Large Strain Consolidation and Hydraulic Conductivity Testing of Fine Tailings

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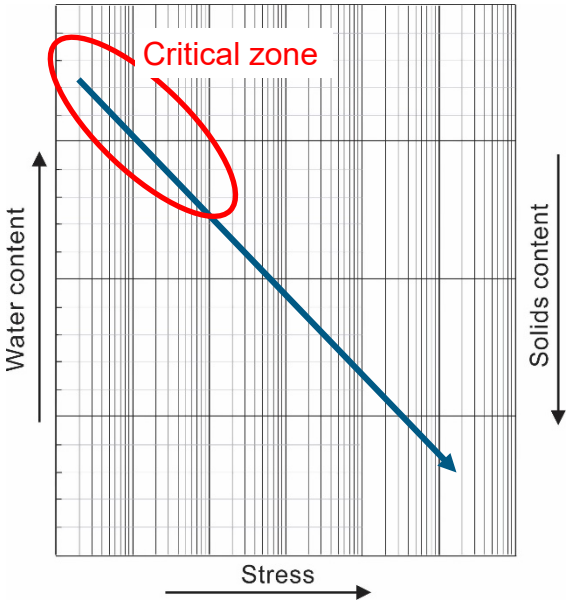
Introduction

Subject

- Measurement of large strain consolidation and hydraulic conductivity of fine tailings

Need

- Time and load required for tailings to consolidate – gain strength - facilitate decommissioning
- Mechanisms to speed tailings dewatering and settlement:
  i. physical loading and dewatering strategies,
  ii. chemical and biological treatments.
- Measurement of hydraulic conductivity



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Introduction

Objectives

- To develop laboratory equipment and procedure capable of:
  - Accurately measuring large strain consolidation,
  - Simultaneously measuring hydraulic conductivity.

Background

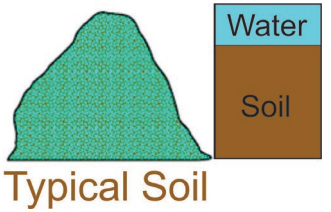
Definitions

Gravimetric water content (ω) = m_{water}/m_{solids}

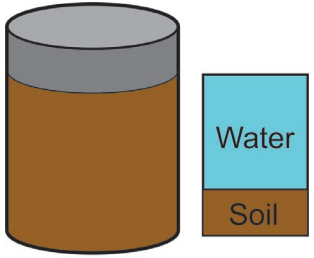
Solids content = m_{solids}/m_{total} = $1/(1 + \omega)$

Void ratio (e) = V_{voids}/V_{solids}

Porosity (n) = V_{voids}/V_{total} = $e/(1 + e)$



Typical Soil



Slurry

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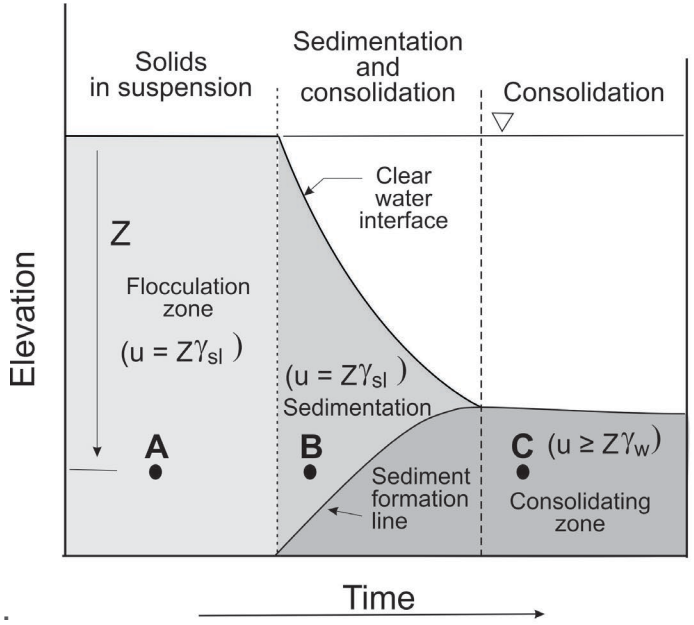
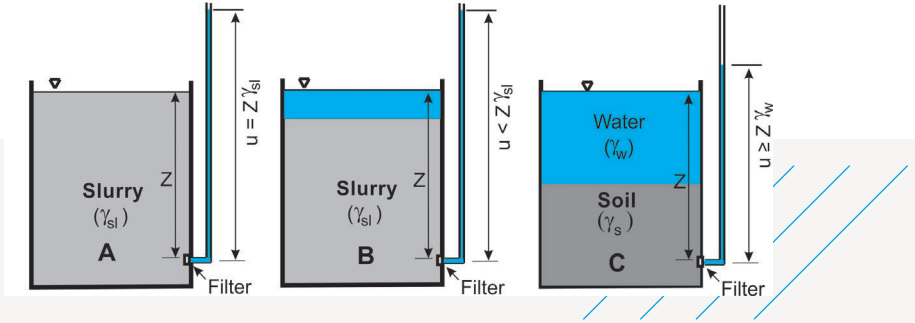
Background

Sedimentation and consolidation

- Stage 1 – Flocculation: Particles coming into contact and growing in size
- Stage 2 – Sedimentation: Soil particles begin to contact one another and settle out.
- Stage 3 – Consolidation: All particles are in contact and begin to carry “load” (consolidate).





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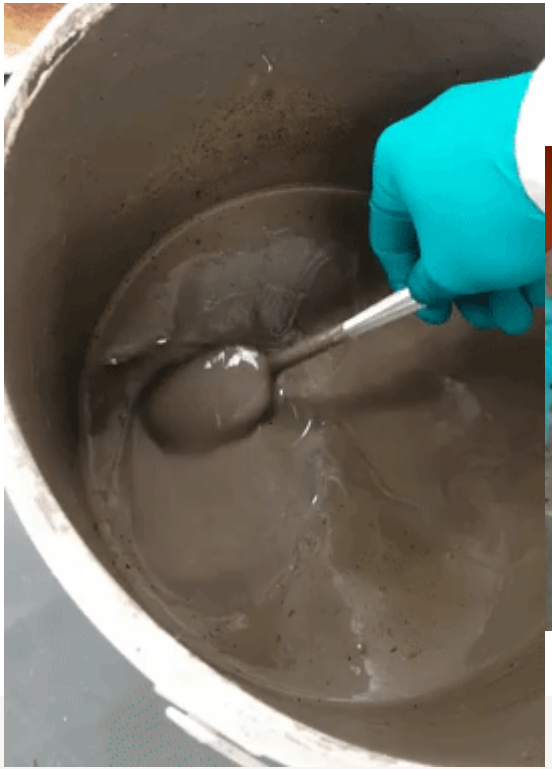
Background

Fine Tailings

- Centrifuge Fines
- Often Polymer Treated



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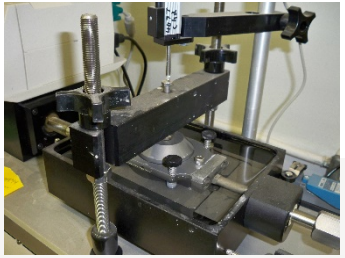
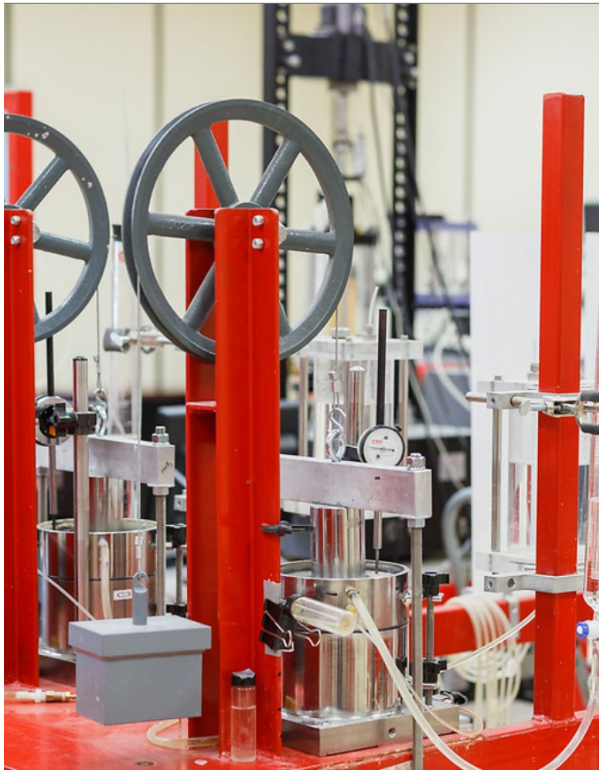
Design Criteria

LSC Testing

- Large deformation capability – tall consolidation cells
- Accurately apply low stress – large diameter cells
- Apply wide range of loads (i.e. precision over large range of loading)
- Ability to measure pore pressure along the height of the sample
- Collect effluent for chemical testing and K-testing





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Design Criteria

Hydraulic conductivity testing

- Constant hydraulic head across the sample for entire LSC test
- K measurements - taking flow measurements with time
- Avoid changes in stress regime due to seepage start/stop

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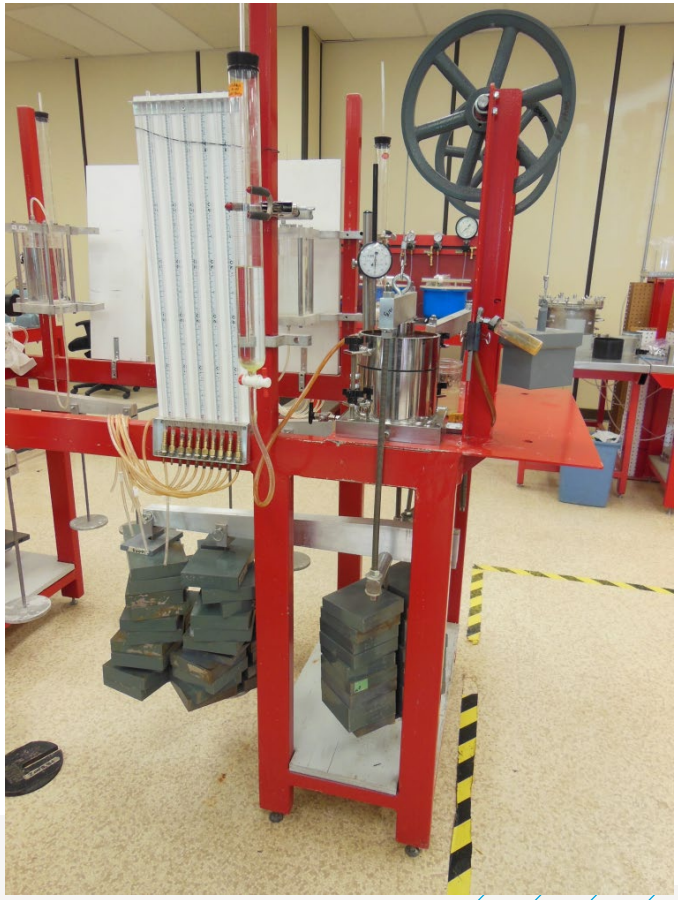
Construction of the Test Equipment

LSC Testing

- 165 mm high consolidation cells
- Stainless Steel – chemical resistance
- **Low Load**
  - Small to start, ~ 0.5 kg
  - Counterweight, low friction
- **High Load**
  - 1000 kg (effective) via mechanical advantage
- Measure pore pressure along the height of the sample
- Ability to collect effluent



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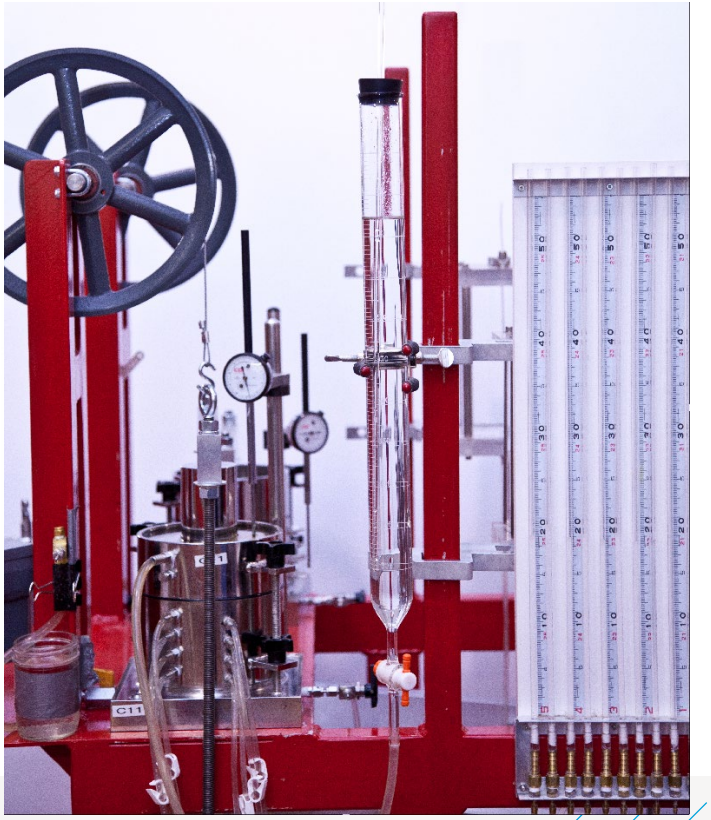
Construction of the Test Equipment

Hydraulic Conductivity

- Hydraulic head, Δh, across the sample (≥ 1 cm)
- Applied continuously during LSC testing
- Marriotte bottle - constant head and eliminates problem with evaporation



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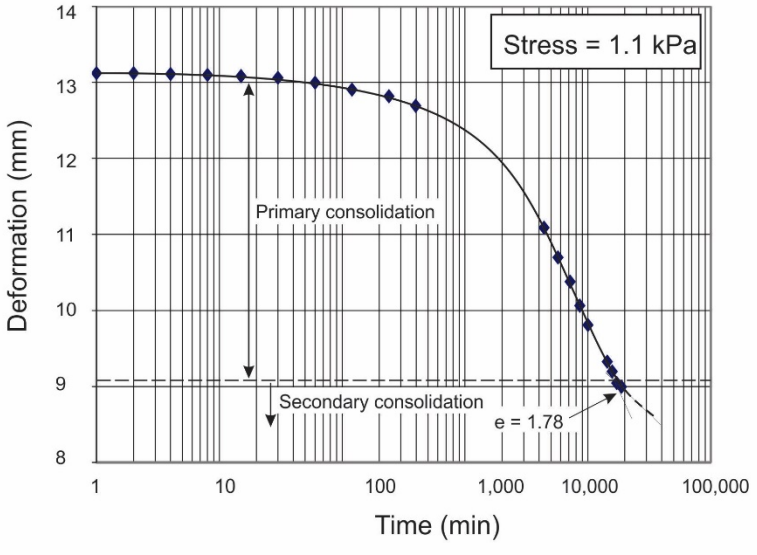
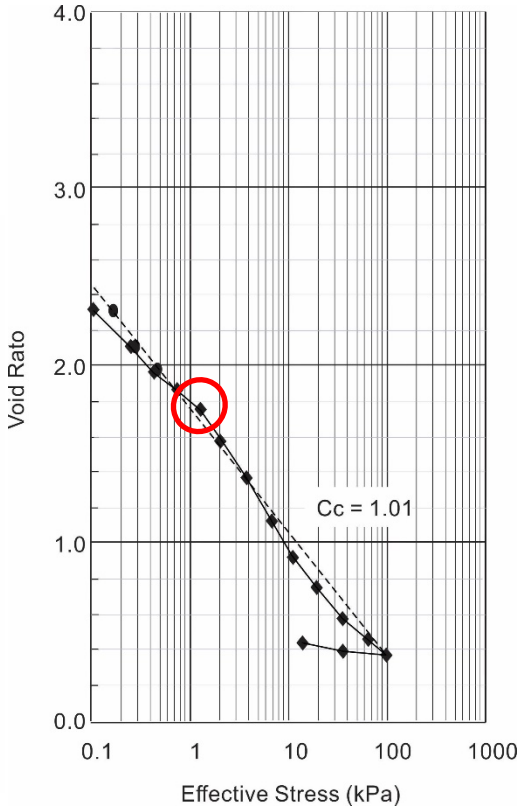
LSC – Test Procedures





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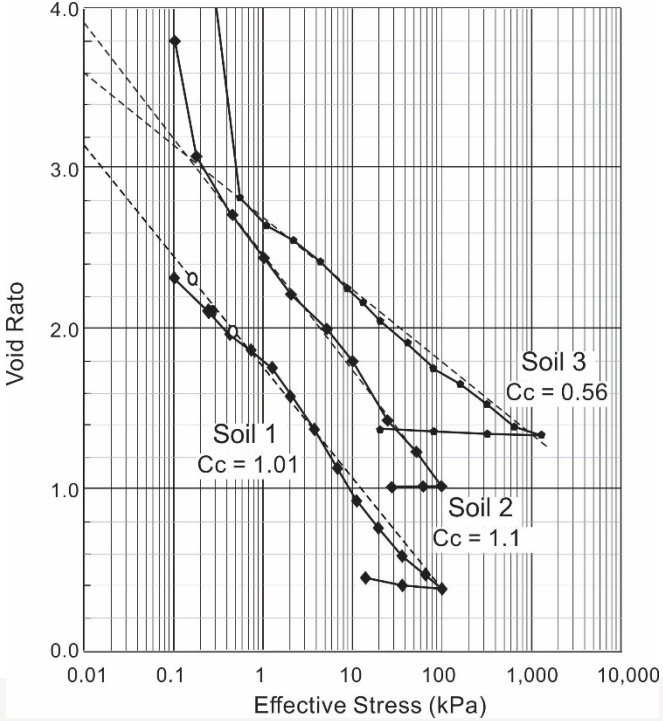
LSC – Test Results – e log P



- Each soil/material has a unique e-log P relationship
- Higher Cc values represent greater compressibility
- e log P relationships can be altered by chemical and biologically induced stress

Typical compression index values (after J M. Pestana-Nascimento)

Normal consolidated clays	0.2 - 0.5
Canada Leda clay	1-4
Organic clays	4+
Peat	10-15
Organic silty clay	1.5 - 4
San Francisco sediments	0.4 - 1.2

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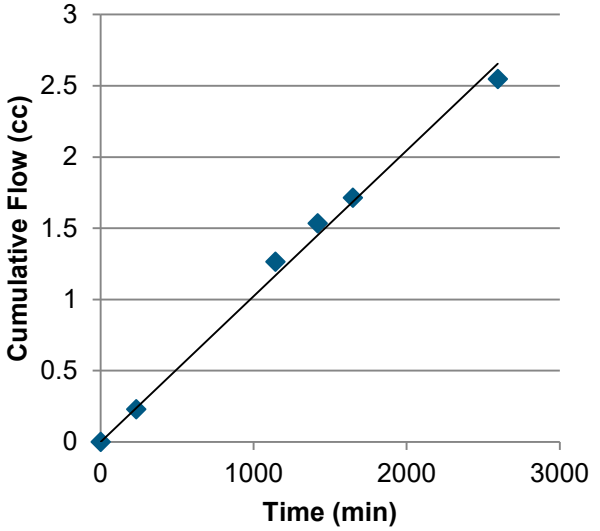
Hydraulic Conductivity – Test Procedures

- e log K (Hydraulic Conductivity) relationship
- After completion of primary consolidation
- Start/Stop Flow → ± Stress → Consolidation
- Seepage induced consolidation critical at low loads.
- Constant, low flow throughout test
  - Constant head tank (Mariotte Bottle)
  - As low as 1 cm head differential



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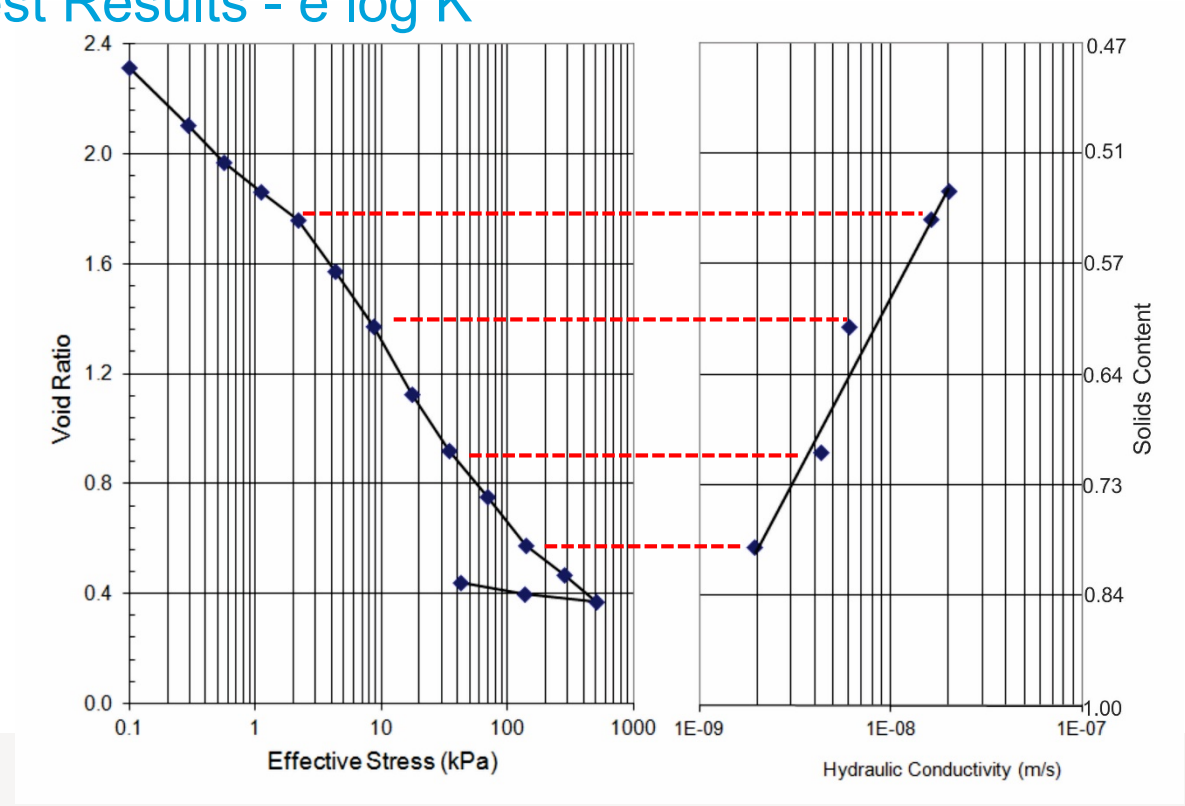
LSC – Test Results - e log K



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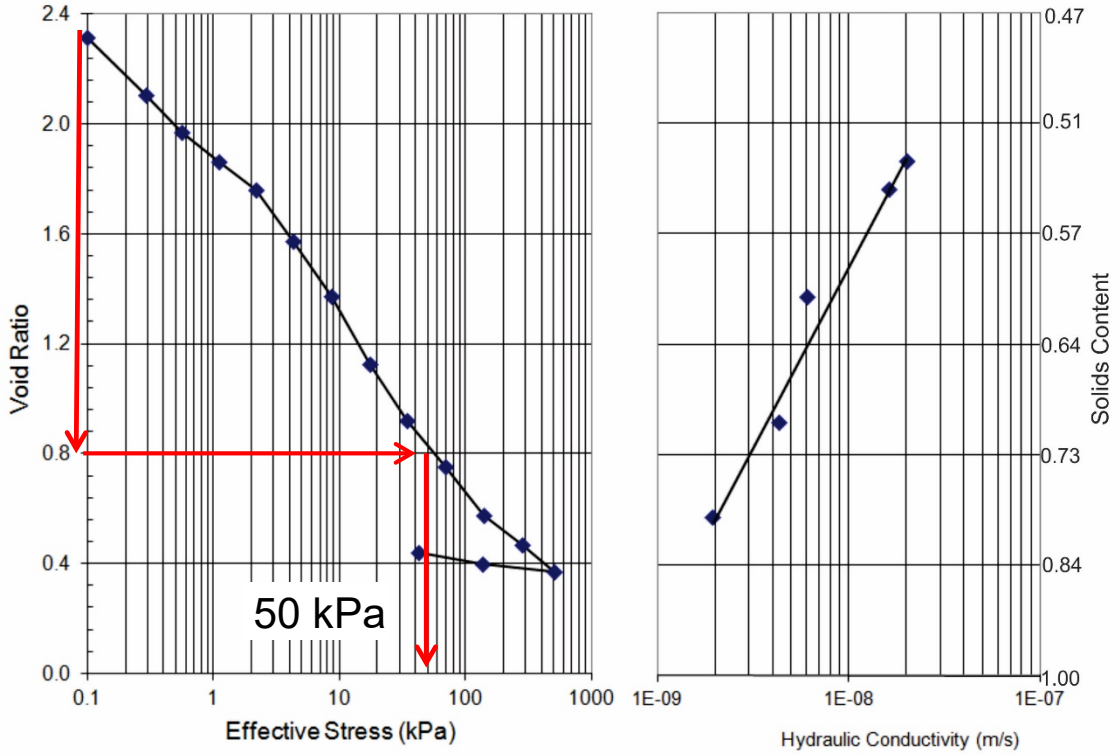
LSC – Practical Application

Initial solids content, 48%

Desired solids content 73% (based on strength)

Required surcharge:

2.8 m sand at 1800 kg/m3 ~ 50 kPa.



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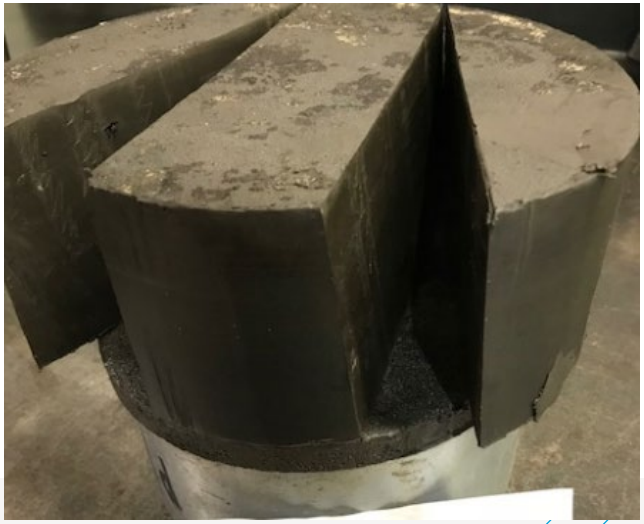
Summary and Conclusions

- Developed Specialized Laboratory Equipment
  - Suitable for tailings from various mines
    - *Oilsands, Base metals, Potash, and Infrastructure*
- 0.1 - 500 kPa or ~ 1 - 1000kg
- Produce accurate and repeatable test results
- Results can be used for prediction of settlement time and loading
- Decommissioning applications



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