An Experimental Study of Unfrozen Water Content in Fine Grained Permafrost Soils

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Agenda

- Geotechnical engineering in permafrost areas
- Unfrozen water content in frozen soil
- Methods for estimating unfrozen water content in frozen soil
Geotechnical Engineering in Cold Areas
Unfrozen Water Content

\[ w = w_u + w_i = \frac{M_w}{M_s} \]

\[ w_u = \frac{M_u}{M_s} \]

- Supply heat
- Reduce strength
- Increased settlements

Mass-volume relationships for frozen and unfrozen soil (Andersland and Ladanyi, 1994)
Methods for Estimating Unfrozen Water Contents

- Liquid limit determination
- Water potential determination
Unfrozen Water Content from Liquid Limit Determination

\[ w_u = \alpha \theta^\beta \quad [%] \]

\[ w_{u,\theta=1} = 0.346 \cdot w_{N=25} - 3.01 \]

\[ w_{u,\theta=2} = 0.338 \cdot w_{N=100} - 3.72 \]
Unfrozen Water Content from Water Potential Determination

- Proposed by Istomin et. al. (2015, 2017)
- Based on experimental correlations and thermodynamic calculations
Comparison of the Results

Unfrozen water content vs. temperature

Unfrozen water content w [%]

$\theta$ [C]

- Water potential AD-d-4-4 15
- Water potential AD-d-2-4 25
- Liquid limit AD-d-2-4
- Liquid limit AD-d-4-4
# Experiences and Comparison of the Methods

<table>
<thead>
<tr>
<th>Liquid Limit Determination</th>
<th>Water Potential Determination</th>
</tr>
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<tbody>
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## Experiences

- **Liquid Limit Determination**
  - Cumbersome
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- **Water Potential Determination**
  - Easy
  - Rather effective
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Summary and Further Work

- Liquid limit testing gave lower estimated unfrozen water content $w_u$
- Water potential method provides more accurate estimates?
- Water potential method should to be further tested and developed