Development of a Subgrade Drainage Model for Unpaved Roads

Ames, IA
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Problem Statement

The combination of subbase moisture and subbase composition leads to the formation of frost boils

- Frost season occurs every year in early spring
- Frost boils usually reoccur at the same locations
- Poor drainage induce fluidization pipes
Problem Statement: it’s even worse!

In addition:

1) Precipitation is expected to increase in the coming decades

2) The subbase soil composition remains unaccounted for in the design in Iowa unpaved roads
Objectives

**Objective 1:**
Determine if county roads are exhibiting moisture related distress or frost boil failure that can be attributed to poor drainage performance.

**Objective 2:**
Determine whether there are design and/or maintenance alternatives that will improve subgrade drainage performance.

**Objective 3:**
Develop a model for evaluating post-construction subdrain performance under saturated and unsaturated conditions.

Boils formation is inevitable with gravel roads, but the extent of impact can be minimized considerably.

To achieve this goal we need to:

1. From the processes...
2. ...through the analysis...
3. ...to the application
#### Tasks overview

**Threefold approach:**

*The combination of field surveys, laboratory experiments and numerical modeling is the winning strategy to succeed*

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Objective</th>
<th>Approach</th>
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<tbody>
<tr>
<td>1. Establish a Technical Advisory Committee (TAC)</td>
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<td>2. Determine which county roads may be prone to frost boil failure due to poor subgrade drainage performance</td>
<td>Obj. 1</td>
<td>Field</td>
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<td>3. Determine whether there are design/maintenance that will improve drainage</td>
<td>Obj. 2</td>
<td>Lab</td>
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<td>4. Develop a model for evaluating post-construction subdrain performance</td>
<td>Obj. 3</td>
<td>PC</td>
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<td>5. Preparation of specific guidelines</td>
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Tasks description

Task 1. Establish a Technical Advisory Committee (TAC)
- To discuss results, receive feedback
- Eng. Wade Weiss, County Engineer for Greene County
- Eng. Dave Barrett, County Engineer for Van Buren County

Task 2. Determine which county roads may be prone to frost boil failure due to poor subgrade drainage performance
- Develop an experimental matrix to incorporate the control variables (soil texture, surrounding land cover, rainfall intensities, etc.)
- Possible selected Counties, which represent the four Hydrologic Soil Groups (HSGs) are: Buchanan, Fayette, Pocahontas, Cass, Adams and Union.
- Continuous monitoring stations will be installed and cores will be periodically extracted
Tasks description – Field

Task 2: Field monitoring

from the processes...

Task 4
Numerical model development

...to the application

Task 3
Laboratory experiments & measurements

...through the analysis...

Camera
Core
Tensiometer
Moisture sensor

...to the application
Task 3 Laboratory experiments & measurements to test design/maintenance alternatives

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<tr>
<td>1</td>
<td>IDOT (2011) Standard Road Plans</td>
<td>40-80% hard stone/20-60% sand/8-15% fines</td>
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<td>2</td>
<td>Geotextiles</td>
<td>Woven/Nonwoven</td>
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<td>3</td>
<td>Polyacrylamide (PAM)</td>
<td>Liquid/Powder</td>
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Double Ring Infiltrometers
Hydraulic conductivity

Sand & Rhodamine
Fluidization and boils

Styrofoam box in the ice room
Artificial freeze-thaw cycle
Tasks description – Alternative design

Task 3 Laboratory experiments & measurements to test design/maintenance alternatives

Polyacrylamide (PAM)

*non-toxic organic polymer used for a variety of purposes*

Non agricultural uses of PAM include:
1) Waste and potable water treatment
2) Processing and washing of fruits and vegetables
3) Dust control on unpaved roads in arid climate

The main agricultural use of PAM is for stabilizing soil and preventing erosion:
1) As a soil conditioner on farm land and construction sites for erosion control

PAM may be a cost-effective practice to minimize boil formation in unpaved roads and increase their expected life
**Task 4** Develop a model for evaluating post-construction subdrain performance

Starting point: MNDRAIN (Voller, 2003)

Improvements will allow for:

1. Simulation of unsaturated flow through the subbase

2. Modeling of frost boils formation

3. Widespread use by IDOT and County engineers.
Summary

Continuous monitoring of County roads

Laboratory evaluation of design alternatives

Development of user-friendly model

Products

1. Provide an evaluation of current and alternative design of subbase drainage system

2. A new and simple to use drainage model to evaluate

3. Improved specifications to design subsurface drainage systems

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<tr>
<th>Task #</th>
<th>Months</th>
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<tr>
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<td>Semester 1</td>
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<td>1 2 3 4 5 6 7 8 9 10 11 12</td>
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Thank you for your attention