SOLMAX

# Failure to Resilience: Managing Frost Heave and Expansive Clay Soils in Infrastructure

Transportation Connects 2025
Edmonton, Alberta

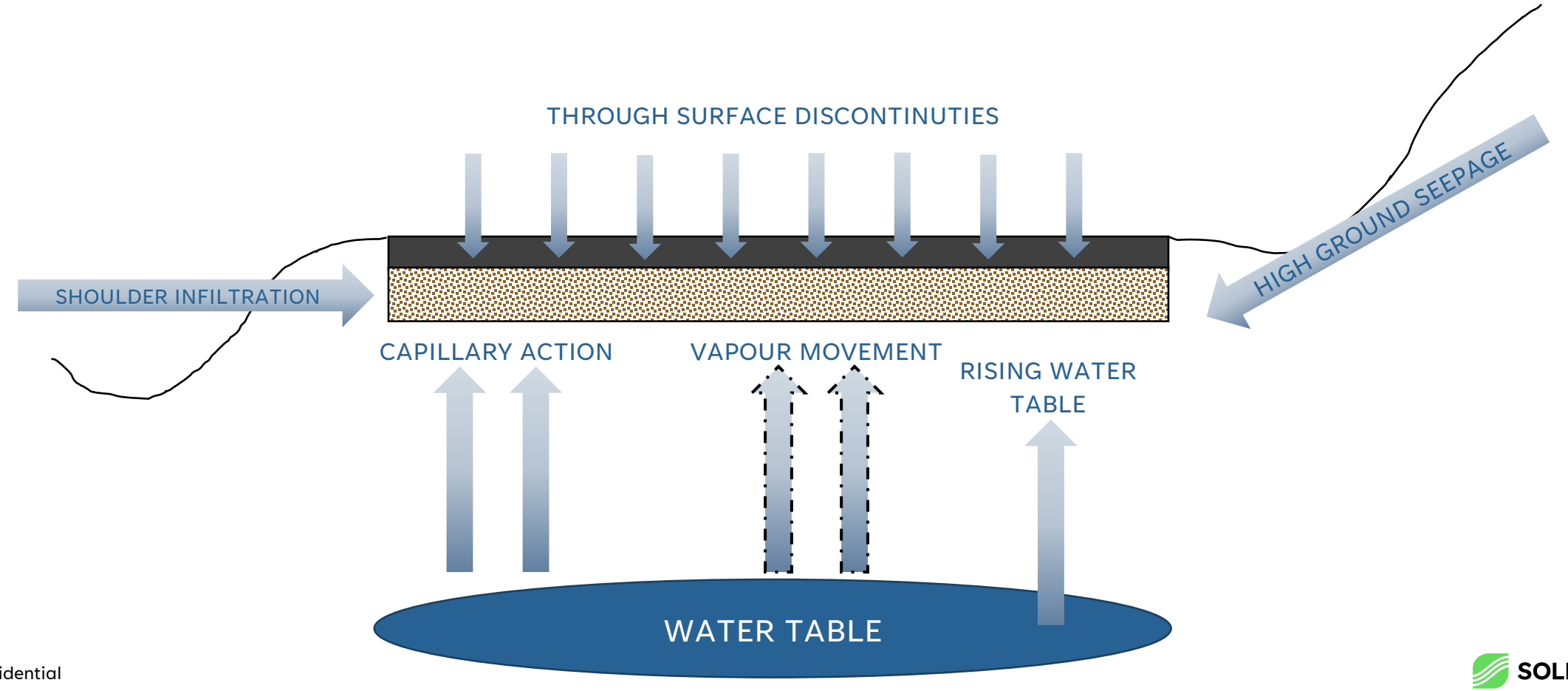
Brock Nesbit, AScT
Engineering Business Manager


TRANSPORTATION RESEARCH
CIRCULAR
Number E-C296
November 2024
Foundation Design and Construction for 100-Year Pavement Systems
NATIONAL ACADEMIES Sciences Engineering Medicine
TRB TRANSPORTATION RESEARCH BOARD



SOLMAX

# *The biggest challenge to achieving the 100-year pavement foundation is moisture.*






SOLMAX

# Failure to Resilience: Managing Frost Heave and Expansive Clay Soils in Infrastructure

## City of Grande Prairie, 116th Street Reconstruction

## CPKC Rail, Scotford Subdivision Ballast Repairs

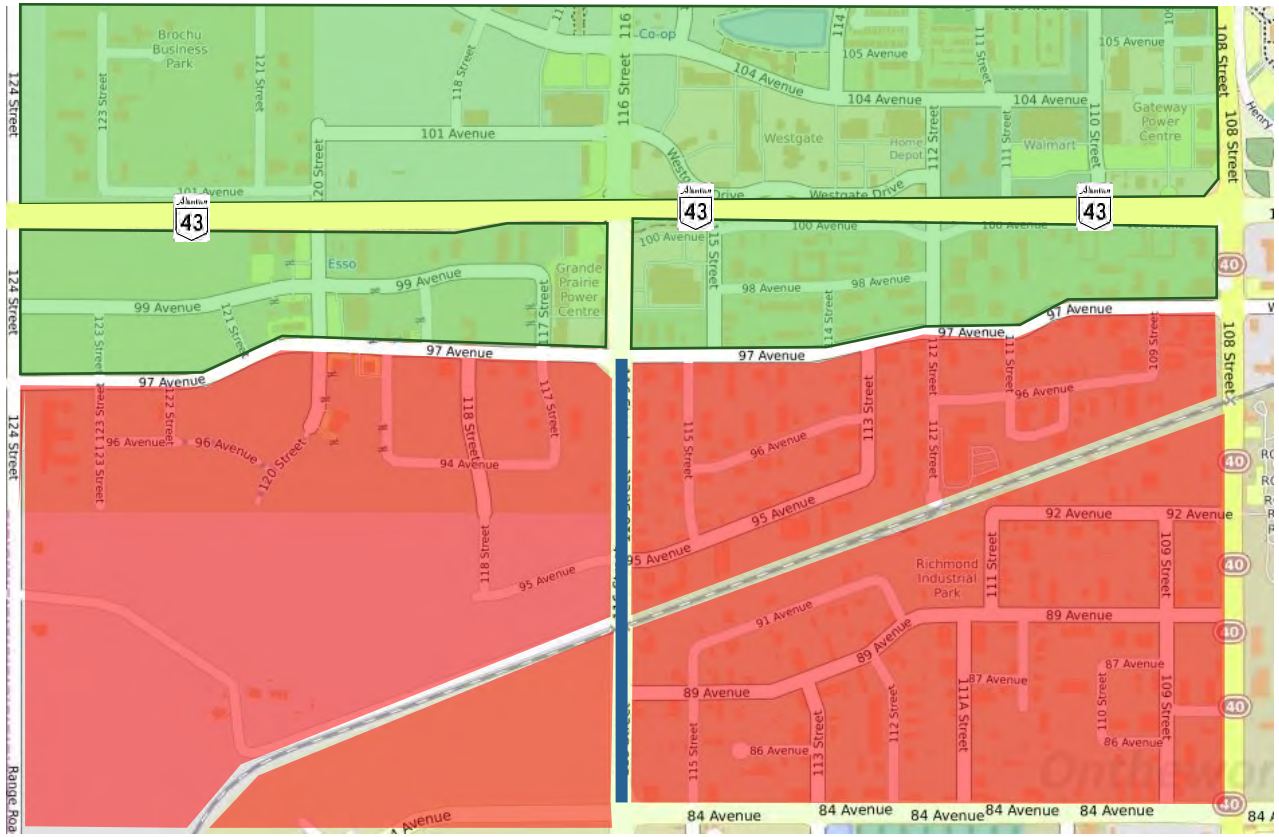


SOLMAX

# 116th Street Reconstruction

## City of Grande Prairie

- **Reconstructed in May 2011**
- **12,290 Average Annual Daily Traffic (AADT)**
- **25-year design ESAL's: 6.0 million**



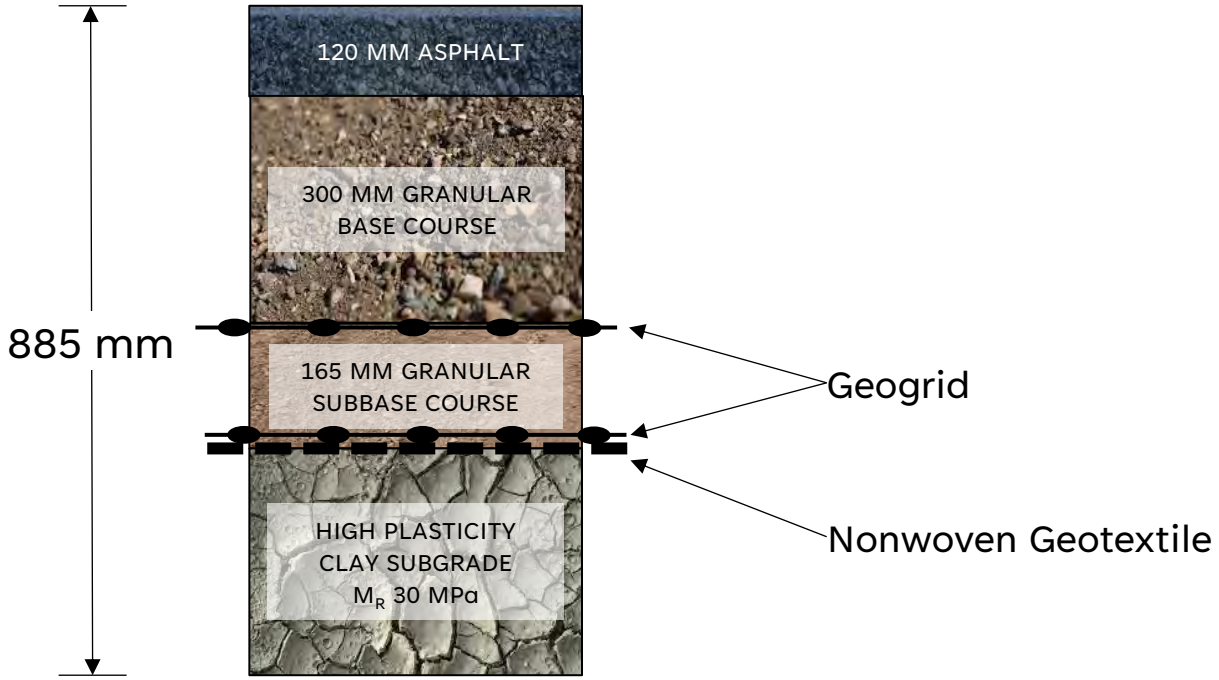



SOLMAX

# 116th Street Reconstruction

## 2011 As-Builts

60 mm ACP – 12.5 mm
60 mm ACP – 16 mm
300 mm GBC – Des2 Cl25
Geogrid
165 mm GSBC – Des2 Cl40
Geogrid
6 oz. Nonwoven Geotextile
300mm Moisture Conditioning






SOLMAX

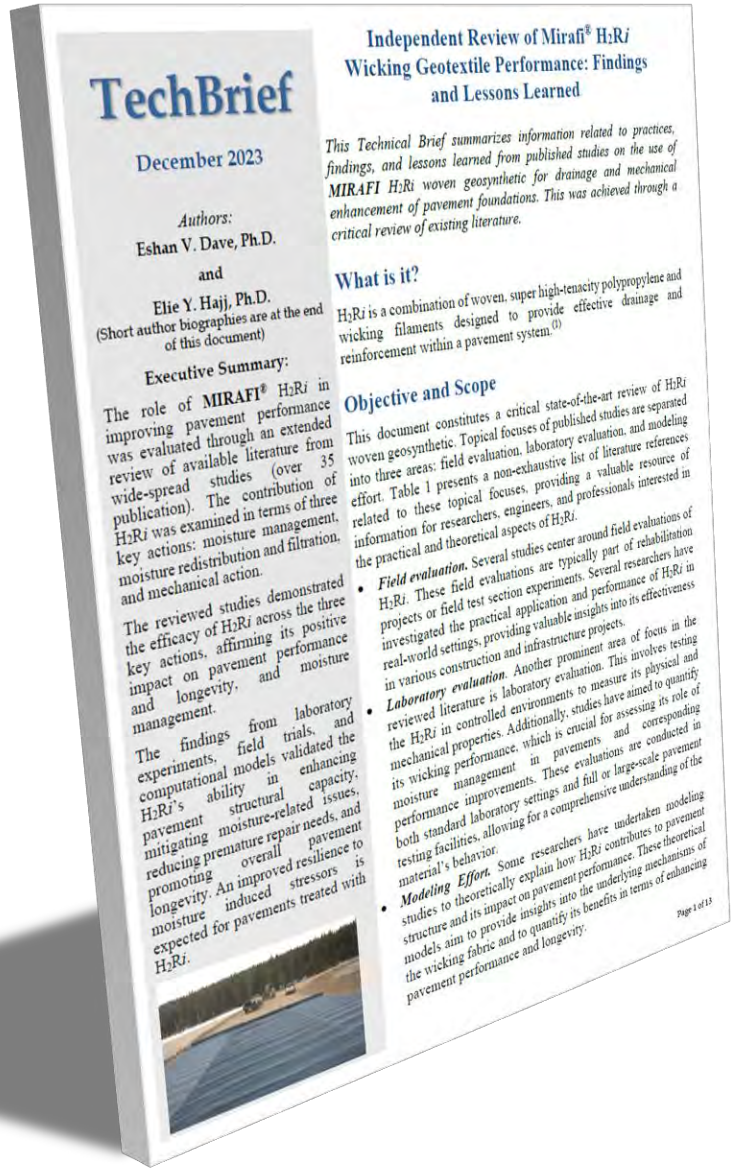
# 116th Street Reconstruction

## City of Grande Prairie

- Reconstructed in May 2011
- 12,290 Average Annual Daily Traffic (AADT)
- 25-year design ESAL's: 6.0 million
- **2018 Geotechnical Investigation**
  - Longitudinal & transverse cracking
  - Moderate block cracking in wheel path
  - 15 mm deep ruts in AC
- **High plasticity subgrade**
  - Expansive / Fat Clays
  - MC of 25% to 35%



SOLMAX



TechBrief

December 2023

Authors:
Eshan V. Dave, Ph.D.
and
Elie Y. Hajj, Ph.D.
(Short author biographies are at the end of this document)

Executive Summary:

The role of MIRAFI® H2Ri in improving pavement performance was evaluated through an extended review of available literature from wide-spread studies (over 35 publication). The contribution of H2Ri was examined in terms of three key actions: moisture management, moisture redistribution and filtration, and mechanical action.

The reviewed studies demonstrated the efficacy of H2Ri across the three key actions, affirming its positive impact on pavement performance and longevity, and moisture management.

The findings from laboratory experiments, field trials, and computational models validated the H2Ri's ability in enhancing pavement structural capacity, mitigating moisture-related issues, reducing premature repair needs, and promoting overall pavement longevity. An improved resilience to moisture induced stressors is expected for pavements treated with H2Ri.

Independent Review of Mirafi® H2Ri Wicking Geotextile Performance: Findings and Lessons Learned

*This Technical Brief summarizes information related to practices, findings, and lessons learned from published studies on the use of MIRAFI H2Ri woven geosynthetic for drainage and mechanical enhancement of pavement foundations. This was achieved through a critical review of existing literature.*

What is it?

H2Ri is a combination of woven, super high-tenacity polypropylene and wicking filaments designed to provide effective drainage and reinforcement within a pavement system.(1)

Objective and Scope

This document constitutes a critical state-of-the-art review of H2Ri woven geosynthetic. Topical focuses of published studies are separated into three areas: field evaluation, laboratory evaluation, and modeling effort. Table 1 presents a non-exhaustive list of literature references related to these topical focuses, providing a valuable resource of information for researchers, engineers, and professionals interested in the practical and theoretical aspects of H2Ri.

- ***Field evaluation.*** Several studies center around field evaluations of H2Ri. These field evaluations are typically part of rehabilitation projects or field test section experiments. Several researchers have investigated the practical application and performance of H2Ri in real-world settings, providing valuable insights into its effectiveness in various construction and infrastructure projects.
- ***Laboratory evaluation.*** Another prominent area of focus in the reviewed literature is laboratory evaluation. This involves testing the H2Ri in controlled environments to measure its physical and mechanical properties. Additionally, studies have aimed to quantify its wicking performance, which is crucial for assessing its role of moisture management in pavements and corresponding performance improvements. These evaluations are conducted in both standard laboratory settings and full or large-scale pavement testing facilities, allowing for a comprehensive understanding of the material's behavior.
- ***Modeling Effort.*** Some researchers have undertaken modeling studies to theoretically explain how H2Ri contributes to pavement structure and its impact on pavement performance. These theoretical models aim to provide insights into the underlying mechanisms of the wicking fabric and to quantify its benefits in terms of enhancing pavement performance and longevity.

Page 1 of 13

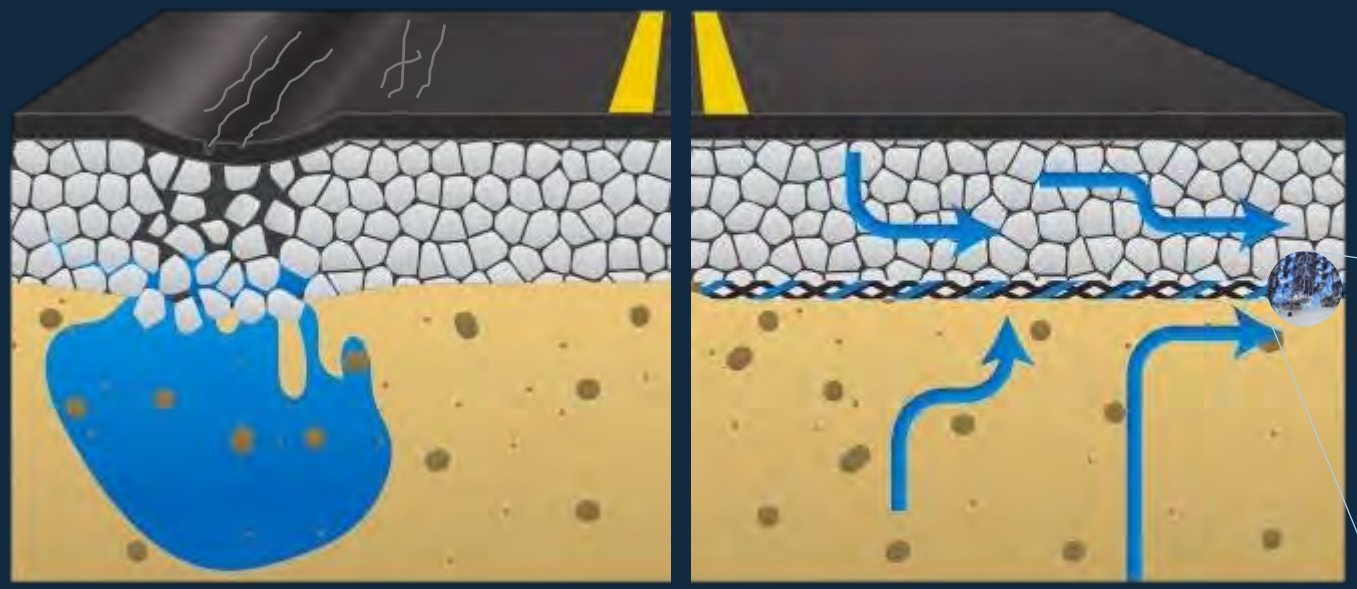
# MIRAFI® $H_2Ri$

## Moisture Management Geosynthetic

- Developed for Frost Heave mitigation
- Calibrated as per AASHTO R50-09 for the AASHTO 93 flexible pavement design method.
- “Proven” status on Alberta Transportation RPL
- Studies in more than 35 publications



SOLMAX





SOLMAX

# Expansive Clay Research

## University of Texas at Austin

- 8 Test sections along highway shoulder
- MIRAFI $H_2Ri$ equalized moisture content over the treated subgrade
- No other geosynthetic generated moisture changes
- MIRAFI $H_2Ri$ should be used to treat entire road subgrade

**The Thesis Committee for Ivan Enrique Garcia Delgado**
**Certifies that this is the approved version of the following thesis:**

**Use of Geotextiles with Enhanced Lateral Drainage in roads over expansive clays**

**APPROVED BY**
**SUPERVISING COMMITTEE:**

**Supervisor:**

Jorge G. Zornberg

Amit Bhasin



SOLMAX

# How Solmax Got Involved

## University of Texas at Austin

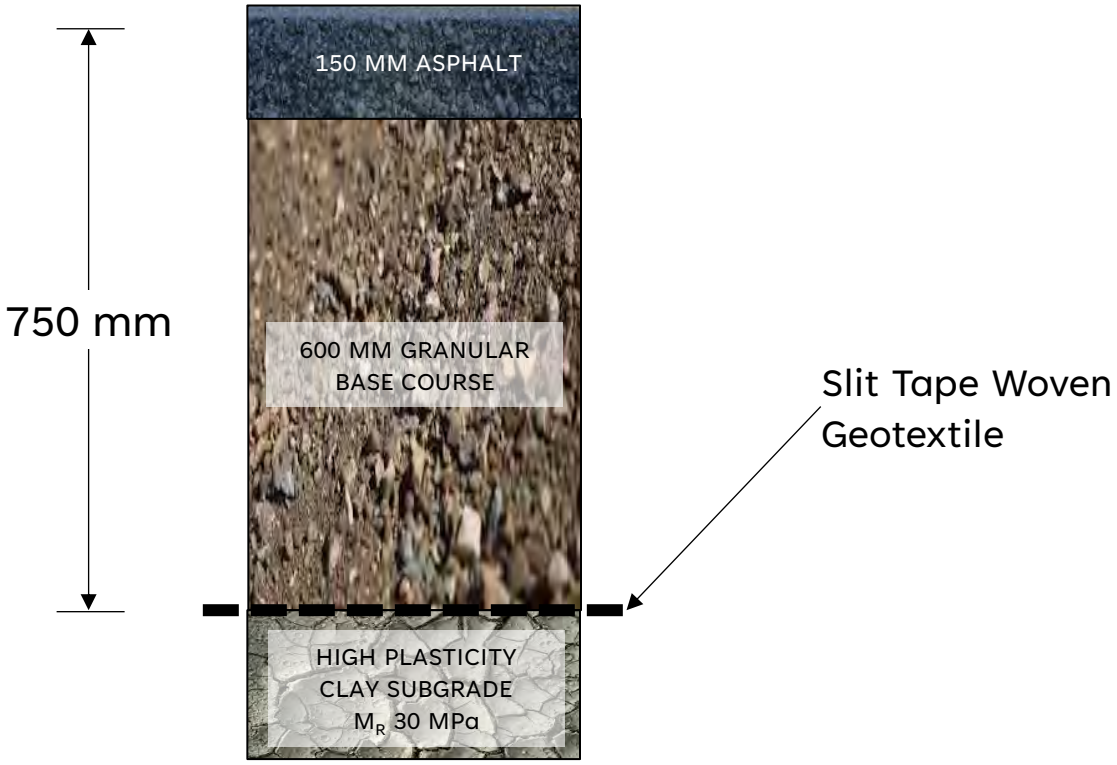



SOLMAX

# 116th Street Reconstruction

## Geotechnical Report, Pavement Structure

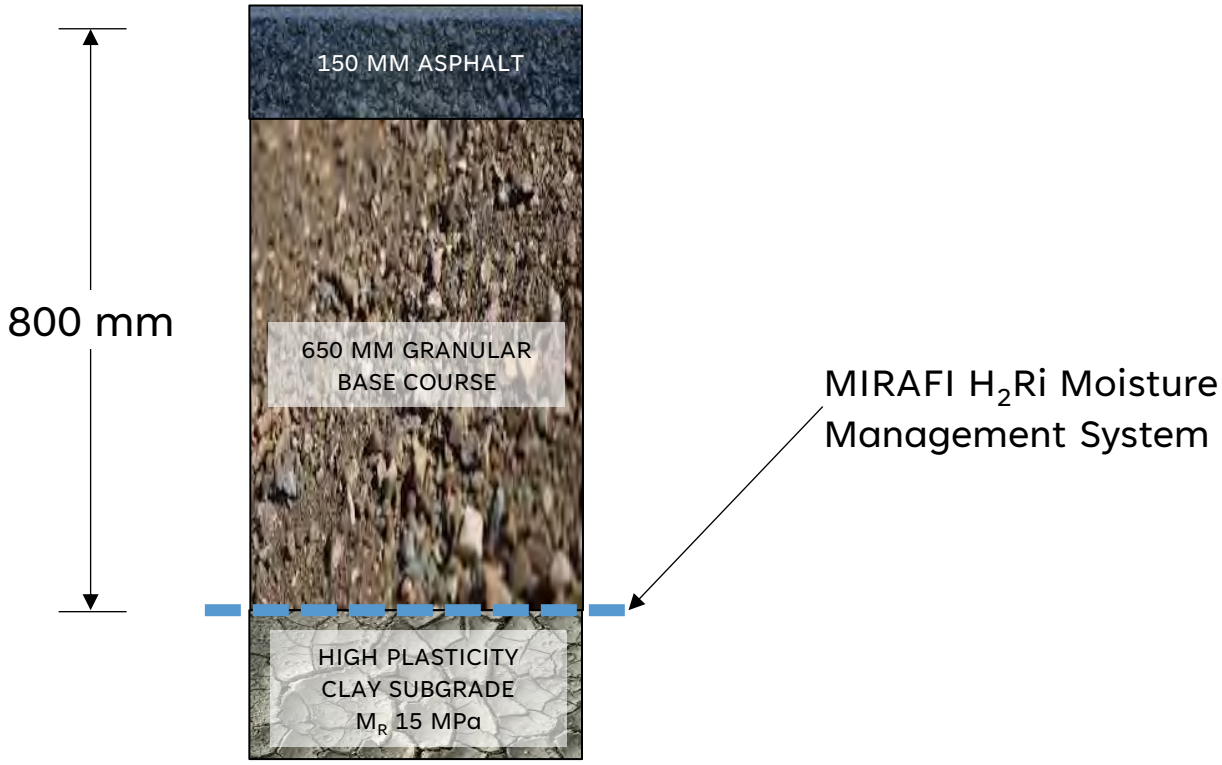
- Increased to 6.4 million ESAL's
- Assumed a subgrade $M_R$ of 30 MPa
- Deflection testing indicated subgrade $M_R$ of 10 to 30 MPA
- Potential for shrinking/swelling increases



# 116th Street Reconstruction

## Solmax Suggestions, 2019 Proposal

- ESAL's of 9.0 million
- Assumed a subgrade $M_R$ of 15 MPa
- Addresses potential for shrinking/swelling increases
- Eliminates the need for subcuts
- No subgrade moisture conditioning required.



## Exposing Subgrade

SOLMAX

Exposing Subgrade

## High Plasticity Clay Soil

SOLMAX


# Installation of Moisture Management Geosynthetic

SOLMAX

*“There’s not a single crack in the pavement after 3 years. I’ve never seen that in my entire career”*

**- Senior Field Inspector**



SOLMAX

# Construction Cost Comparison

| | 2011 Structure | $H_2Ri$ Moisture Management Treated Structure |
|---|---|---|
| Asphalt Pavement | $27.00 | $33.75 |
| Granular Base Course | $19.20 | $41.54 |
| Geosynthetic Layer 1 | $7.00 | $15.00 |
| Granular Subbase Course | $8.80 | $0 |
| Geosynthetic Layer 2 | $7.00 | $0 |
| Geosynthetic Layer 3 | $4.00 | $0 |
| Moisture Conditioned Subgrade | $10.00 | $0 |
| Total Cost | $83.00 | $90.29 |
| ESAL's | 6,000,000 / 2,200,000** | 9,000,000 |
| **Cost per Million ESAL** | **$13.85 / $37.70**** | **$10.05** |

** Actual Design Life/Cost



SOLMAX

# CPKC Rail Scotford Subdivision



SOLMAX

## Scotford Subdivision

# The Problem

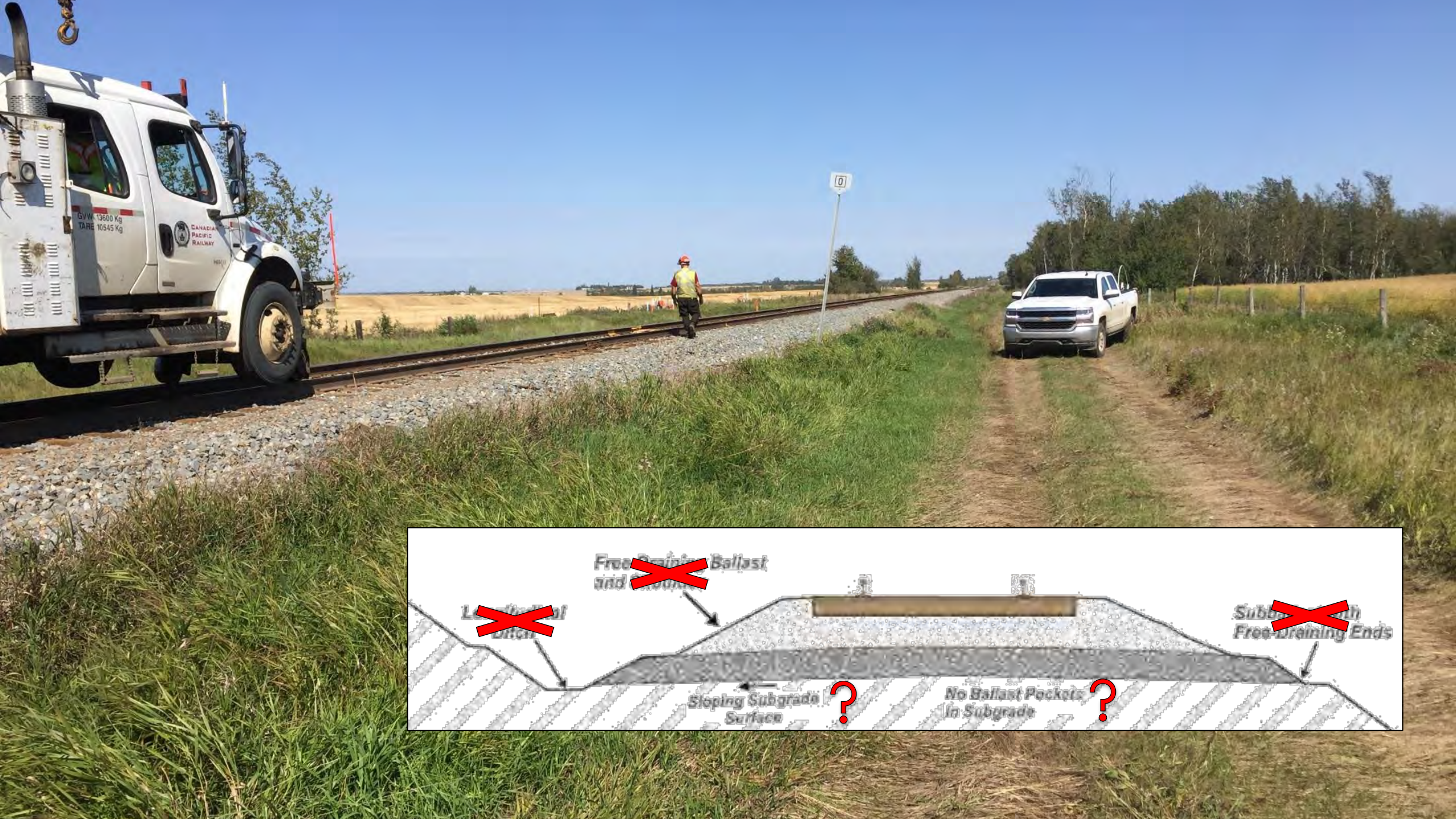
- Significant differential in rail cross-elevation
- High water table
- High capillarity subgrade soils
- Contaminated ballast structure.



SOLMAX

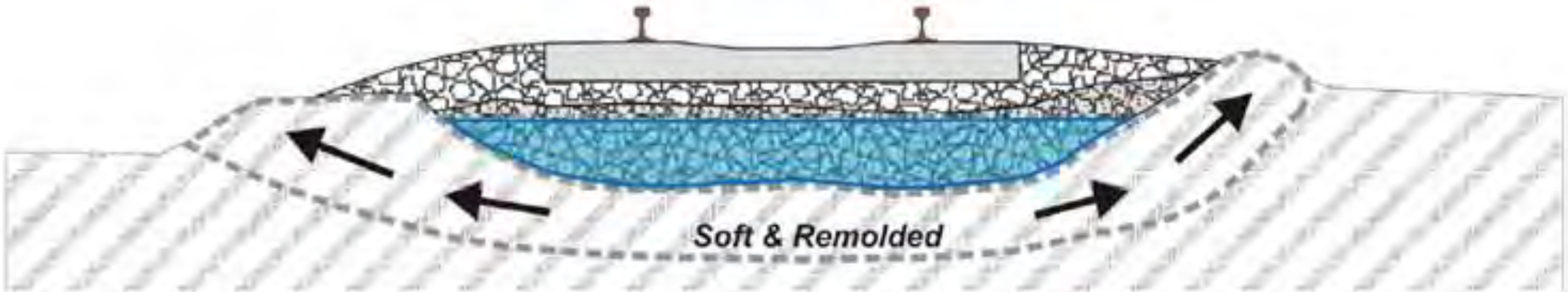

SOLMAX


GVW 13600 Kg
TARE 10545 Kg
CANADIAN PACIFIC RAILWAY
0


Free Draining Ballast
Sloping Subgrade Surface
?
No Ballast Pockets In Subgrade
?
Free Draining Ends


CAT

## Site Conditions

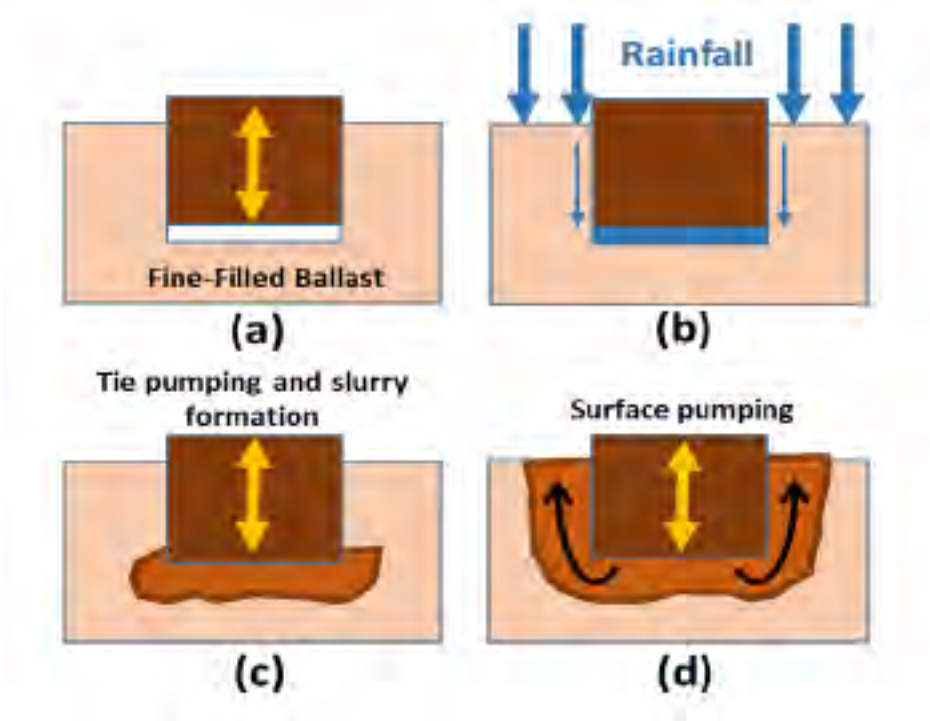



SOLMAX

## Mud-Pumping

## Mud-Pumping

# Mud Pumping




- Ballast
  - wet fines within the ballast
- Subgrade
  - ballast pockets
  - poor external drainage
  - high water table
  - flooding.

“[Mud-pumping] corresponds to poor drainage, loss in track geometry, reduced ballast strength and stiffness, and in the worst case leading to track failure.”

*- Wilk, S., Dingqing, L. (2020) ‘Ballast and Subgrade Studies By Transportation Technology Center, Inc.’,*

Mud-Pumping

Ballast Contamination

Scotford Subdivision

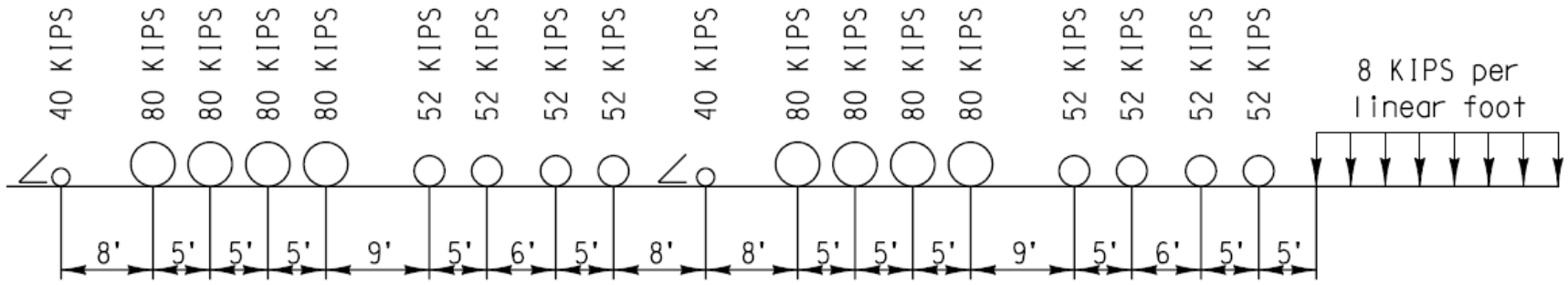
# The Solution

- Support traffic loads
- Address moisture / frost heave issues
- Eliminate need for future maintenance
- Be fast to implement (7-hour Construction Window)



SOLMAX

Limited Field Information




COOPER E80 LOAD

- Train Velocity: 40 MPH (65 km/hr)
- Rail Tie Dimensions:  7” wide x 9” deep x 8.5’ (175 mm x 225 mm x 2.6m)
- Rail Tie Spacing: 20” (500 mm)
- Wheel Diameter: 36” (900 mm)
- Rail Loading: Cooper E-80

SOLMAX

# Design Method

Talbot Equation

$$h = \left(16.8 \frac{\rho_m}{\rho_c}\right)^{\frac{4}{5}}$$

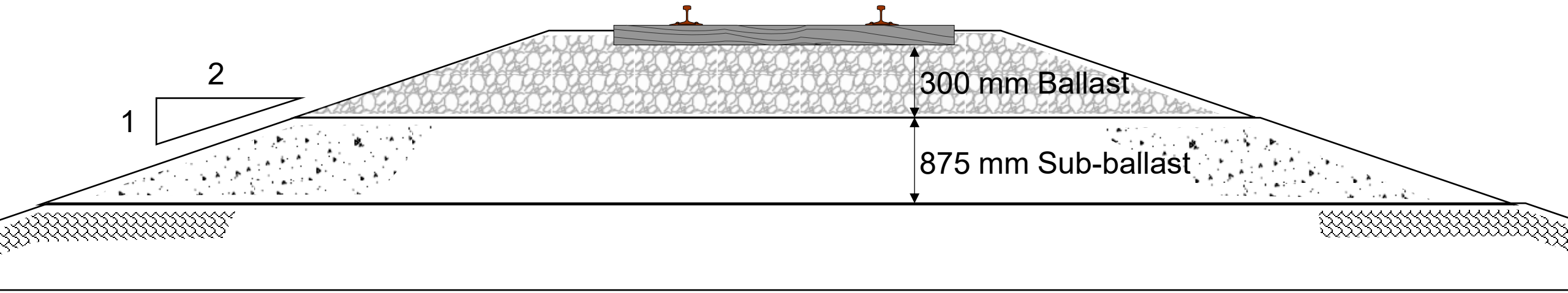
American Railway Engineering and Maintenance-of-Way Association

$h$ = ballast thickness

$\rho_m$ = uniform distributed pressure over tie face

$\rho_c$ = bearing pressure on subgrade including FoS

# Unreinforced Ballast Section

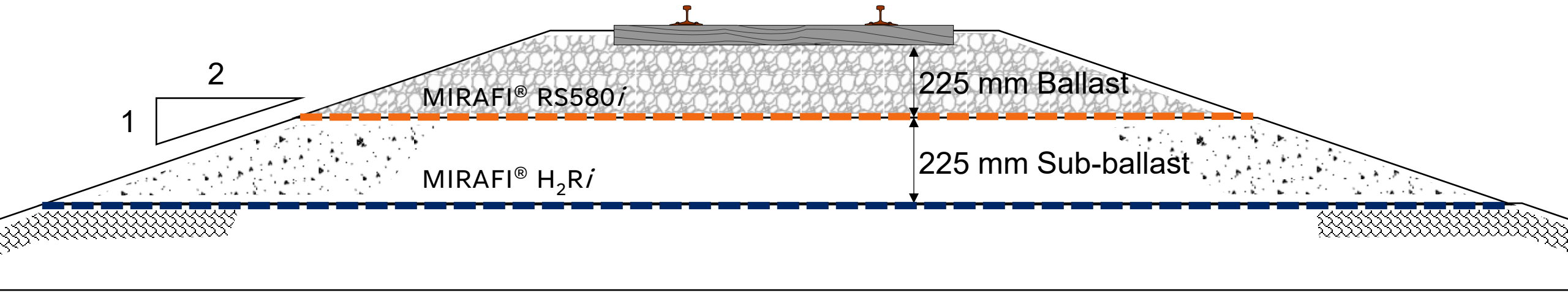



SOLMAX

# Geosynthetic Stabilized Ballast Section

66% Reduction in Ballast & Sub Ballast Requirements

30% Reduction in overall width

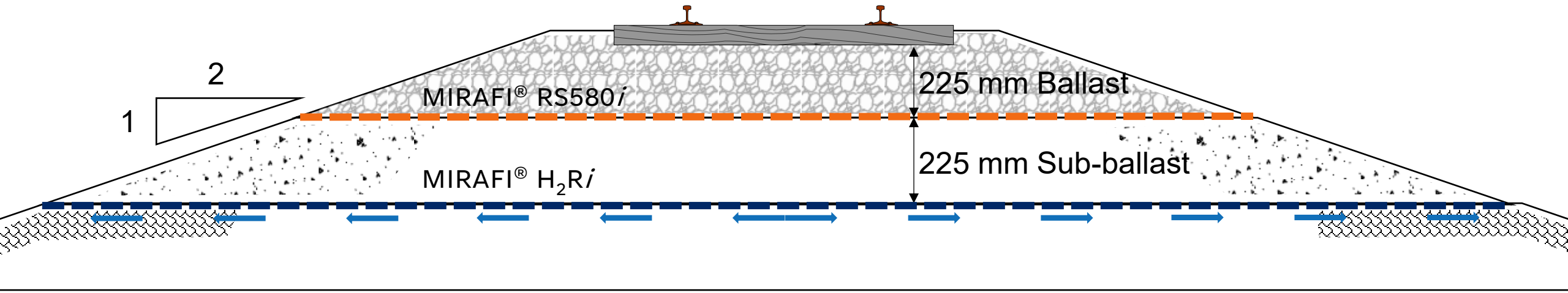



SOLMAX

# Geosynthetic Stabilized Ballast Section

66% Reduction in Ballast & Sub Ballast Requirements

30% Reduction in overall width




SOLMAX


# Subgrade

MIRAFI $H_2$Ri Moisture Management System deployment


# Sub-Ballast Compaction


## Rail Panel Installation


Lock Doors
RF-029DOOR3
CP

6-years Post Construction

6-years Post Construction

# Railway Ground Hazard Research Program

UNIVERSITY OF ALBERTA

Monitoring of the change of moisture beneath a railway embankment and the effectiveness of a wicking geotextile


- Camila Alvarenga (M.Sc.)
- Parisa Haji Abdulrazagh (Ph.D)
- Michael T. Hendry (Ph.D)


SOLMAX

# Railway Ground Hazard Research Program

Monitoring of the change of moisture beneath a railway embankment and the effectiveness of a wicking geotextile

- **9% difference in subgrade water content**

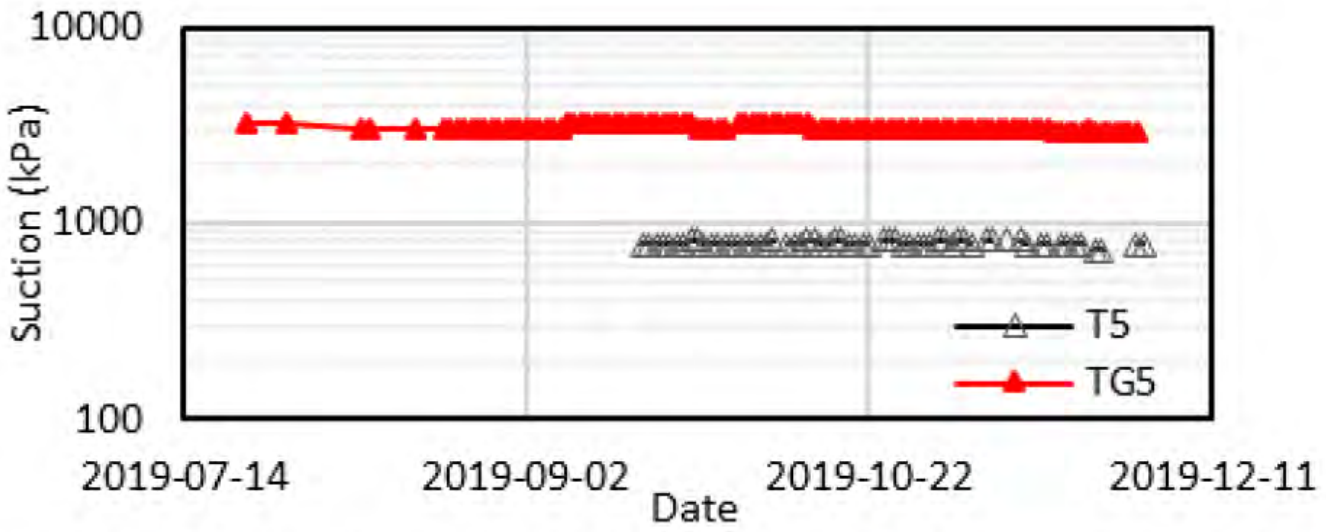
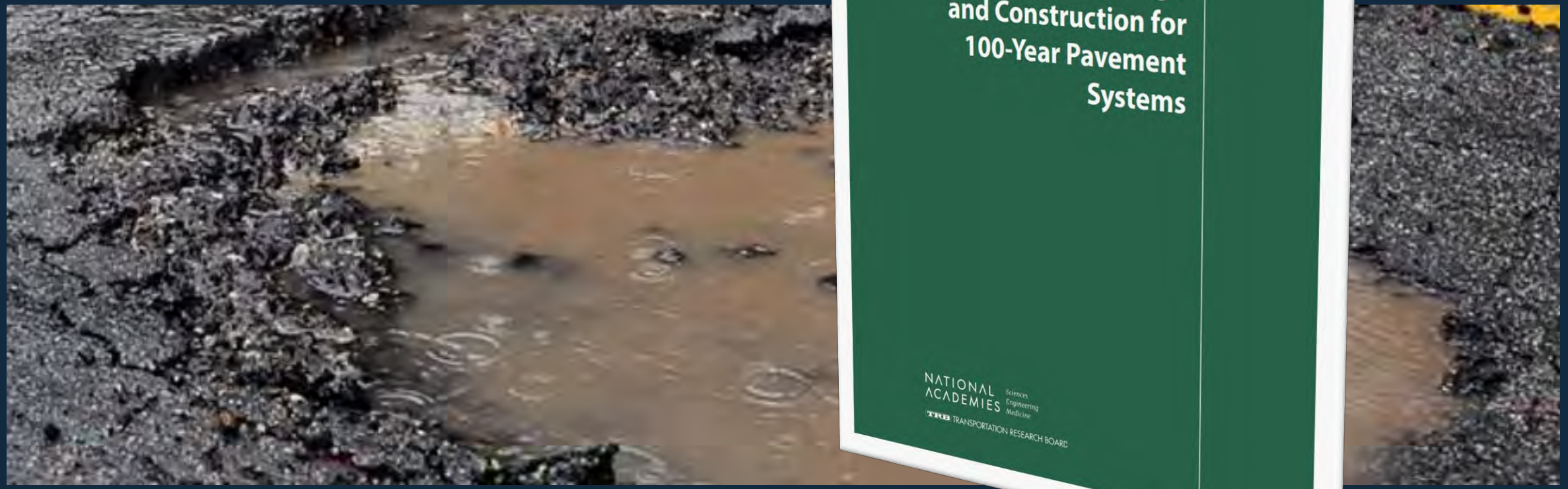



Figure 12. Suction values for control (T5) and remediated section (TG5).

SOLMAX


TRANSPORTATION RESEARCH
CIRCULAR
Number E-C296
November 2024
Foundation Design and Construction for 100-Year Pavement Systems
NATIONAL ACADEMIES Sciences Engineering Medicine
TRB TRANSPORTATION RESEARCH BOARD



SOLMAX

SOLMAX

# Thank-you!

Brock Nesbit, AScT (BC)
bnesbit@solmax.com
(604) 842-8860