DETERMINING BEARING CAPACITY FOR SAND CAP PLACEMENT AT JACKPINE MINE DDA1

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PREMIUM VALUE. DEFINED GROWTH. INDEPENDENT.
Overview

• Purpose and Scope
• Conceptual Models
• Material Properties
• Results and Discussion
• Summary and Conclusions
Purpose and Scope

• Engineering related to sand capping is complicated
  – Oil sands tailings has low shear strength
  – Sand cap has the higher density
  – Bearing capacity failure problems – inversion or overturning

• Can a sand cap of 3-5 m thick be placed on the top of tailings?
  – If yes, what would be the strength required for the tailings at the surface to support this?
  – What would be the depth of the tailings with a higher (improved) strength to support this much sand cap?

• Will not model
  – How the sand cap will be placed on the top of tailings
  – How the required high strength (improvement) of the tailings at the surface will be achieved
Modeling Assumptions

• Tailings
  – Total thickness = 30 m (improved layer + centrifuged tailings)
  – Improved (high strength) layer thickness \( (H_d) = 1, 3, 5, 10, \) and 15 m

• Sand cap
  – Sand cap thickness \( (H_s) = 3 \) to 5 m
  – Sand cap slope = 1.5%
  – Local slope in sand cap
  – Step slope thickness in sand = 0.5 to 1.0 m

• Slope stability package (SVSLOPE) will be used for rotational bearing capacity failure analysis
  – No deformation analysis
Conceptual Models

Model #1 – Hydraulic placement of sand

Model #2 – Mechanical placement of sand
Conceptual Models (contd.)

Model #3 – Hydraulic placement of sand with anomaly

Model #4 – 3-D Mechanical placement of sand
## Material Properties

<table>
<thead>
<tr>
<th>Materials</th>
<th>Peak shear strength (kPa)</th>
<th>Unit weight (kN/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tailings</td>
<td>1</td>
<td>13.83</td>
</tr>
<tr>
<td>Improved (densified) layer</td>
<td>To be found</td>
<td>17.79</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials</th>
<th>Cohesion (kPa)</th>
<th>Friction angle (deg.)</th>
<th>Unit weight (kN/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Cap</td>
<td>0</td>
<td>31</td>
<td>19.5</td>
</tr>
</tbody>
</table>

Ground water table: Below the improved layer
• The relation between $s_u$ (tailings) and thickness of the densified layer is nonlinear.

• At 1 m improved layer thickness, $s_u = 210-250$ kPa (equiv. to stiff clay) for 3 and 5 m sand cap, respectively.

• At 10 m improved layer thickness, $s_u = 22-24$ kPa for 3 and 5 m sand cap.

• Similarly, if the improved layer thickness is 15 m, the $s_u = 13-16$ kPa (equiv. to very soft clay) for 3 and 5 m sand cap.
Model#2 Results – Bearing Capacity Failure Analysis for FOS = 1

• The relationship between $s_u$ (tailings) and thickness of the densified layer is nonlinear.

• At 1 m improved layer thickness, $s_u = 270-577$ kPa for 3 and 5 m sand cap, respectively.

• At 10 m improved layer thickness, $s_u = 41 -71$ kPa for 3 and 5 m sand cap.

• Similarly, if the improved layer thickness is 15 m, the $s_u = 28-45$ kPa for 3 and 5 m sand cap
The relation between $s_u$ (tailings) and thickness of the densified layer is nonlinear.

- At 1 m improved layer thickness, $s_u = 307-329$ kPa for 3 and 5 m sand cap, respectively.

- At 10 m improved layer thickness, $s_u = 29-31$ kPa for 3 and 5 m sand cap.

- Similarly, if the improved layer thickness is 15 m, the $s_u = 19-20$ kPa for 3 and 5 m sand cap.
Model#4 Results – Bearing Capacity Failure Analysis for FOS = 1

- Graph showing undrained shear strength of improved layer vs. thickness of improved layer (m)
- Different colors represent different sand cap thicknesses (0.5 m, 1 m, 3 m, 4 m, 5 m)

Graph labels:
- Y-axis: Undrained shear strength of improved layer (kPa)
- X-axis: Thickness of improved layer (m)

Graph notes:
- The results indicate the influence of sand cap thickness on bearing capacity.
- Higher sand cap thicknesses generally lead to increased bearing capacity.
Model#4 Results – Bearing Capacity Failure Analysis for FOS = 1

• Conceptual model #4 is an extension of conceptual model #2 in 3-D in a quadrant

• The relationship between improved layer thickness and undrained strength is nonlinear
  – At 1 m improved layer thickness, $s_u = 230-400$ kPa for 3 and 5 m sand cap, respectively.
  – At 10 m improved layer thickness, $s_u = 24-42$ kPa for 3 and 5 m sand cap.

• In general, 2-D slope analysis yields a conservative FOS compared to 3-D results

• For the same strength, the 3-D/2-D FOS ratio varies between 1.17 to 1.72 (i.e., 17% to 72% higher)
Summary and Conclusions

- The relation between $s_u$ (improved layer tailings) and thickness of the improved layer is nonlinear
  - With increasing the thickness of the improved layer, the strength required to support the sand cap decreases nonlinearly

- Conceptual Model #1: 3-5 m sand cap
  - For 1 m improved layer, the strength needs to be 210-250 kPa to support 3-5 m sand cap
  - For 10 m improved layer thickness, $s_u = 22 - 24$ kPa to support 3-5 m sand cap
  - For 15 m improved layer, the strength needs to be 13-16 kPa to support 3-5 m sand cap

- Conceptual Model #4: 3-5 m sand cap
  - For 1 m improved layer, the strength needs to be 230-400 kPa to support 3-5 m sand cap
  - For 5 m improved layer, the strength needs to be 48-82 kPa to support 3-5 m sand cap
  - For 10 m improved layer, the strength needs to be 24-42 kPa to support 3-5 m sand cap