

Title : Polyaxial Test Cell for Large Scale Testing of Rocks

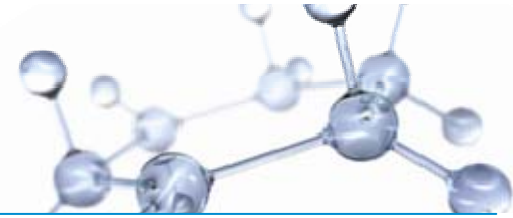
Authors: Peeyush Bhargava & Jennifer Hommema

European Sand Management Conference '2010

Date : 3/10/2010

Polyaxial Test Cell for Large Scale Testing of Rocks

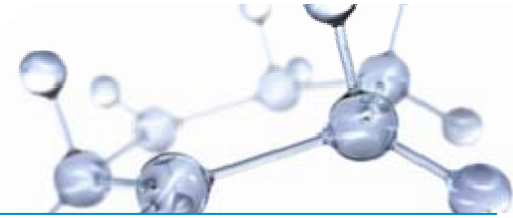
Overview



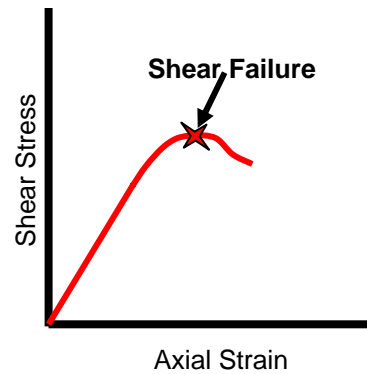
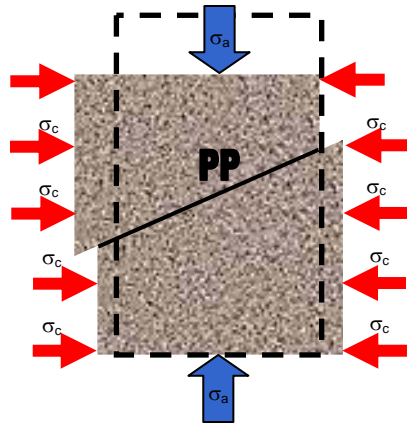
- Why Perform Large Scale Testing in a 3-D environment?
- Polyaxial Test Cell Description
 - Capacity and Maximum Rock Size
 - Boroscope and Laser Detection
- Typical Experiments
 - Mode of Testing
 - Characterization of Failure
 - Sand Volume Measurements
 - Onset and Catastrophic Failure
- Brief Discussion of Material Modeling

Polyaxial Test Cell for Large Scale Testing of Rocks

Traditional Triaxial Testing



- Current technology for Geomechanical Characterization
 - Traditional Triaxial Testing



Typical Conditions

σ_a = Axial Stress
 σ_c = Confining Pressure
PP = Pore Pressure

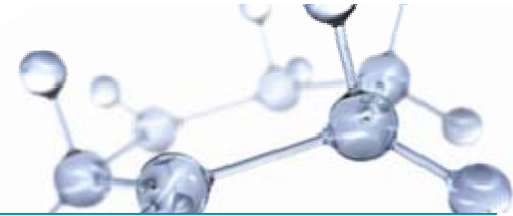
Test Variations

1. $\sigma_c = 0$: UCS Test
2. $\sigma_a = \sigma_c$: Hydrostatic Test
3. TWC Test

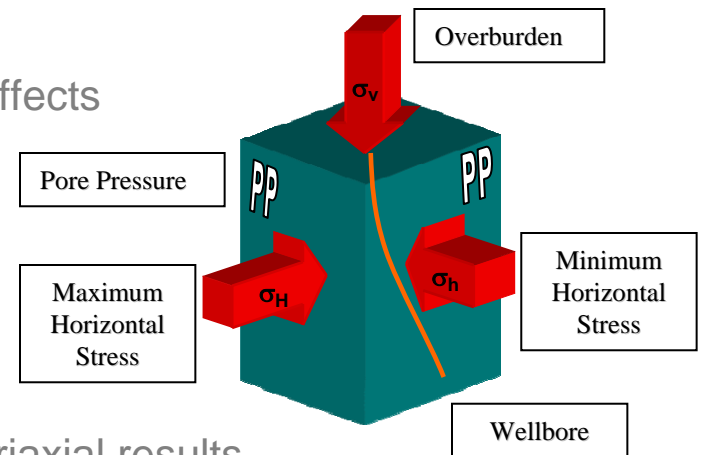
- Material Modeling - Mohr Coulomb, Drucker-Prager, Hoek-Brown etc.
- State of loading not truly triaxial in traditional methods
- Size and Boundary effects in traditional methods
 - Closer boundary leads to higher stress concentrations
 - Smaller size leads to higher strength (Typical size ~ 1.5 " by 3")
 - Catastrophic failure rarely observed in small samples

Polyaxial Test Cell for Large Scale Testing of Rocks

Polyaxial Testing - Advantages

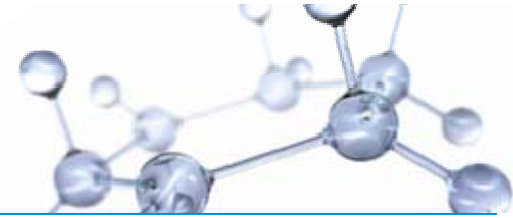


- The state of stress in Earth is three dimensional, hence characterizing rock behavior under three dimensional loading is important
- Rock Behavior and Material Modeling - Dependence on Intermediate stress can be captured
- Size and Boundary effects
 - Larger sized sample help reduce size & boundary effects
 - Catastrophic failure events can be observed
- Applications
 - Characterize three dimensional behavior of rocks
 - Correlate three dimensional behavior to traditional triaxial results
 - Quantify 'Onset' of sand production more accurately
 - Observe and quantify catastrophic failure

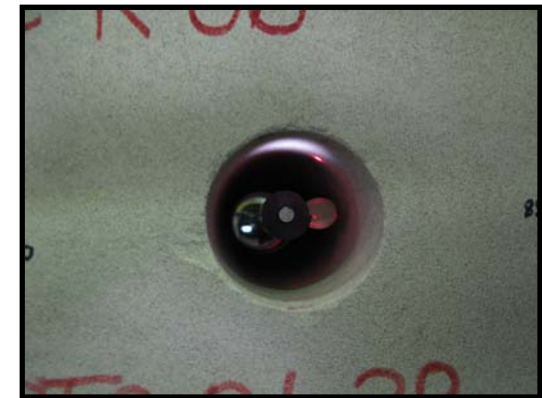
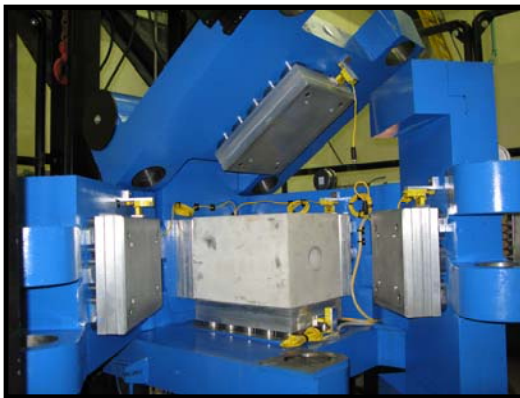


Polyaxial Test Cell for Large Scale Testing of Rocks

Polyaxial Test Cell Description



- Load and Displacement control capability
- Independent control in all three directions
- Maximum sample size - 12" by 12" by 18"
- Up to 5000 psi of stress on maximum sample size (~ 1M lbs of force)
- Real-time surface observations with boroscope
- Real-time surface mapping with laser displacement sensor
- Sand volume quantification at different stages of test
- Safety features – Electrical and mechanical shutdowns, alarms for events, physical barriers during testing, fail-safe alarms
- Currently studying properties of Castlegate rocks



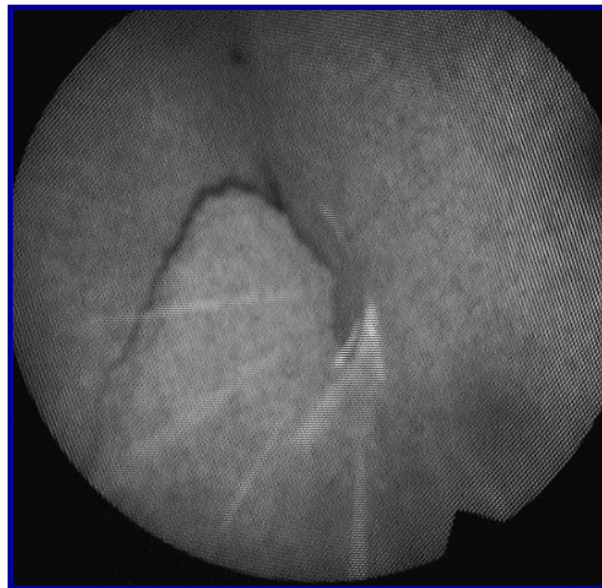
Polyaxial Test Cell for Large Scale Testing of Rocks Boroscope and Laser Mapping



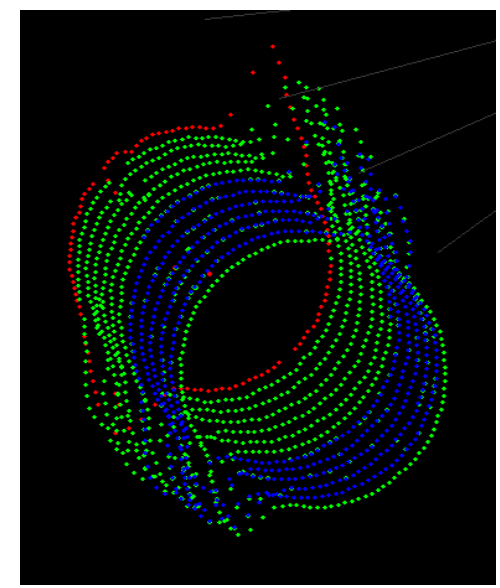
- Boroscope live view enables surface observation including detection and location of failure, identifying catastrophic failure
- Laser detection system mounted enables surface mapping pre and post failure, real time information about location and extent of breakout



Boroscope and Laser Configuration



Image/ Video from Boroscope

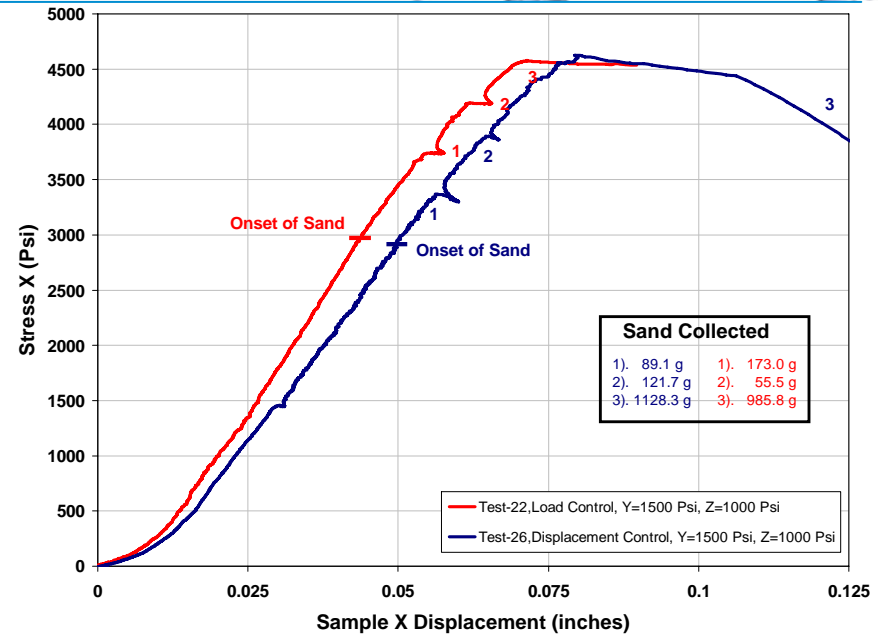
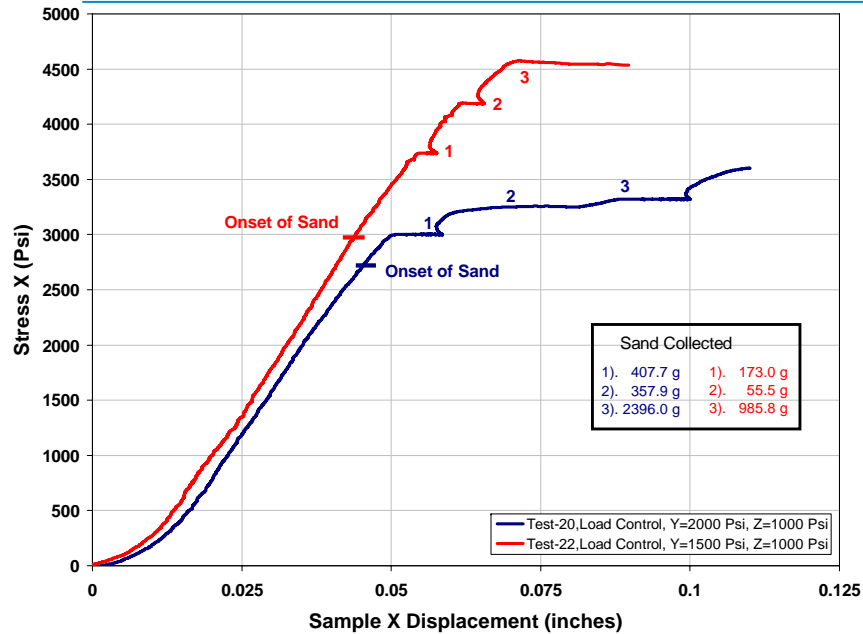
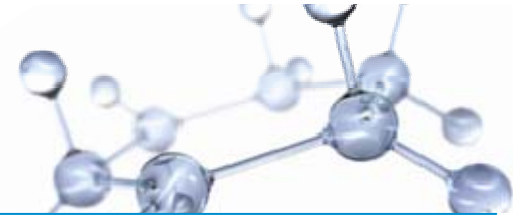


Laser Surface Mapping

- Breakout shape and size enables estimating stress or strains with changing geometry

Polyaxial Test Cell for Large Scale Testing of Rocks

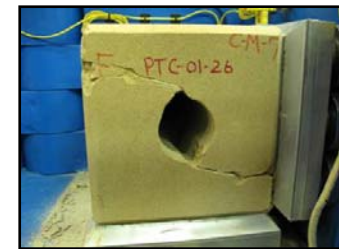
Typical Test Results and Material Modeling



- Intermediate stress changes ‘Onset’ of sand failure
- Intermediate stress changes ‘Volume’ of sand produced
- ‘Load Control’ vs. ‘Displacement Control’
 - Different volumes of sand measured
 - Strain rate variable vs. constant
 - Stable vs. Unstable test
 - Ultimate strain to failure
- Material Modeling
 - Use Laser data to study evolution of stress/ strain around borehole
 - Study Onset and Catastrophic failure of sandstone



Test 22 – Post failure



Test 26 – Post failure