INTRODUCTION

Excess water within pavement structures is the major cause of deteriorations. The existing subsurface drainage systems can only drain “free” water, but not capillary water. Conventional treatments are not effective in dealing with excess water induced deteriorations. A new wicking geotextile has the potential to dehydrate the road embankment and improve the long-term performance of the pavement system. This research aims at exploring the working mechanism of the wicking geotextile, quantifying the benefits of via numerical simulations, and incorporating the benefits into the existing pavement design.

PROBLEM STATEMENT

Adverse Effect of Water

- Pothole
- Land Dropoff
- Frost Heave

Conventional Treatments NOT Working

- Good-Quality Material: 
  - Expensive and not readily available
  - Mechanical Reinforcement 
  - Benefits deviate under unsat. condition
  - Excess water accumulation

Proposed Solution: Wicking Geotextile

- Dual-Function Geotextile
  - PE fiber: reinforcement 
  - 4DG nylon fiber: drainage
- Drain Both “Free” Water and Capillary Water
- Subsurface Drainage Design 
  - Sustainable 
  - Cost-effective

Objectives:

- Understand Working Mechanism 
- Quantify Engineering Benefits 
- Incorporate into existing design methods

MATERIAL CHARACTERIZATIONS

Summary of Material Characterizations

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Mechanical Properties</th>
<th>Hydraulics Properties</th>
<th>Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient Modulus Test</td>
<td>Wide-Width Tensile Strength Test (from Specification)</td>
<td>Large-Scale Direct Shear Test</td>
<td></td>
</tr>
<tr>
<td>SWCC</td>
<td>Hold Water</td>
<td>Pressure Plate</td>
<td>Capillary Rise Test</td>
</tr>
<tr>
<td>SWCC</td>
<td>Salt Concentration</td>
<td>Pressure Plate Test</td>
<td>Section Controlled Odometer Test (AEV)</td>
</tr>
<tr>
<td>Trans. Water</td>
<td>Constant Head Test</td>
<td>Constant Head Test</td>
<td>Water Vapor Transmission (WVT)</td>
</tr>
</tbody>
</table>

Laboratory Characterizations of Soil, Geotextile, and Their Interactions

NUMERICAL MODEL

Coupled Hydro-Mechanical Model

\[
\begin{align*}
\frac{\partial (\rho u)}{\partial t} + \nabla \cdot (\rho u u) &= \rho f, \\
\frac{\partial (\rho h)}{\partial t} + \nabla \cdot (\rho h u) &= 0, \\
\frac{\partial (\rho e)}{\partial t} + \nabla \cdot (\rho e u) &= -\nabla \cdot \sigma + \rho g w, \\
\frac{\partial (\rho a)}{\partial t} + \nabla \cdot (\rho a u) &= 0
\end{align*}
\]

Challenges

- Nonlinearity
- Soil-Vegetation Climate Interactions

Climatic Factors Influencing Soil-Climatic Interactions

CONCLUSIONS

This research studies the possibility of using a wicking geotextile to dehydrate road embankment using numerical simulations. Laboratory tests were performed to characterize the mechanical and hydraulic properties of soil, geotextile, and their interactions. Then, a coupled hydro-mechanical model was proposed to simulate the soil-vegetation-climate interactions. The pavement performances with and without the wicking geotextile were evaluated. A more accurate and representative effective resilient modulus value could be determined, which could be used as a critical material input in the AASHTO 1993 design guidelines. Base on the case studies, using the wicking geotextile, the resilient modulus increased by 87% and the base course thickness can be reduced from 21 in to 15 in.

ACKNOWLEDGEMENTS