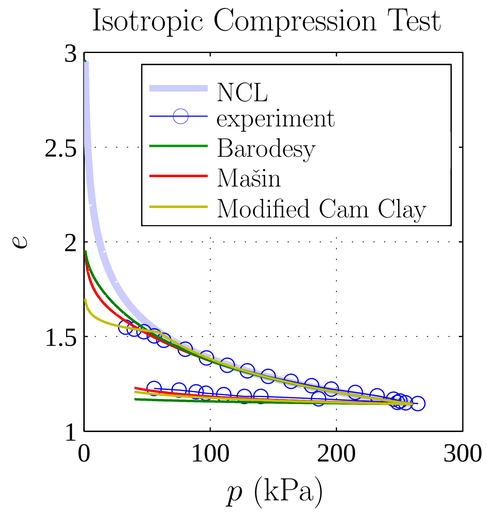




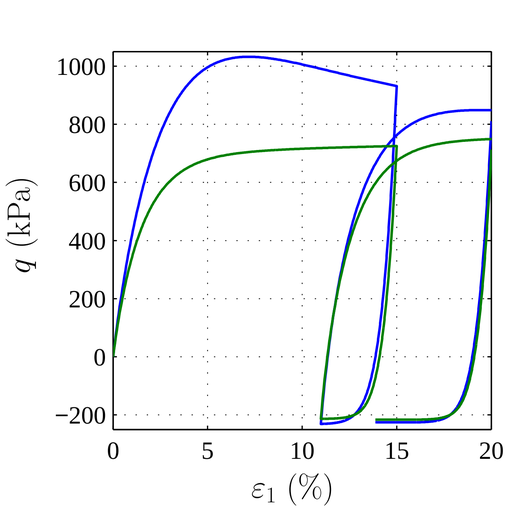


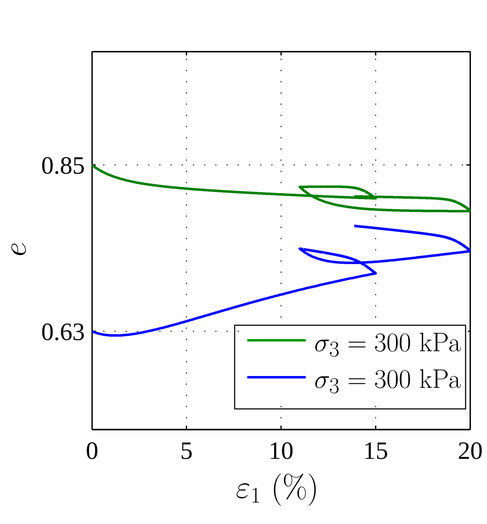
Barodesy for Clay





Barodesy for Sand





References to Barodesy: www.uibk.ac.at/geotechnik/res/refbaro