Laboratory Plate Load Testing of Non-Segregating Tailings

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Preamble

- Non-segregating tailings (NST) are produced by mixing either mature fine tailings or thickened tailings with sand derived from cyclone underflow coarse tails.
- Coagulants (e.g. CO2, CaO) are added to accelerate solids settling and densification.
- It’s typically prepared at a target sand-to-fines (SFR) ratio of about 4 or more, thereby producing a predominantly frictional material.
- The objective was to conduct plate load tests on NST samples prepared at different solids contents by weight (SBW), and estimate the ultimate bearing capacity of each sample.
- Solids content would then be used as a measure to assess the deposit’s trafficability and readiness for capping or landform construction activities and monitor progress towards reclamation.
Outline

1. Lab Testing Setup
   › NST Material Preparation
   › NST Strength Characterization
   › Plate Load Testing
2. Lab Testing Results
3. Final Remarks
Lab Testing Setup

1. NST material preparation
2. NST strength characterization
3. Plate load testing
NST Material Preparation

1. A single batch of NST material was produced at a solids content of 64.4% and a sand-to-fines ratio (SFR) of about 5.

2. The NST was tremied into four 1.0 m × 1.0 m × 0.7 m (length × width × height) aluminum pans, and dewatered until target solids contents were achieved.
NST Dewatering Schemes

1. Mounting lights and fans to enhance evaporation.
2. Decanting “free” water accumulated on the tailings surface.
3. Pumping seepage water out the French drain (previous slide).

We tracked the change in solids content by monitoring pan weight with Desna scales.
Dewatered NST

- Pan #12 [Target 65%]
- Pan #11 [Target 70%]
- Pan #09 [Target 75%]
- Pan #08 [Target 80%]

- Average Solids Content by Weight (%)
- Days of Measurement

- Plate load test on Pan #08
- 80.7, 0.63
- 80.3, 0.64

- Decant water pumped out from Pans #11, #09, #08
- 76.3, 0.81

- 75.4, 0.85

- Crust

- PAN 12: 75.4%
- PAN 11: 76.3%
- PAN 09: 80.3%
- PAN 08: 80.7%
NST Strength Characterization

1. Pocket penetrometer.
2. Vane shear device.
3. Rimik® cone.

We also conducted a series of index testing: Atterberg limits, solids content, bitumen content, particle size distribution.
Plate Load Test Setup

1. Custom-made loading reaction frame.
2. 200 mm (8-inch) diameter steel plate.
3. Hydraulic ram, adapters and extension rods.
4. Load cell, LVDT, data acquisition system, laptop.
Plate Load Testing

1. Tests were carried out on:
   - Pan #11 (76.3%)
   - Pan #09 (80.3%)
   - Pan #08 (80.7%)

2. NST on Pan #12 (75.4%) was too soft for testing and there was time constraints.

3. Tests were conducted at two locations as shown in this figure.
Lab Test Results

1. NST strength characterization
2. Plate load testing
Strength Characterization

- The results from different strength characterization methods correlated relatively well.
- Shear strengths were comparatively higher at the crust (around 3-5 kPa) but much lower (around 2 kPa) 20 cm below the crust.

Pan #08: 80.7%
Pan #09: 80.3%
Pan #11: 76.3%
Plate Load Testing Results

- For Pans #09, 08, bearing capacities at a displacement of 10% plate diam. are about 12-15 kPa.
- Using simple bearing capacity formulations, an equivalent shear strength of 3 to 5 kPa can be calculated for the NST at 80% solids content, which is about the upper limit of the liquid limit.
Ternary diagram

Solids Content - Geotechnical ($M_s/M_T \%$)

Fines-Water Ratio ($M_{fw}/(M_{fw} + M_w) \%$)

Fines Content - Geotechnical II ($M_{fb}/M_s \%$)

Liquid Limit

Plastic Limit

OUR RESULTS
Trafficicability

NST at 80-81% solids content is not trafficable, but it can be capped...

Source: Jakubick et al. (2003)
Reclamation

- Results from plate load testing align quite nicely with range published in McKenna et al. (2016) IOSTC paper.

- Capping option would include sand beaching (hydraulic placement to form a cap).
Final Remarks

• Bearing capacity of the NST material varied from about 1 kPa for the 76.3% SBW material to around 9–12 kPa for the 80.3–80.7% SBW material.

• Ultimate bearing capacity was found to increase with plate settlement, as expected for a sand dominated frictional material, whose shear strength depends on stress and confinement levels.

• There was insufficient data to derive a reliable relationship between bearing capacity and solids content.

• This relationship is very likely to be non-linear, as is the case for undrained shear strength and void ratio (Sobkowicz et al., 2013; Moore et al., 2014).
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