Development of a Subgrade Drainage Model for Unpaved Roads

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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

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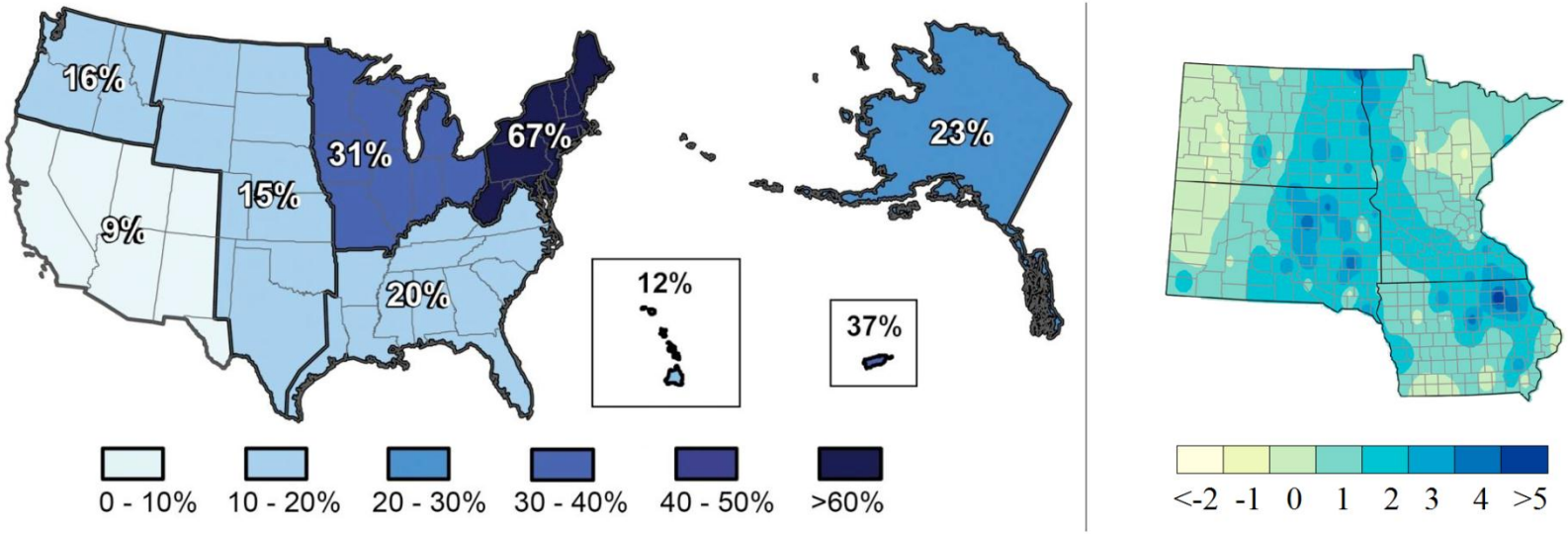
Problem Statement: it's even worse!

<u>In addition</u>:

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

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

To achieve this goal we need to:

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.

Tasks overview

Threefold approach:

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

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

Tasks description

<u>Task 1</u>. 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

<u>Task 2</u>. 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

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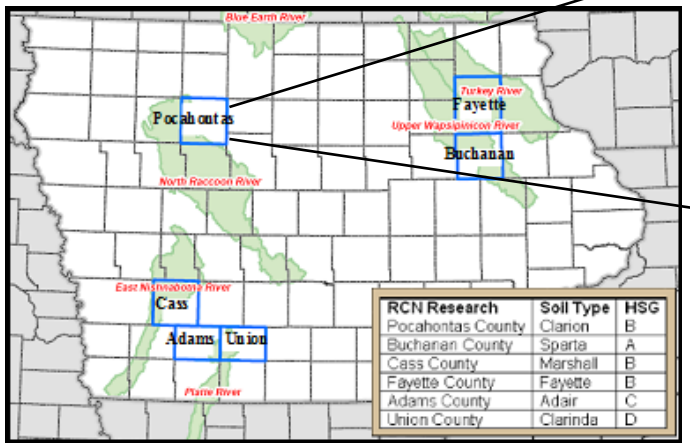
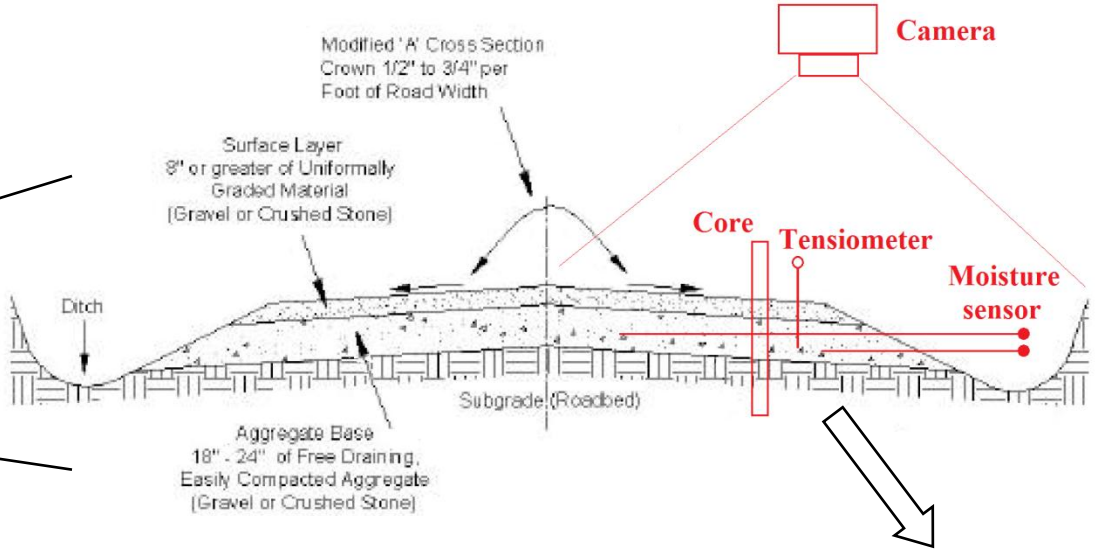
Tasks description – Field

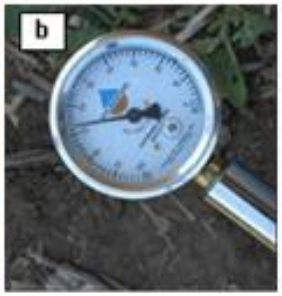
from the processes…

Task 2: Field monitoring



RCN Research	Soil Type	HSG
Pocahontas County	Clarion	B
Buchanan County	Sparta	A
Cass County	Marshall	B
Fayette County	Fayette	B
Adams County	Adair	C
Union County	Clarinda	D





…through the analysis…

Task 3
Laboratory experiments & measurements

…to the application

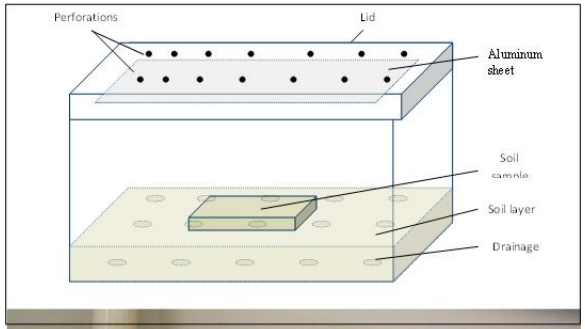
Task 4
Numerical model development

Tasks description – Lab

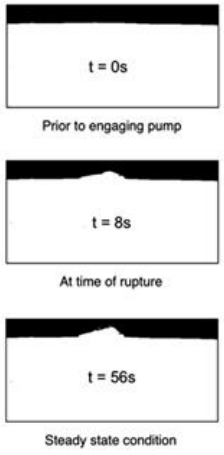
Task 3 Laboratory experiments & measurements to test design/maintenance alternatives

1	IDOT (2011) Standard Road Plans	40-80% hard stone/20-60% sand/8-15% fines
2	Geotextiles	Woven/Nonwoven
3	**Polyacrylamide (PAM)**	**Liquid/Powder**

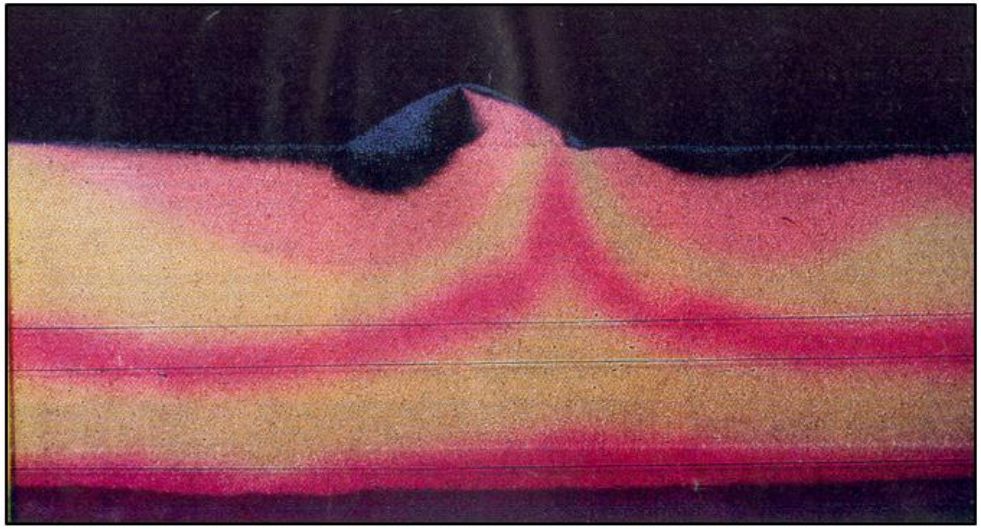
Double Ring Infiltrometers
Hydraulic conductivity



Styrofoam box in the ice room
Artificial freeze-thaw cycle



Sand & Rhodamine
Fluidization and boils



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

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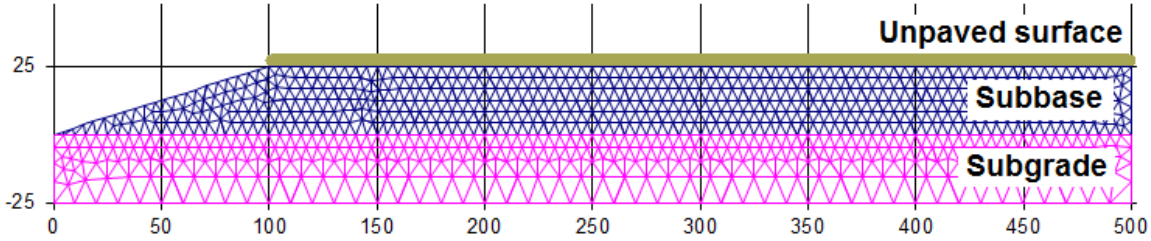
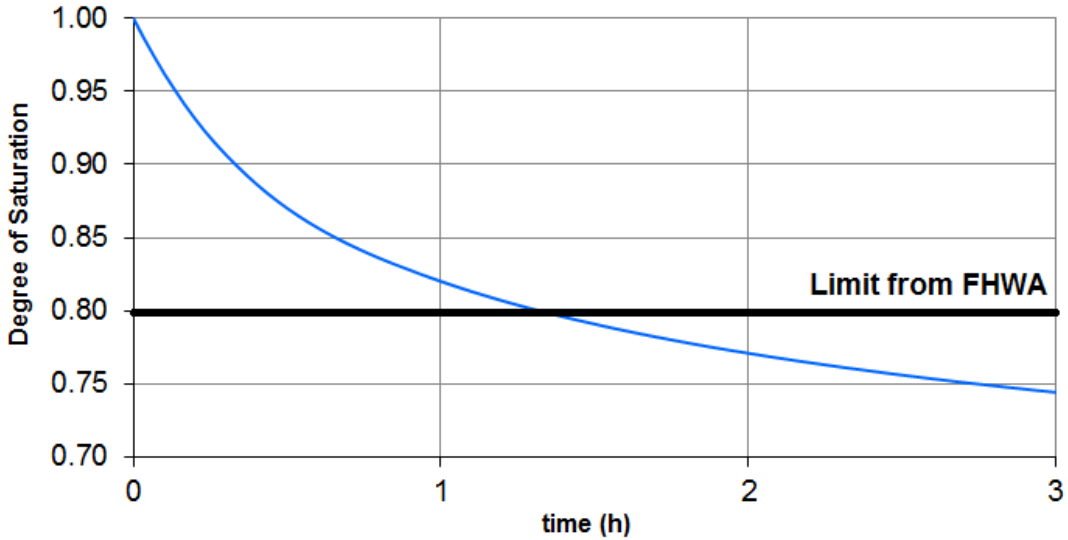
Tasks description – PC

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.

Quality of Drainage	Time to Drain
Excellent	Less than 2 hours
Good	2 to 5 hours
Fair	5 to 10 hours
Poor	Greater than 10 hours
Very Poor	Much greater than 10 hours

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Summary

from the processes… Continuous monitoring of County roads

…through the analysis… Laboratory evaluation of design alternatives

…to the application 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**

	Task #	Months																	
		Semester 1						Semester 2						Semester 3					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Task 1																		
	Task 2																		
	Task 3																		
	Task 4																		
	Task 5																		

Thank you for your attention