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Training

Geomechanics

Critical State Material Models

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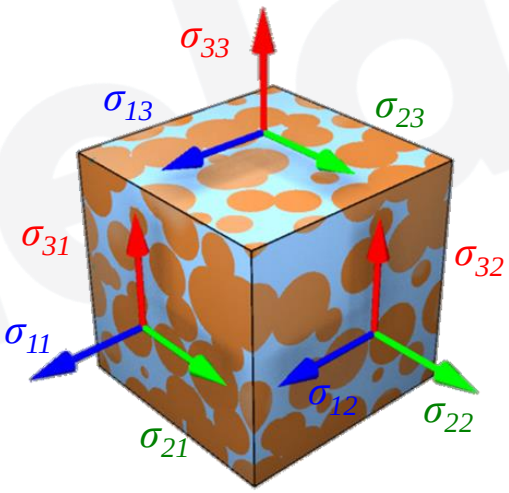
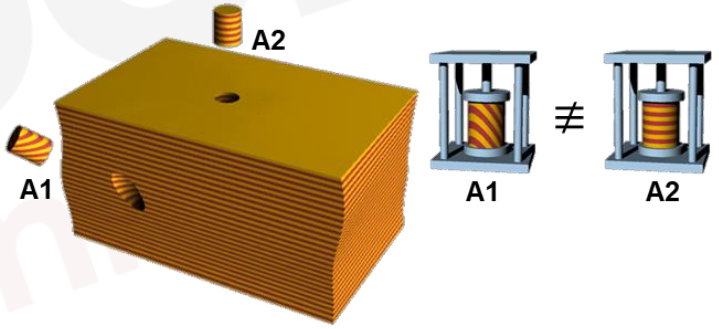
Introduction to Stress and Strain in Geomaterials

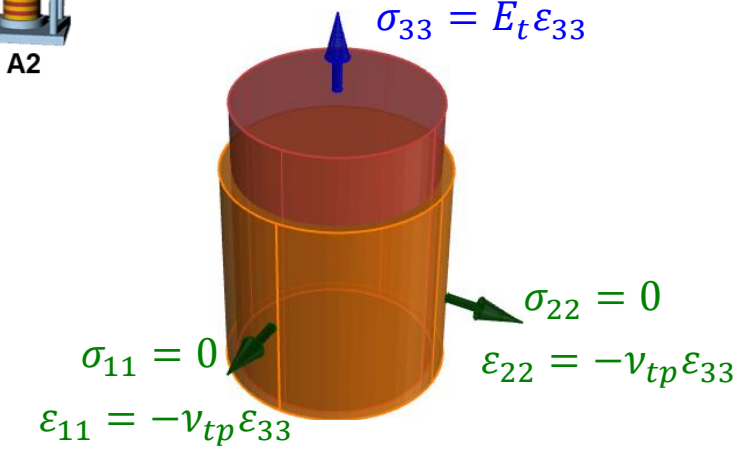
Within this section you will be guided through:

a. Stress/strain components and invariants
b. Elasticity – Young's modulus and Poisson's ratio, anisotropy
c. Poroelasticity (pore pressure and mechanical interaction)
d. Elastoplastic models; how they work





$$\begin{bmatrix}\sigma_{11}\\ \sigma_{22}\\ \sigma_{33}\\ \sigma_{23}\\ \sigma_{13}\\ \sigma_{12}\end{bmatrix} = \frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix}1-\nu & \nu & \nu & 0 & 0 & 0\\ & 1-\nu & \nu & 0 & 0 & 0\\ & & 1-\nu & 0 & 0 & 0\\ & & & (1-2\nu)/2 & 0 & 0\\ & symm & & & (1-2\nu)/2 & 0\\ & & & & & (1-2\nu)/2\end{bmatrix}\begin{bmatrix}\varepsilon_{11}\\ \varepsilon_{22}\\ \varepsilon_{33}\\ 2\varepsilon_{23}\\ 2\varepsilon_{13}\\ 2\varepsilon_{12}\end{bmatrix}$$



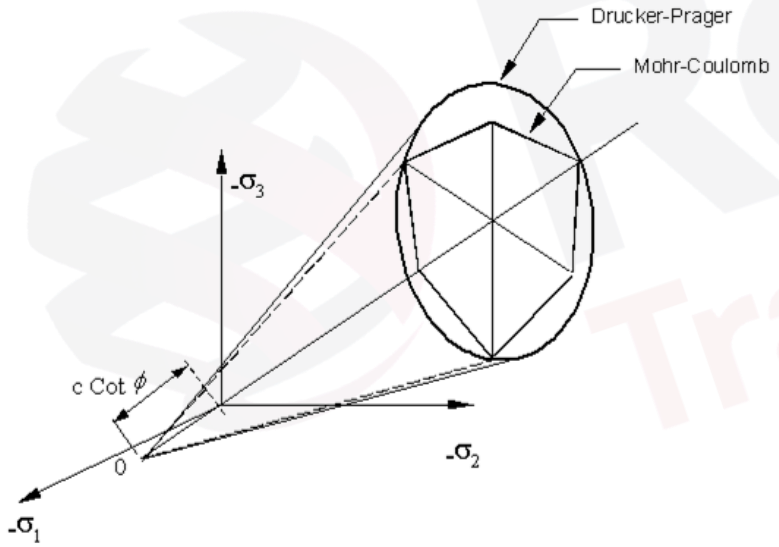
Conventional Models and Extension to Critical State

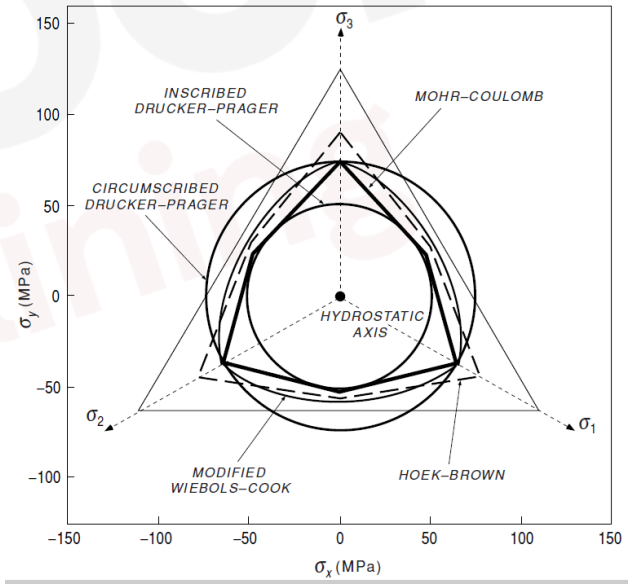
Within this section you will be guided through:

a. Brief description of critical state and non-critical state

b. Mohr Coulomb, Drucker Prager, Modified Lade – description and examples

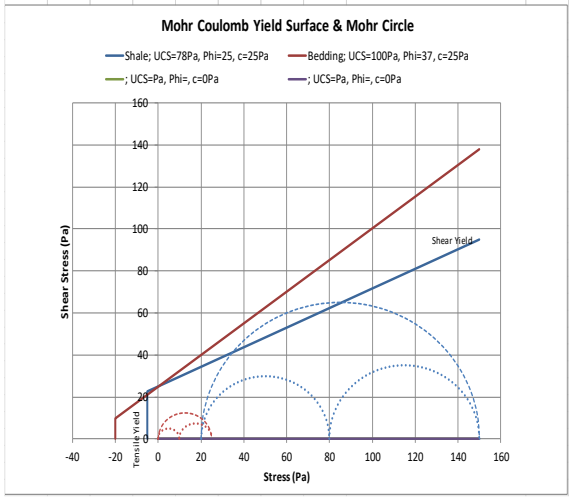
c. Limitations of non-critical state models





Units: Pa

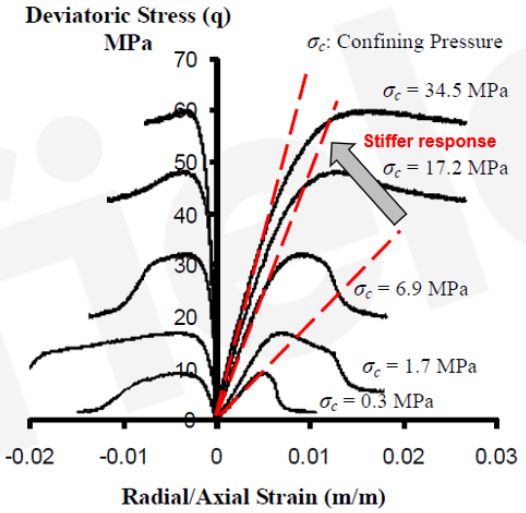
Input				Calc	Input			Legend
Name	UCS	Phi	Tensile	c	Min Strs	Int Strs	Max Strs	
Shale	78	25	5	25	20	80	150	Shale; UCS=78Pa, Phi=25, c=25Pa
Bedding	100	37	20	25	0	10	25	Bedding; UCS=100Pa, Phi=37, c=25Pa
				0				; UCS=Pa, Phi=, c=0Pa
				0				; UCS=Pa, Phi=, c=0Pa

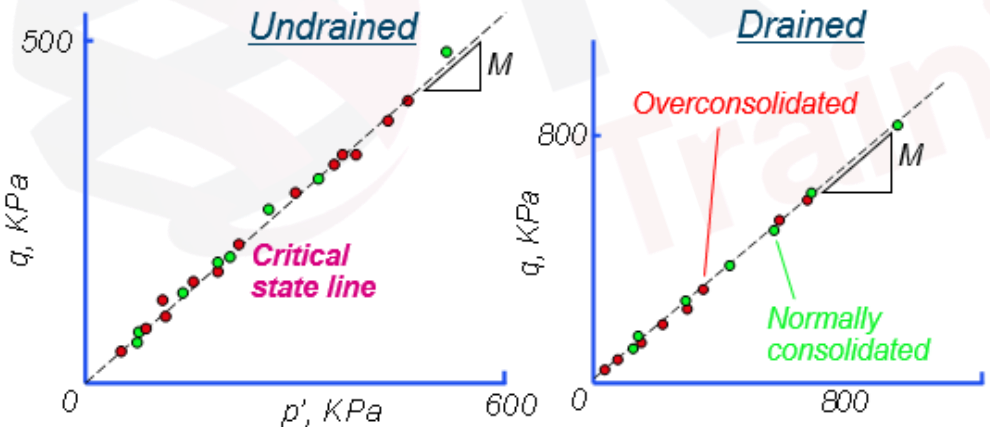


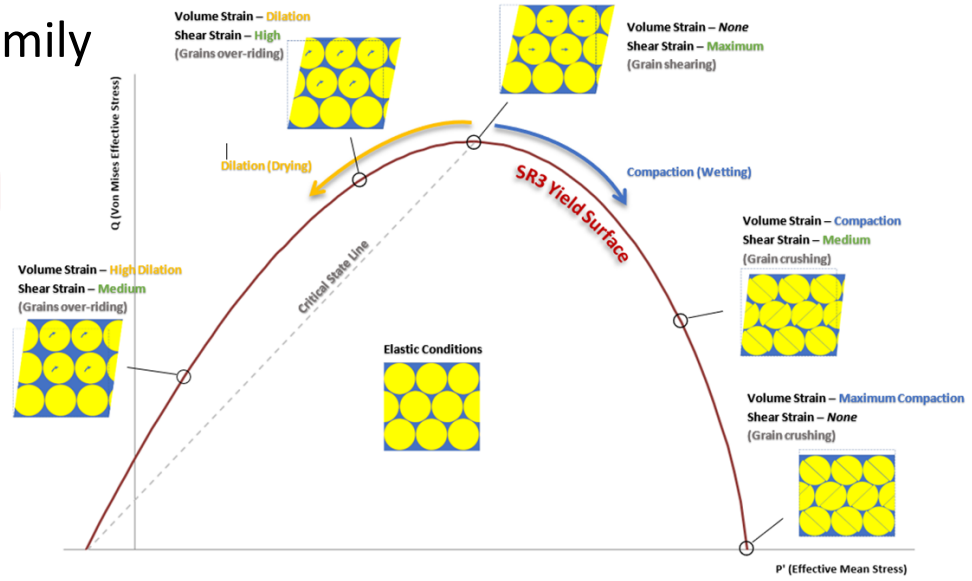
Critical State Material Models

Within this section you will be guided through:

a. Introduction to Critical State
b. Experimental observations
c. The Modified Cam Clay (MCC) model
d. Extending MCC; an introduction to the SR3 model
e. Advanced constitutive modelling – extended SR3 family



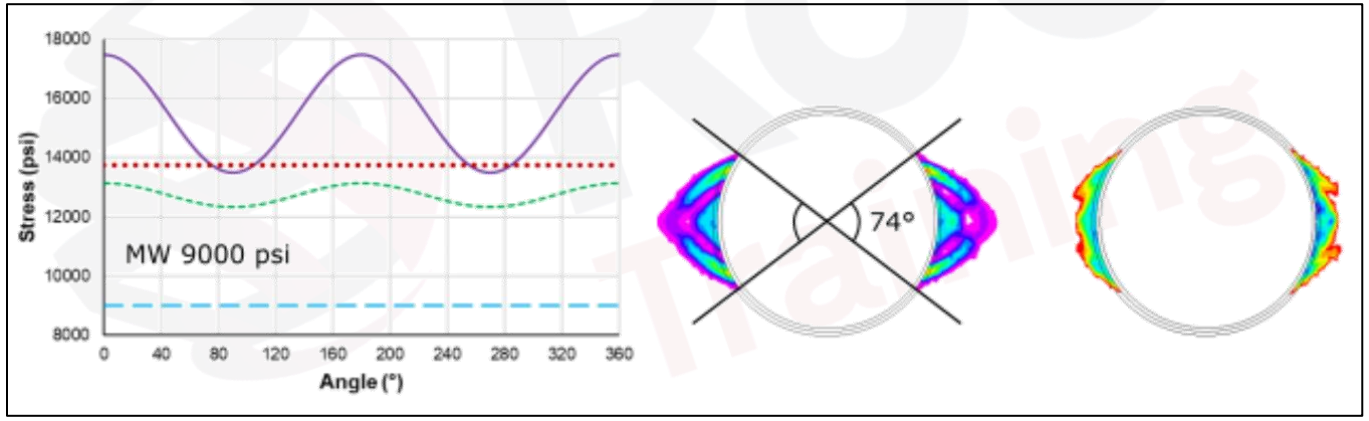


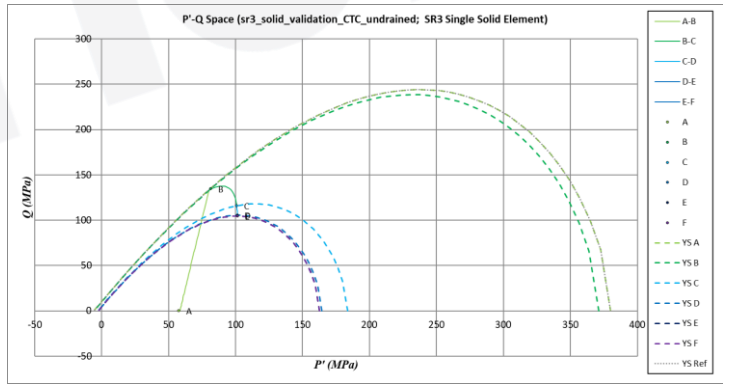


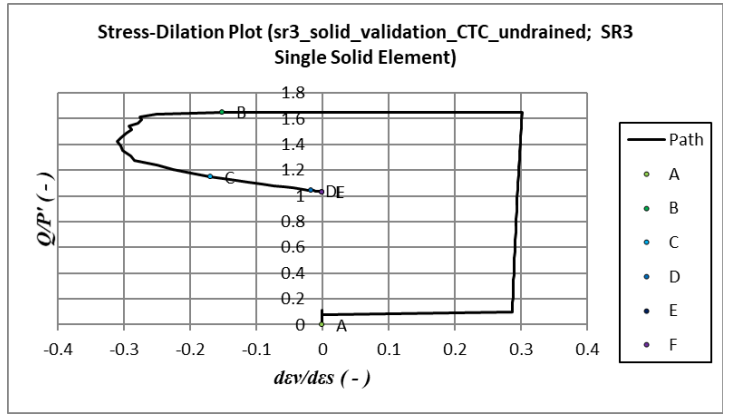
Exercises

Although participants will be provided exercises throughout the course, specific examples include:

a. Elfen wellbore – demonstration of elastic, perfectly plastic and shear softening
b. Stress path assessments for typical material responses
c. Material characterisations from lab tests



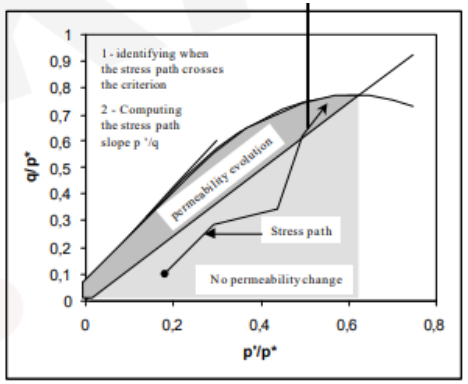


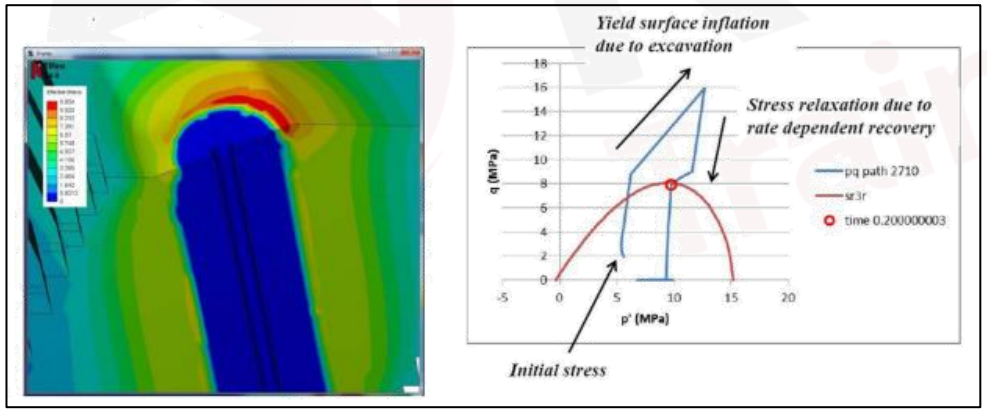


Field Examples

To conclude the course, participants will be introduced to field examples where critical state and advanced constitutive behaviours are observed

a. Wellbore stability – rupture modes, influence of bedding/anisotropy
b. Shale creep – activating shale to form well barriers
c. Reservoir stress paths and permeability evolution
d. Sanding failure modes





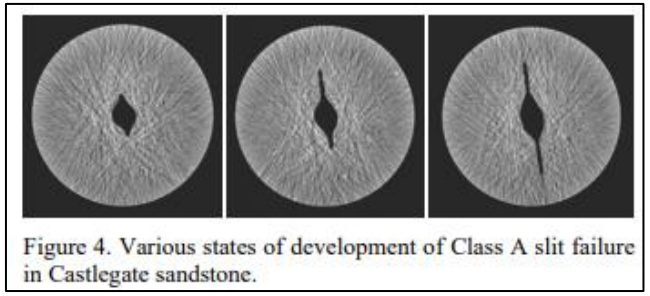
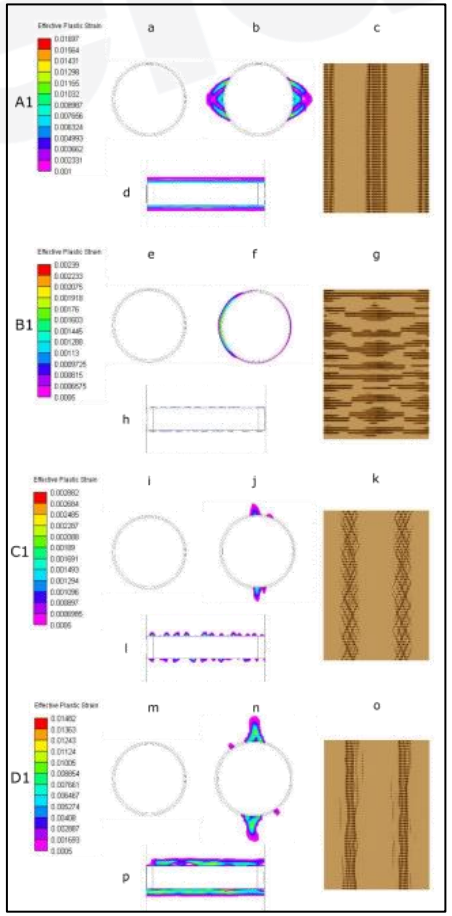


Figure 4. Various states of development of Class A slit failure in Castlegate sandstone.



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