SWCC: EXPERIMENTAL RESULTS OF COPPER TAILINGS AND SPENT ORE

José Riquelme Olivares
SRK Consulting Chile. riquelme@srk.cl

Cristian Godoy Leiva
SRK Consulting Chile. cgodoy@srk.cl
Introduction

Unsaturated soils

Geotechnical structures associated with mining works

Flow or seepage studies.

Soil Water Characteristic Curve (SWCC).

Experimental determination and estimation methods.
Soil Water Characteristic Curve (SWCC)
Soil Water Characteristic Curve (SWCC)
Empirical Determination SWCC Curves

Pressure plate test

- Place sample in molds and consider duplicate
- Saturate and apply suction
- When equilibrium is reached, no more water comes out
- Remove samples and weigh wet sample and dry sample after oven
- Determine gravimetric water content
Empirical Determination SWCC Curves
van Genuchten and Fredlund & Xing Fits

\[
w(\psi) = w_r + (w_s - w_r) \left[ \frac{1}{1 + (a_{vg} \psi)^{n_{vg}}} \right]^{m_{vg}} \\
w(\psi) = w_s \left[ 1 - \frac{\ln \left( 1 + \frac{\psi}{h_r} \right)}{\ln \left( 1 + \frac{10^6}{h_r} \right)} \right] \left[ \frac{1}{\ln \left( e + \left( \frac{\psi}{a_f} \right)^{n_f} \right)} \right]^{m_f}
\]

Where:
- \( w(\psi) \) Water content as a function of suction
- \( \psi \) Suction, capillarity or negative pore pressure
- \( w_s \) Saturation water content
- \( w_r \) Residual water content
- \( a_f, n_f, m_f, h_r, a_{vg}, n_{vg}, m_{vg} \) Fit parameter of the models
Estimation Methods

Fredlund & Wilson consider granulometric properties and volume-mass relationships, and making use of neural networks makes the estimation.

Vereecken uses a regression model using as input parameters the percentages of sand and clay and density of material.

Aubertin uses the Kovacs modified method to perform the estimation from the porosity, density, void index, D_{10} and D_{60} of material.
Comparison Between Estimation Methods and Empirical Curves

Nash-Sutcliffe efficiency coefficient
Comparison Between Estimation Methods and Empirical Curves

Nash-Sutcliffe efficiency coefficient
Alternative Work Focus

Alternative similar to experimental results without investing too much time, resources or money.

Three points determination of SWCC
1. Saturation water content (low suction)
2. Air Entry Value (intermediate level according to soil type)
3. Permanent wilting point (high suction)
Alternative Work Focus

<table>
<thead>
<tr>
<th>Point</th>
<th>Spent ore Suction (kPa)</th>
<th>Tailing Suction (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>1500</td>
<td>1500</td>
</tr>
</tbody>
</table>

Graph showing gravimetric water content vs. suction for different materials.
Fit Efficiency Alternative Focus

Efficiency fit methods in tailings with three points

Tailing 1
Tailing 2
Tailing 3
Tailing 4
Tailing 5
Tailing 6
Tailing 7
Tailing 8
Tailing 9
Tailing 10
Tailing 11

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Efficiency fit methods in spent ore with three points

Spent ore 1
Spent ore 2
Spent ore 3
Spent ore 4
Spent ore 5
Spent ore 6
Spent ore 7
Spent ore 8
Spent ore 9

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Legend:

van Genuchten
Fredlund Xing
Summary

• SWCC were experimentally determined for spent ore and tailings from different mining operations in Chile. These curves can be used as references for studies of unsaturated flow tailing deposits, spent ore dump and heap leach, with similar materials.

• When comparing experimental results with different estimation methods, we noted that none represents in a satisfactory way this phenomenon for all this cases, according to calculated efficiency coefficient.
Summary

• If total determination of SWCC is not possible, it is recommended to use proposed three-point method, because it shows greater efficiency values than indirect methods, representing a more reliable alternative.
Thank you!
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