Shoulder Stabilization with Geosynthetics

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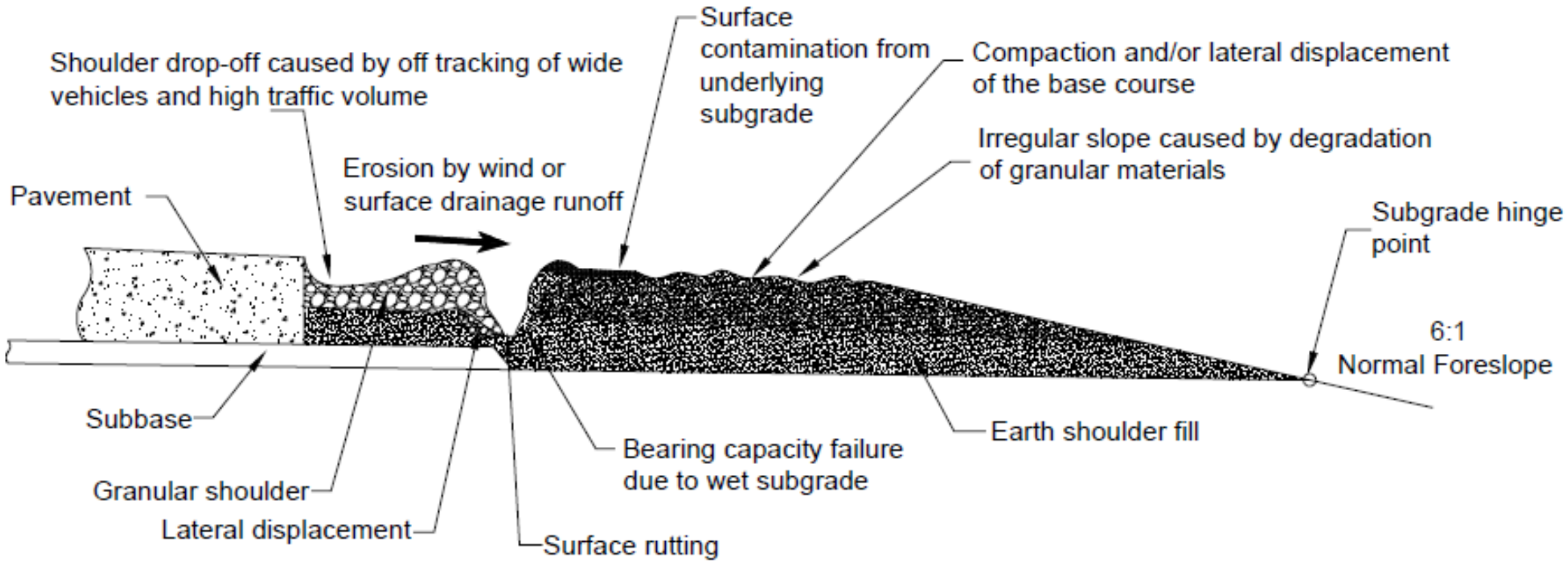
Outline of Presentation

- Introduction
- Geosynthetic Types, Mechanisms, and Benefits
- Case Studies
  - Geogrid for Stabilizing Unpaved Shoulders
  - Wicking Geotextiles for Improving Paved Shoulders
  - Geocell for Stabilizing Unpaved Shoulders
- Concluding Remarks

Uses of Road Shoulders

Common Shoulder Problems



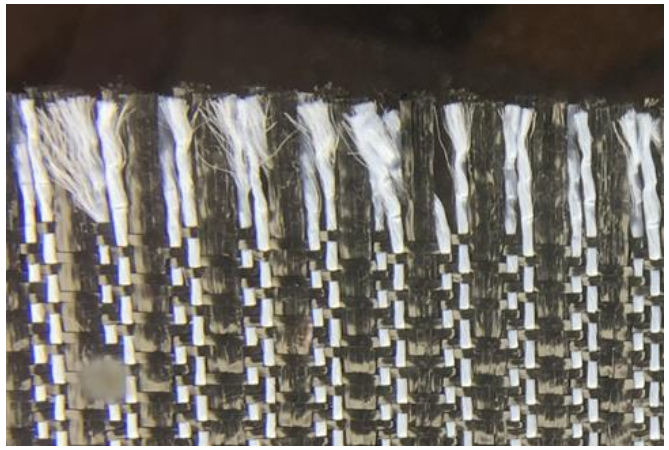
White et al. (2007). Effective Shoulder Design and Maintenance. Center for Transportation Research and Education Iowa State University.

Common Shoulder Problems

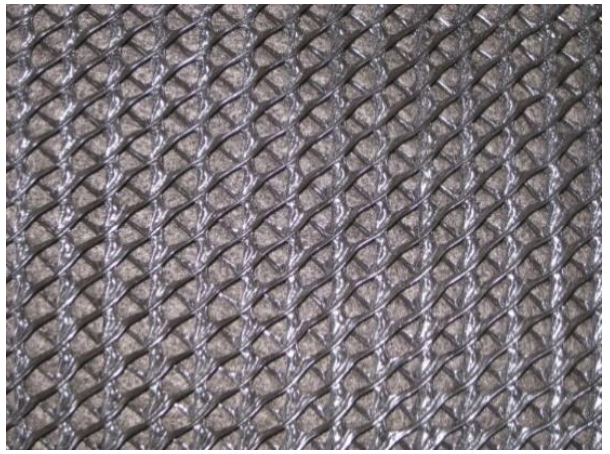
Geosynthetics for Shoulder Stabilization

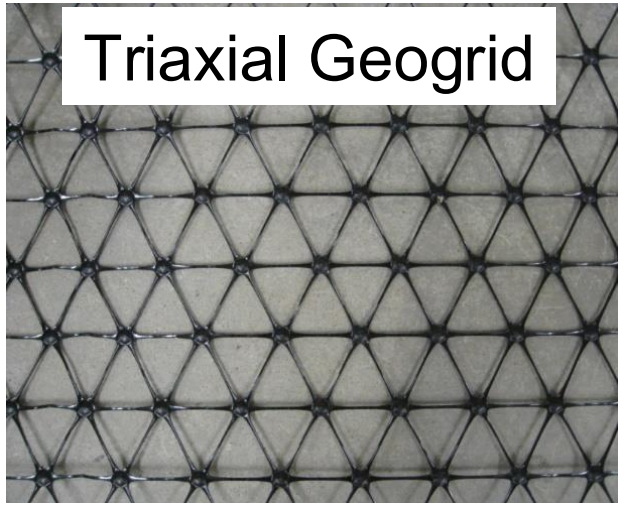
Nonwoven & woven geotextile

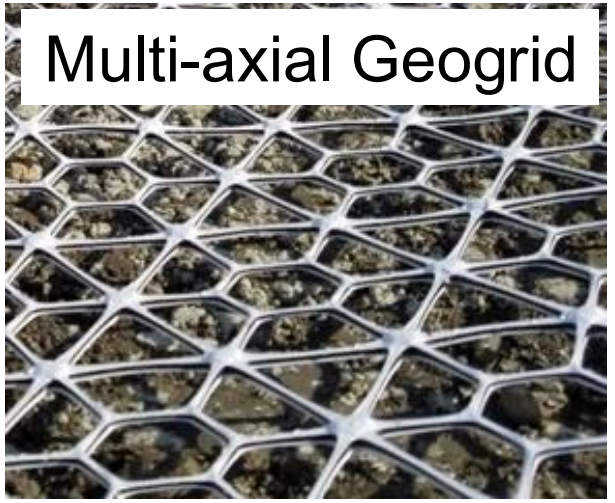
Wicking geotextile



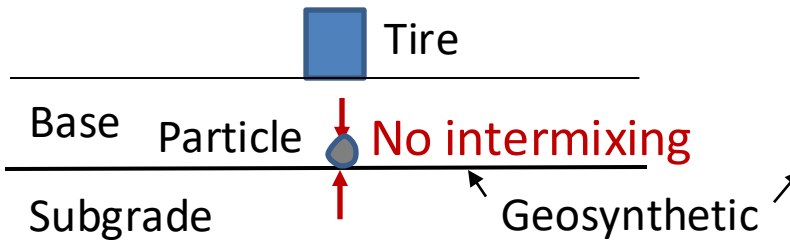
Geonet & geocomposite



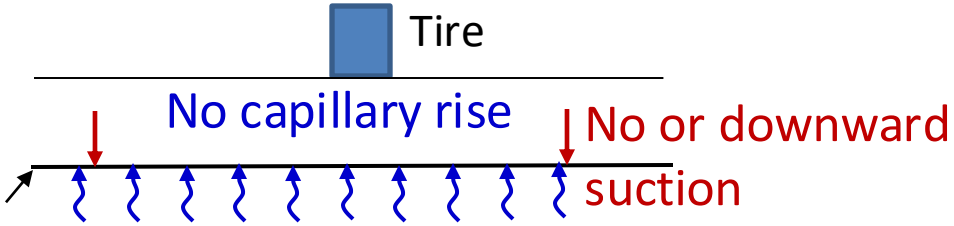




Mechanisms & Benefits of Geosynthetics

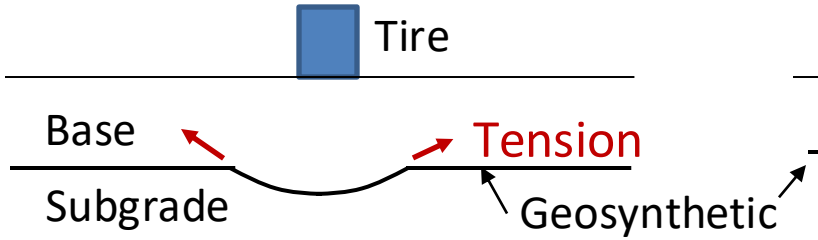


(a) Separation

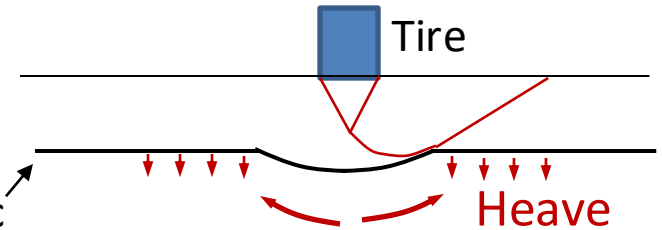


(b) Capillary barrier

Maintain strength & modulus of base course

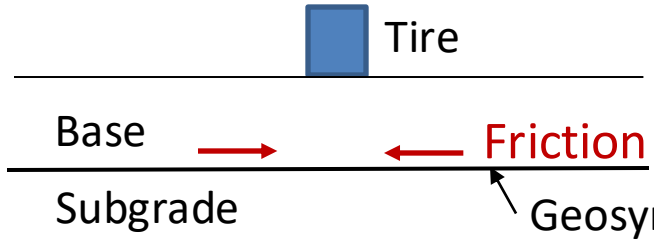


(c) Tensioned membrane

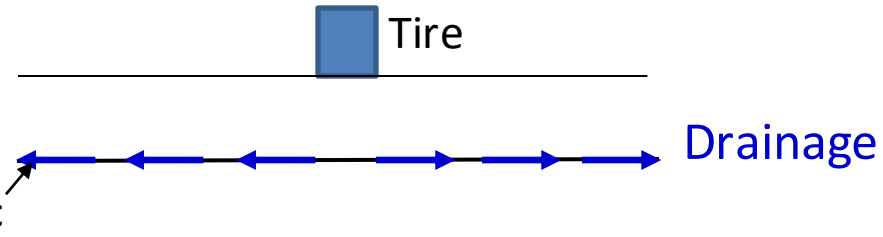


(d) Vertical restraint

Increase strength of subgrade & base course



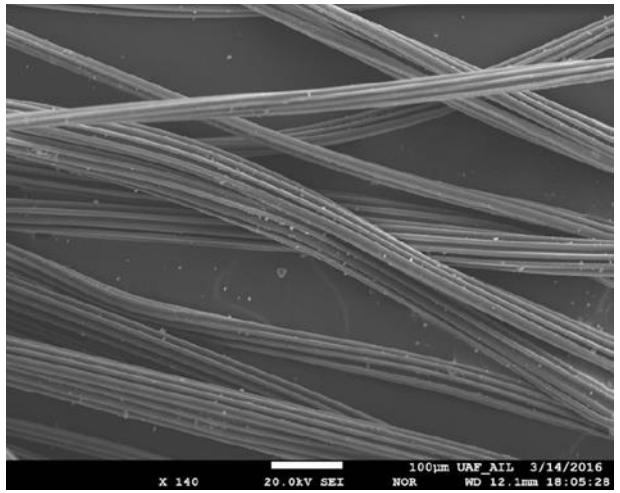
(e) Lateral restraint

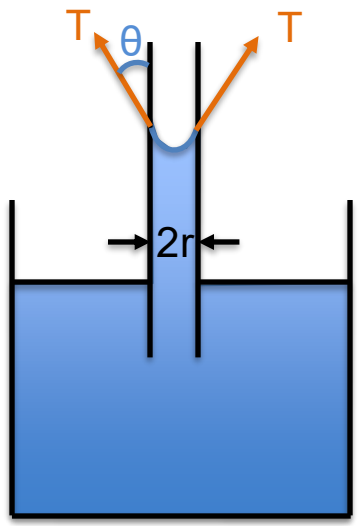


(f) Lateral drainage

Increase strength & modulus of base course

Wicking Drainage





Wicking fibers with small diameter channels

↓

Higher capillary force

↓

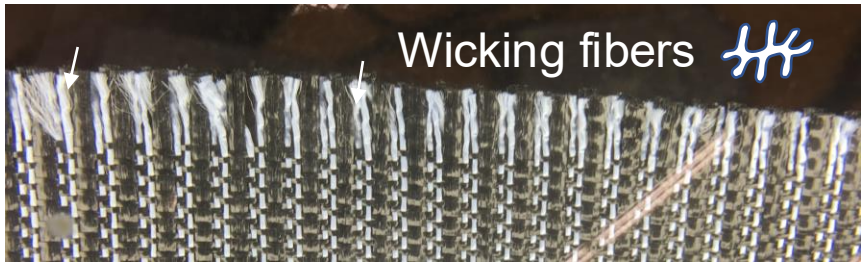
Water wicked into channels

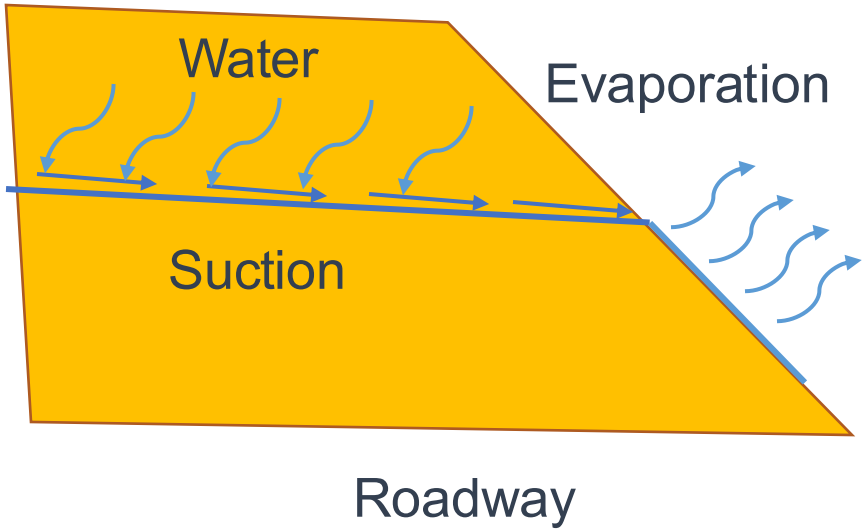
↓

Water traveling to exposed geotextile

↓

Water evaporating into air

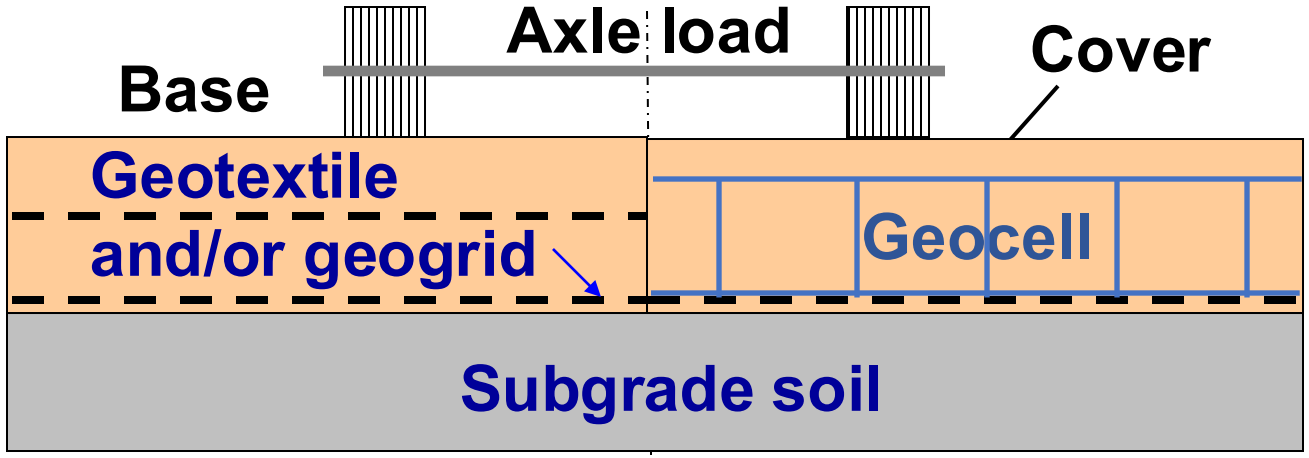




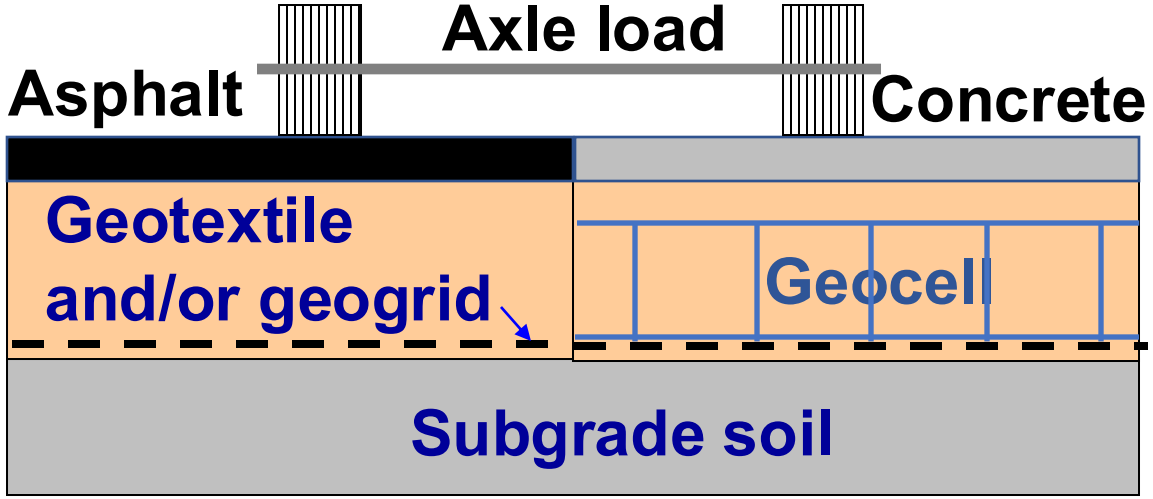
Effective in removing water in unsaturated soil

Applications of Geosynthetics in Roads

Unpaved Roads



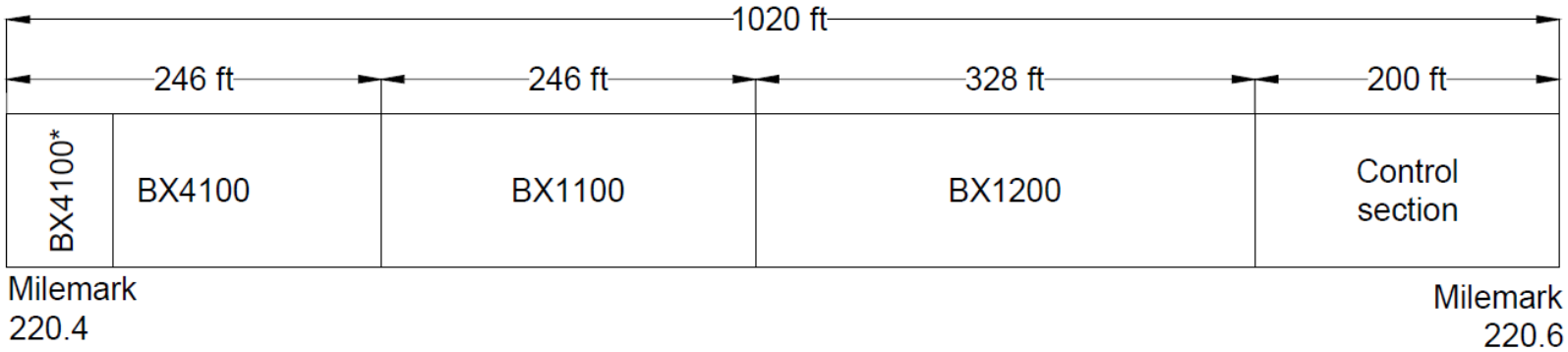
Paved Roads



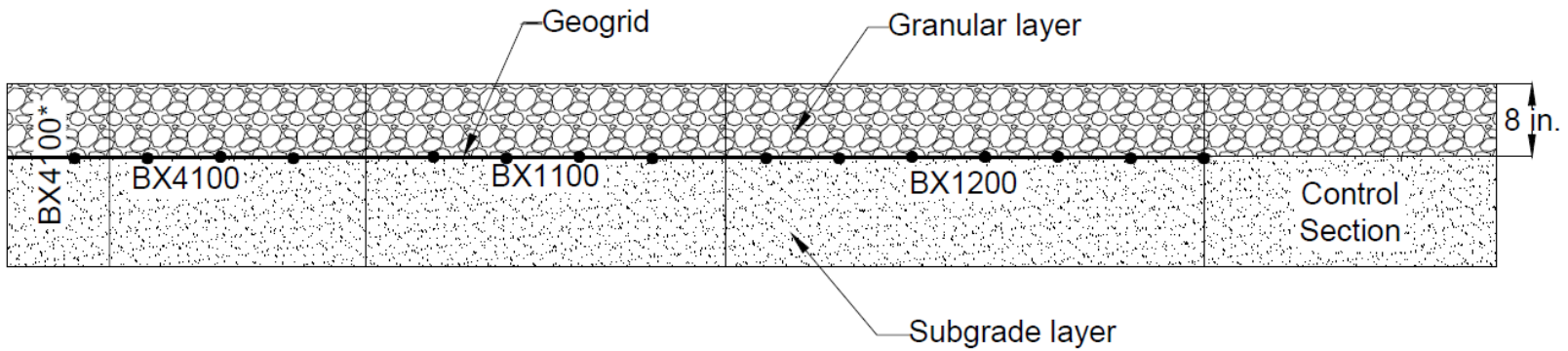
Geogrid Stabilization

Highway 218, Nashua, IA

Rut > 6”



(a) Plan view



(b) Cross section

White et al. (2007). Effective Shoulder Design and Maintenance. Center for Transportation Research and Education Iowa State University.

Construction

Construction

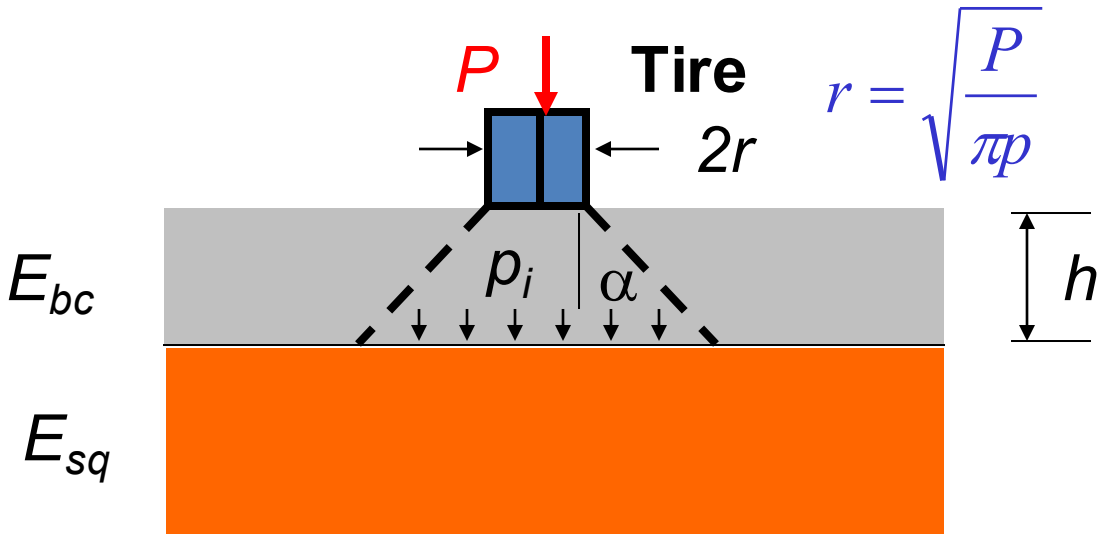
Field Monitoring

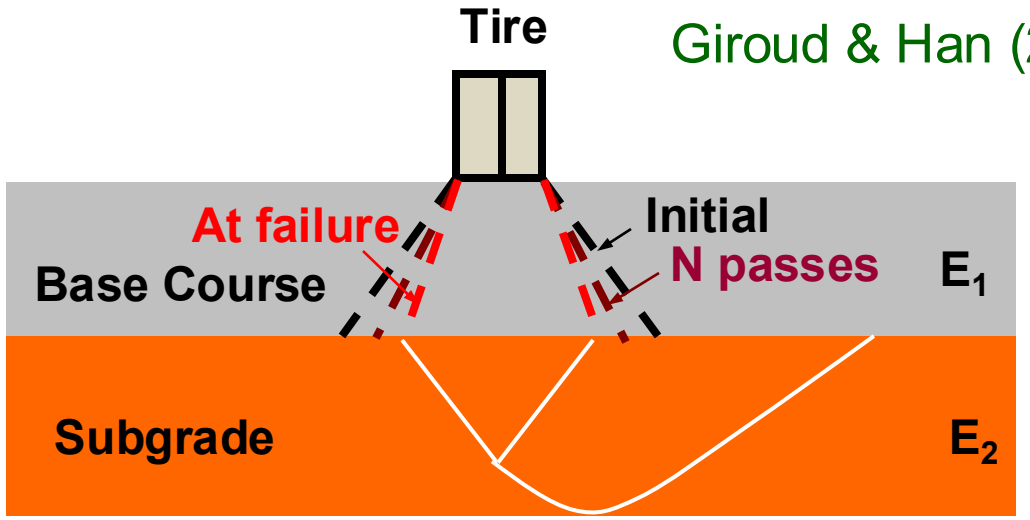
One year later

No geogrid

With geogrid

Design of Unpaved Roads on Soft Subgrade



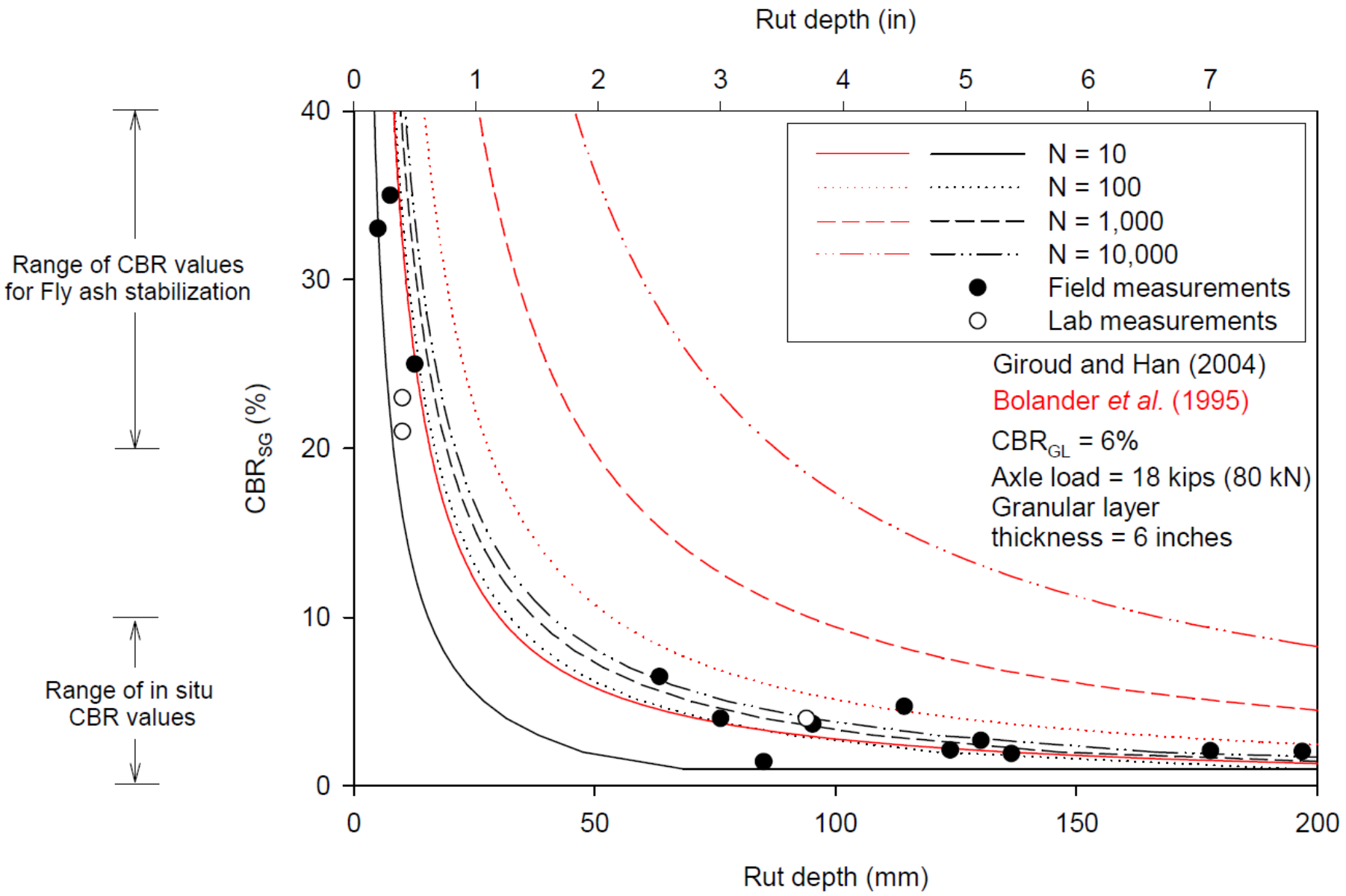


$$p_i = \frac{P}{\pi (r + h \tan\alpha)^2} \le mN_c c_u \quad \Rightarrow \quad h = \frac{r}{\tan\alpha}\left(\sqrt{\frac{P}{\pi r^2 mN_c c_u}} - 1\right)$$

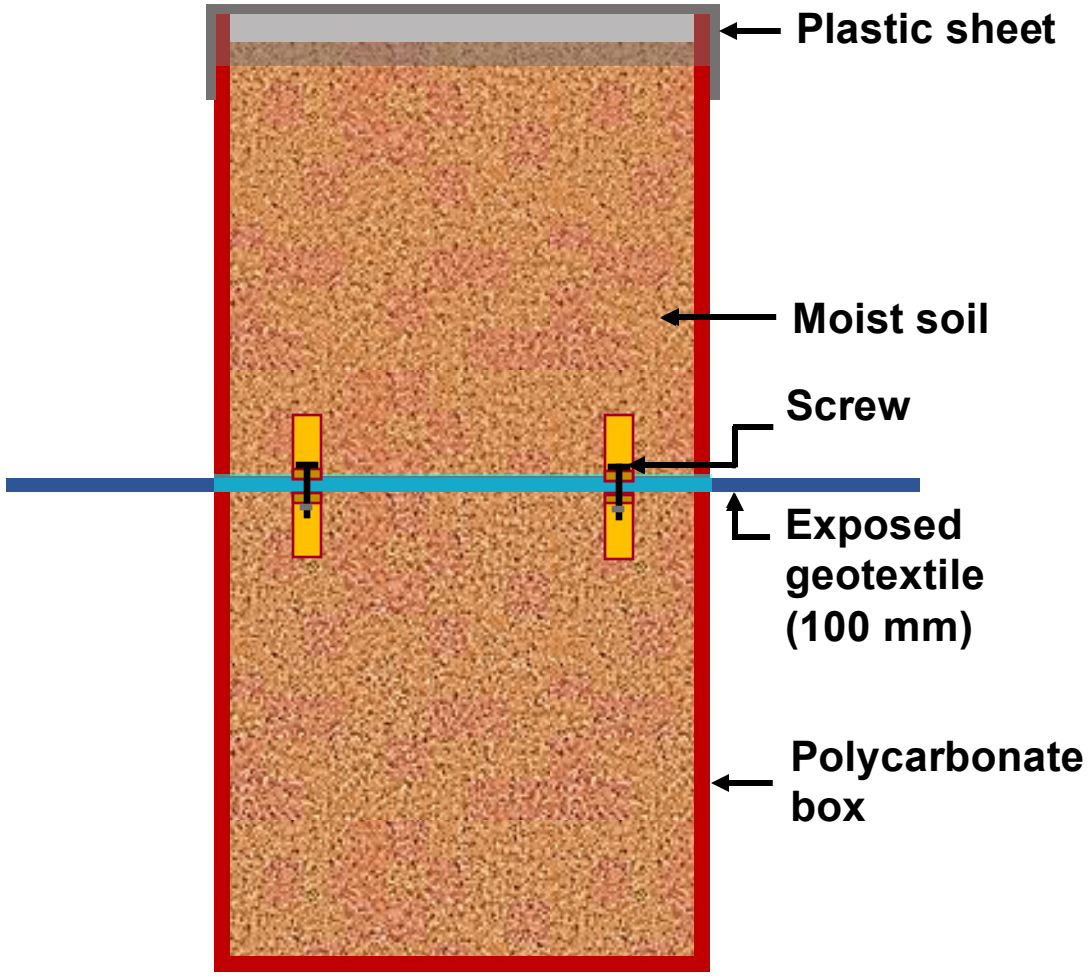
m = bearing capacity mobilization factor at different rut

Control: $N_c = 3.14$ Geotextile-stabilized $N_c = 5.14$
Geocell-stabilized $N_c = 5.14$ Geogrid-stabilized $N_c = 5.71$

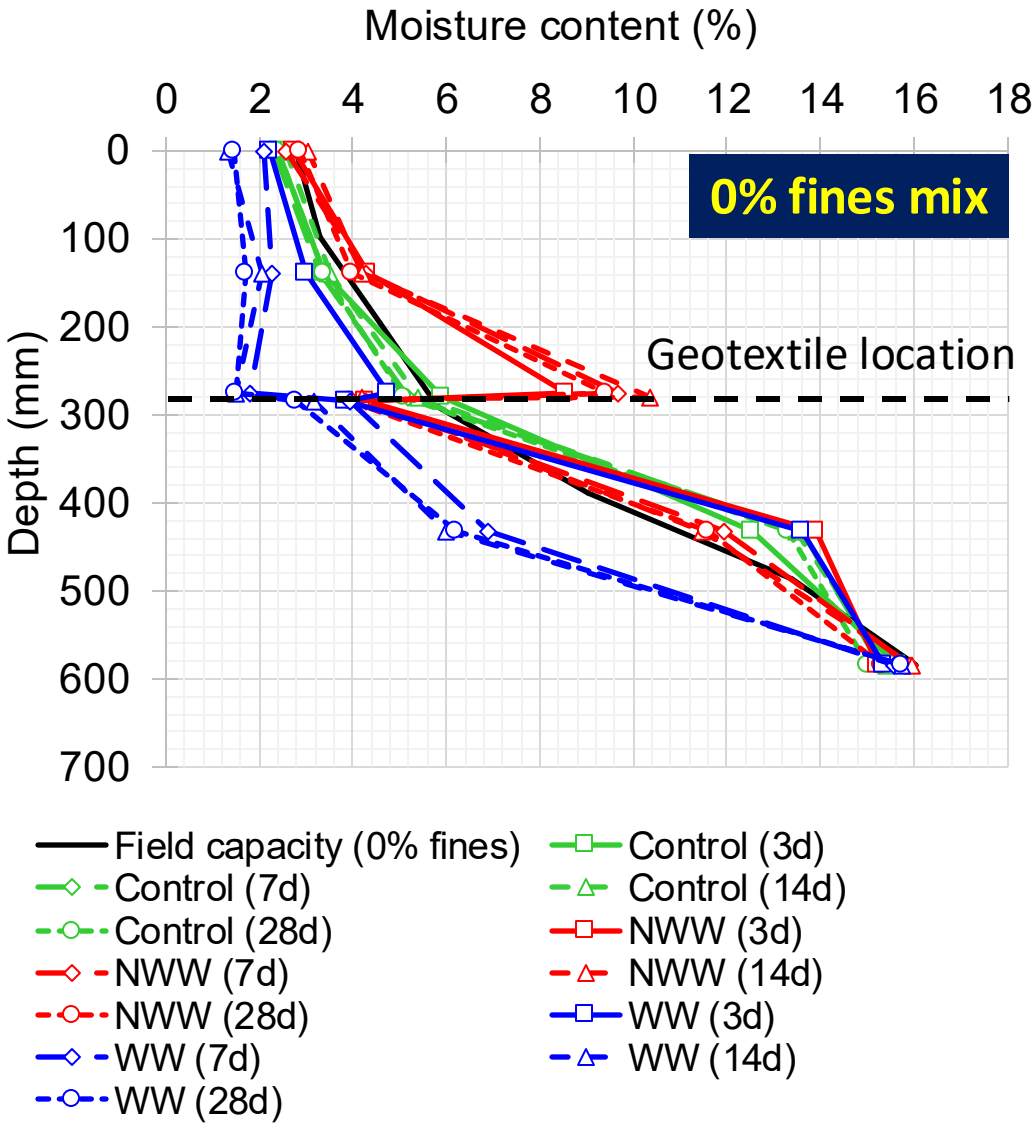
Verification



Moisture Reduction with Geotextile



300 x 300 x 600 mm high (12” x 12” x 24”)



Mitigating High Groundwater Table and Freeze-thaw Problems for Concrete Pavement

US169 in Iola, Kansas , USA

Pavement Condition before Reconstruction

Most frequent level of faulting

Fault Score per segment

Avg. no. of distressed joints per location

YEAR	LANE	RIDE			RIGID DISTRESS									
		IRI in/mi	Mays in/mi	PL	F	FS	J0	J1	J2	J3	J4	F1	F2	F3
2014	0	55	39	1	0.6	6.3	0.5	-	-	-	-	6.1	-	-
2015	0	68	50	1	-	-	-	-	-	-	-	-	-	-
2016	0	82	61	1	1.0	24.6	0.6	-	-	-	-	21.6	1.3	0.1
2017	0	88	68	1	1.3	34.1	1.8	0.3	0.1	-	-	26.6	3.0	0.4
2018	0	119	9	2	1.6	46.9	-	-	0.1	-	1.1	35.4	4.3	0.8

International Roughness Index

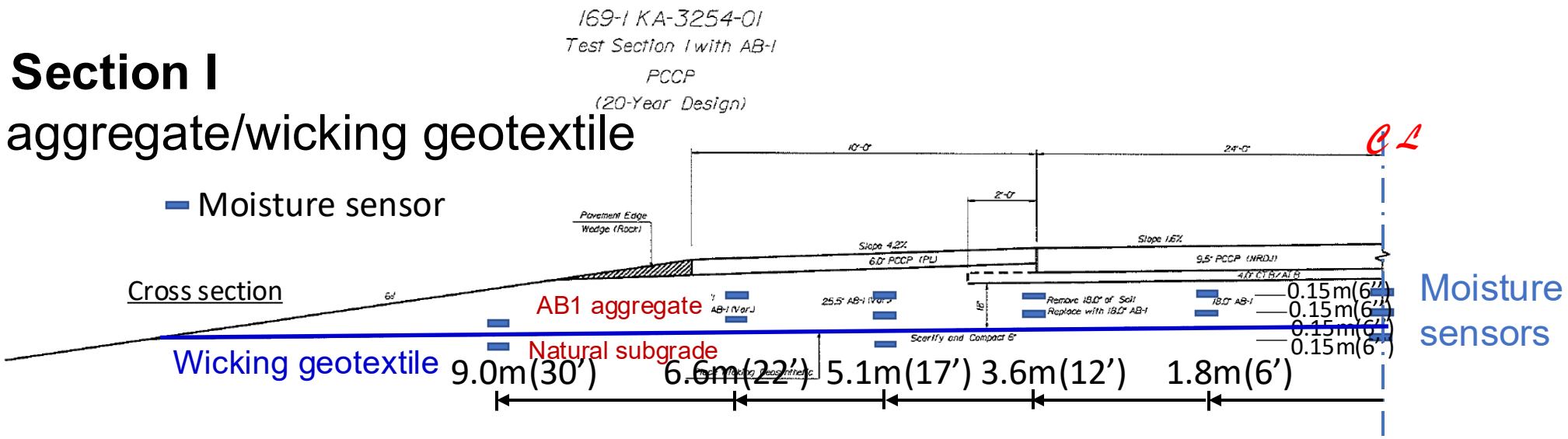
Performance Level

Liu, H., Han, J., Al-Naddaf, M., Parsons, R.L., and Kakrasul, J.I. (2022). “Field monitoring of wicking geotextile to reduce soil moisture under a concrete pavement subjected to precipitations and temperature variations.” Geotextiles and Geomembranes, 50(5), 1004-1019.

Instrumented Test Sections with Moisture Sensors

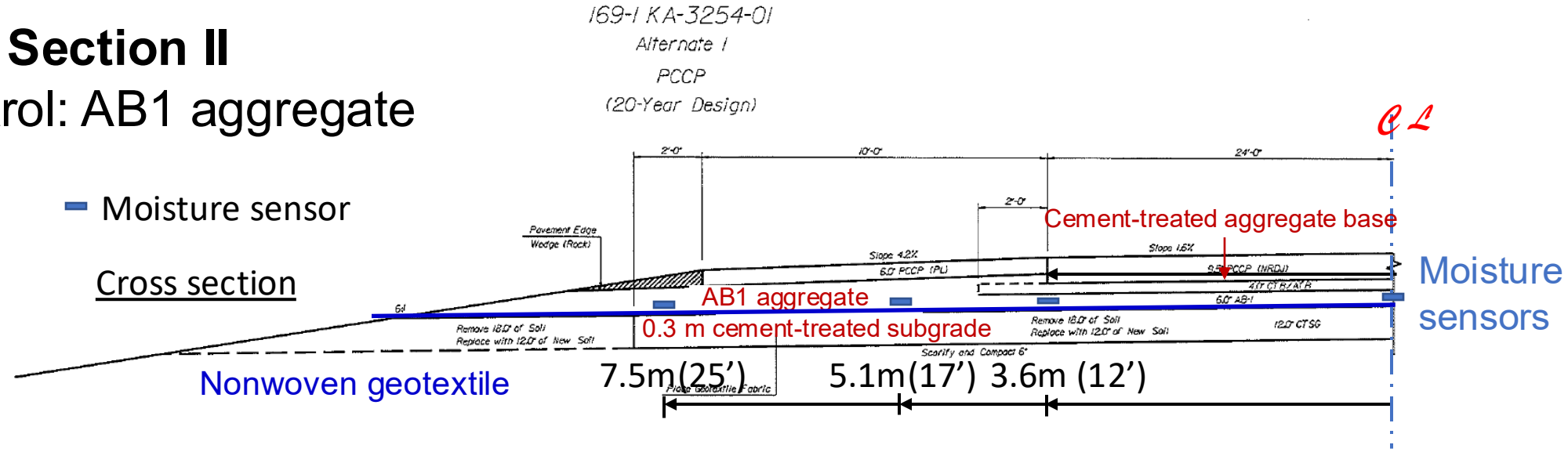
Test Section I

AB1 aggregate/wicking geotextile



Test Section II

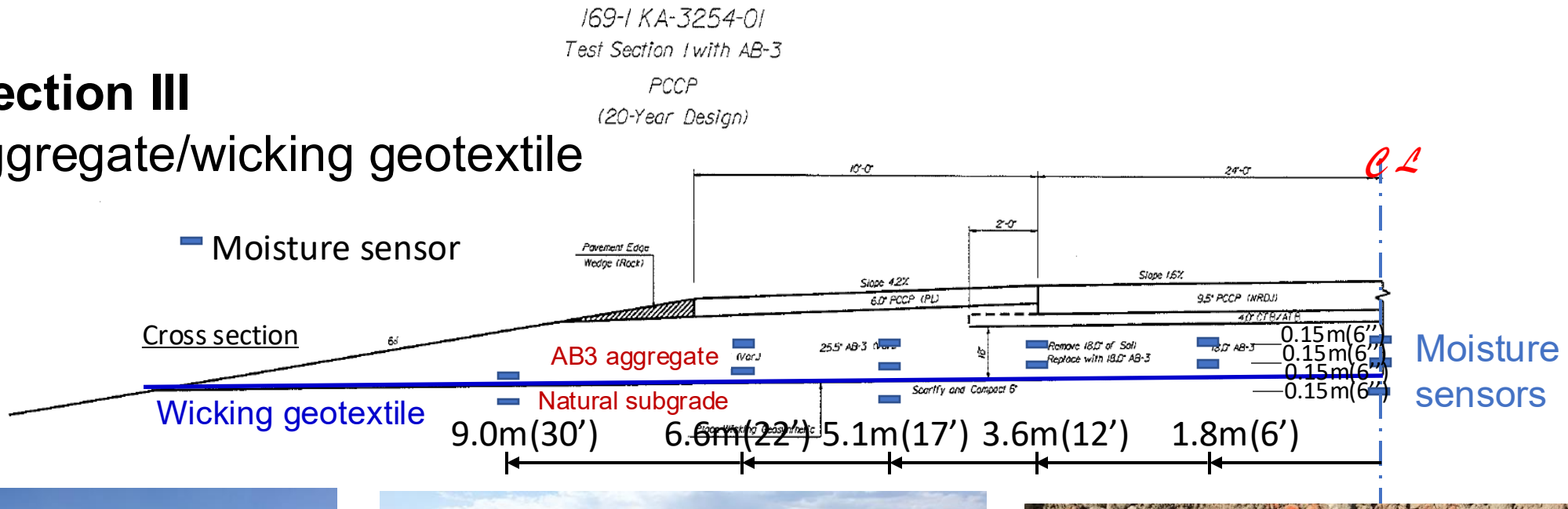
Control: AB1 aggregate



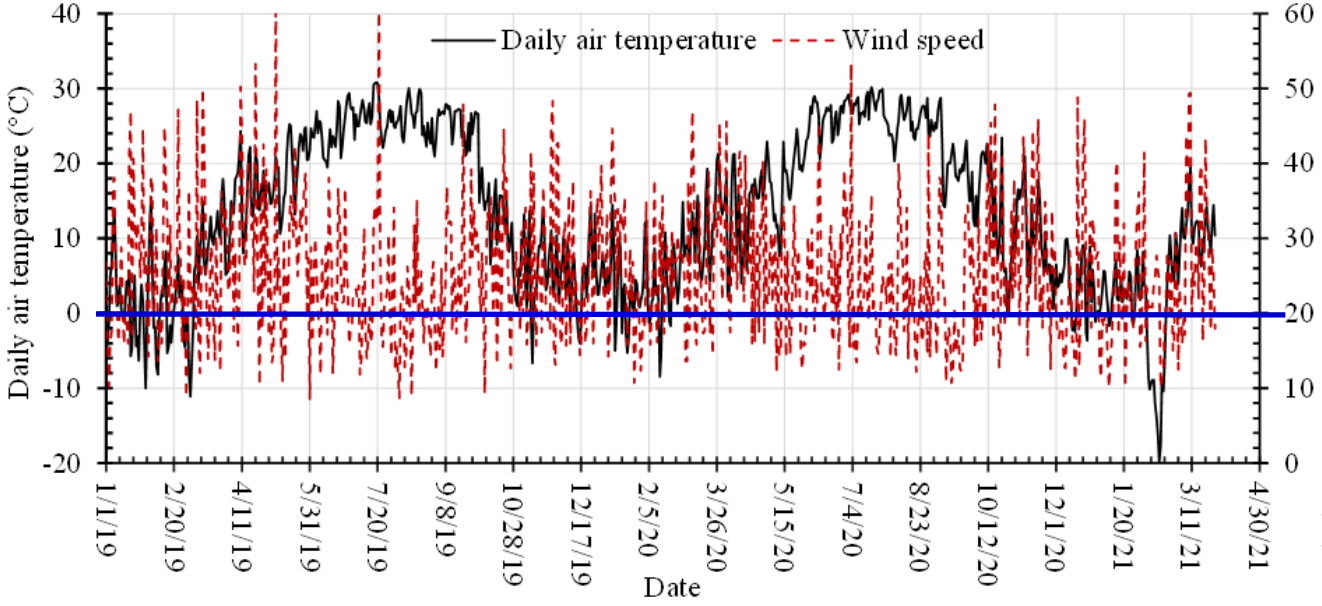
Instrumented Test Sections with Moisture Sensors

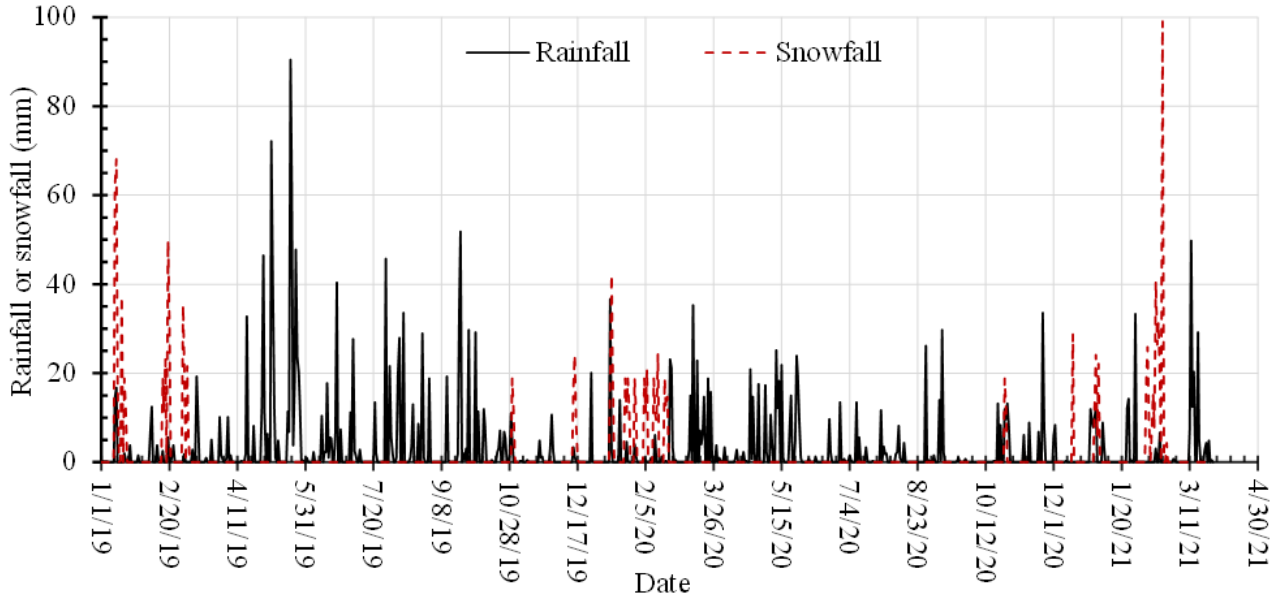
Test Section III

AB3 aggregate/wicking geotextile



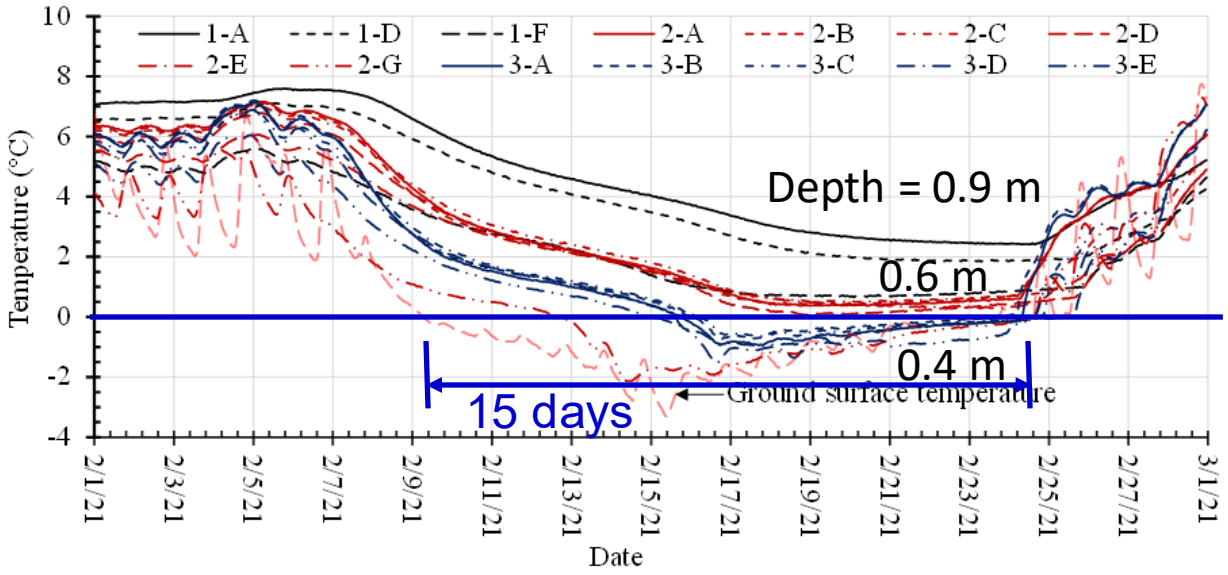
Climatic Condition





Test Section III

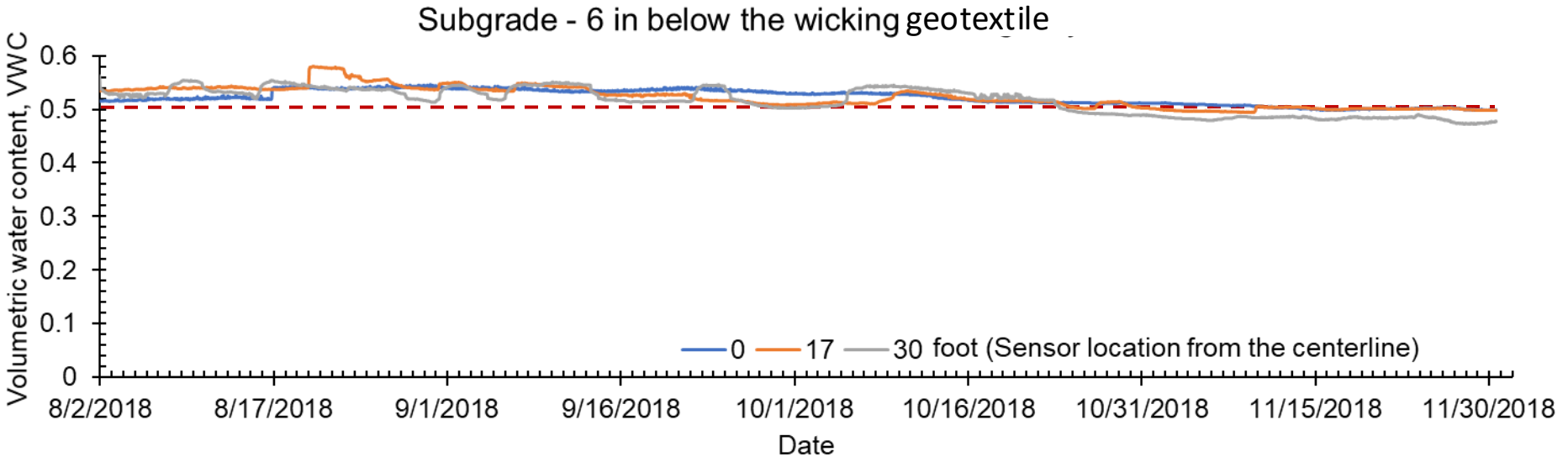
AB3 aggregate/wicking geotextile

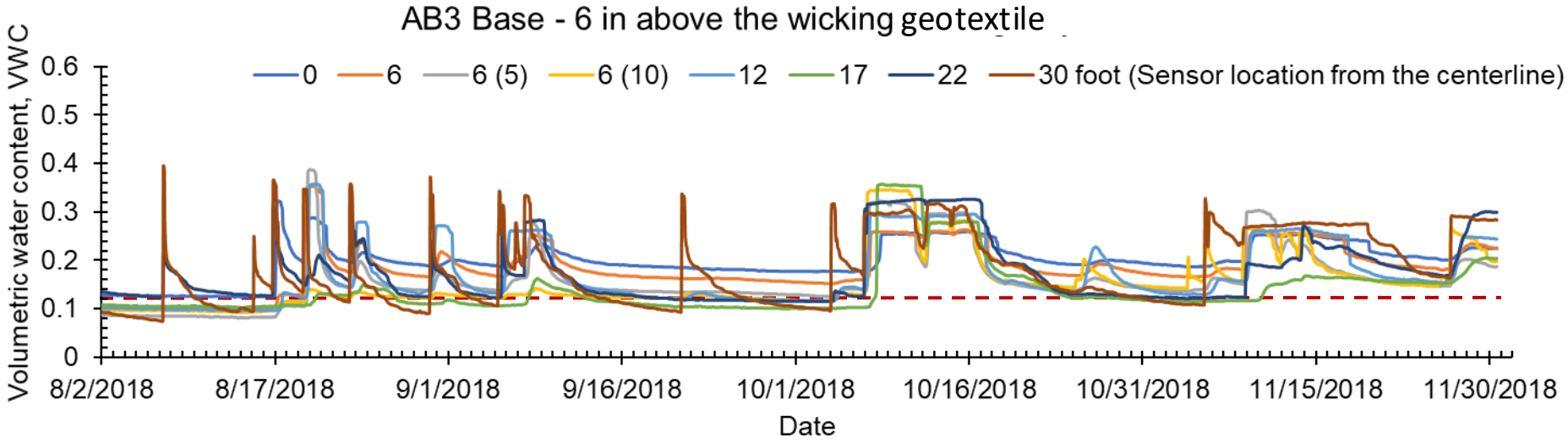


Frozen depth = 0.6 m

Field Monitoring Results

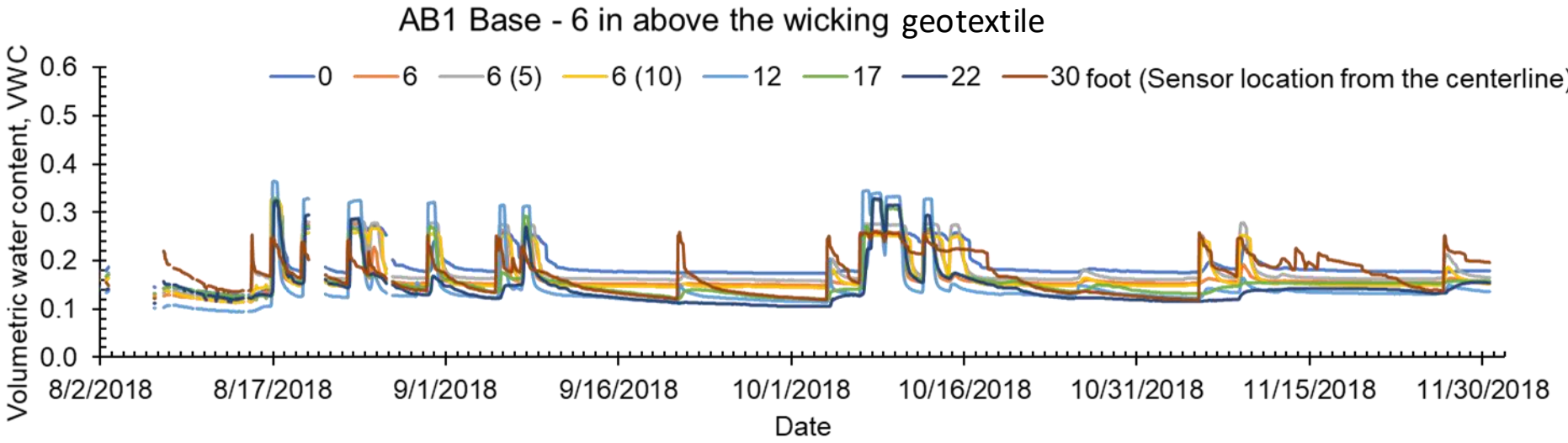
Test Section III: AB3 aggregate/wicking geotextile

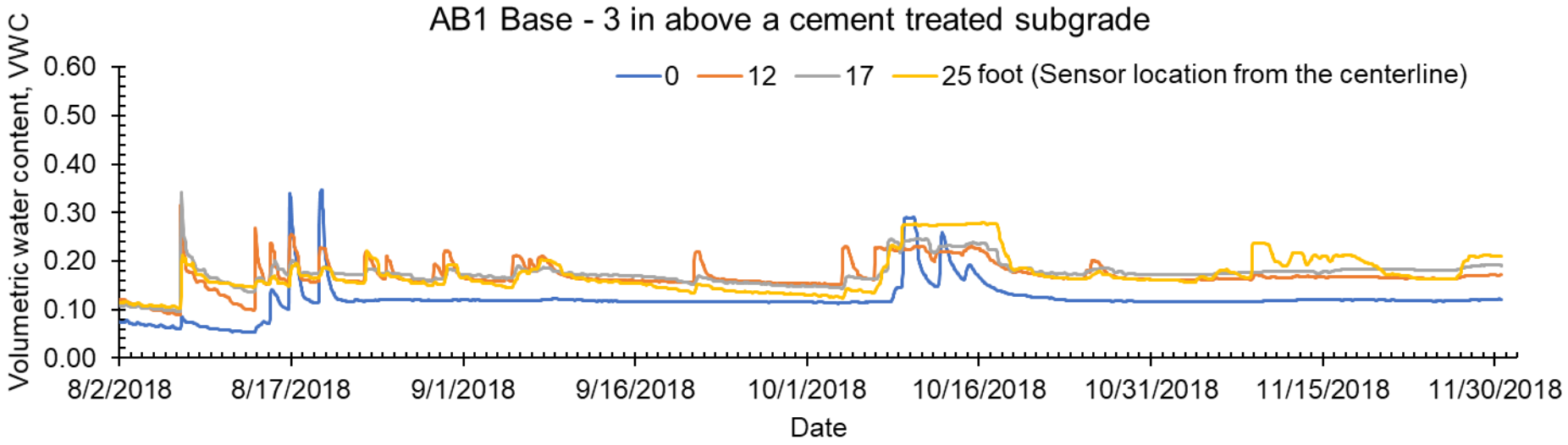




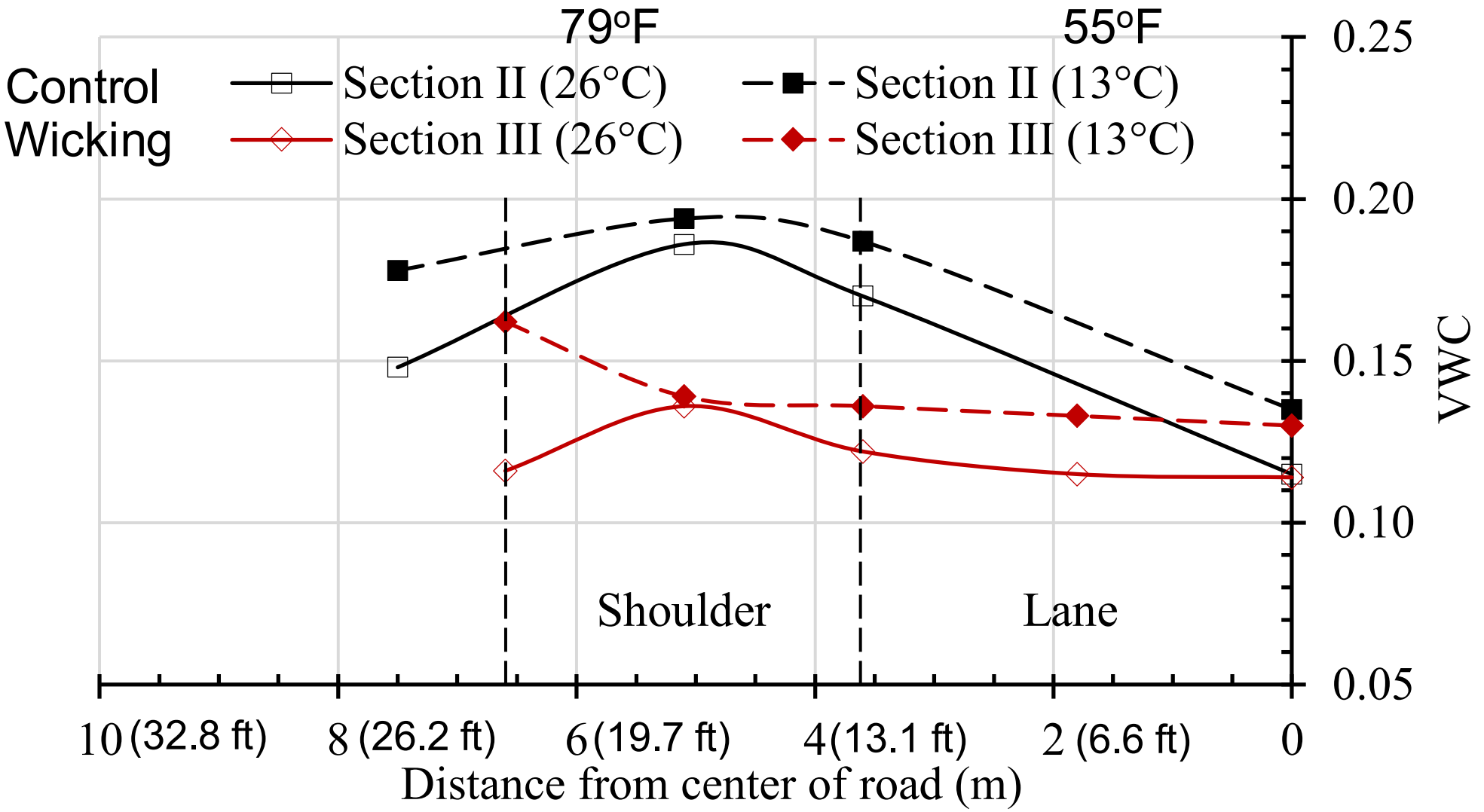
Field Monitoring Results

Test Sections I & II: AB1 aggregate/wicking geotextile & Control





Field Monitoring Results



Both evaporation and drainage reduce moisture content.

Field Monitoring Results

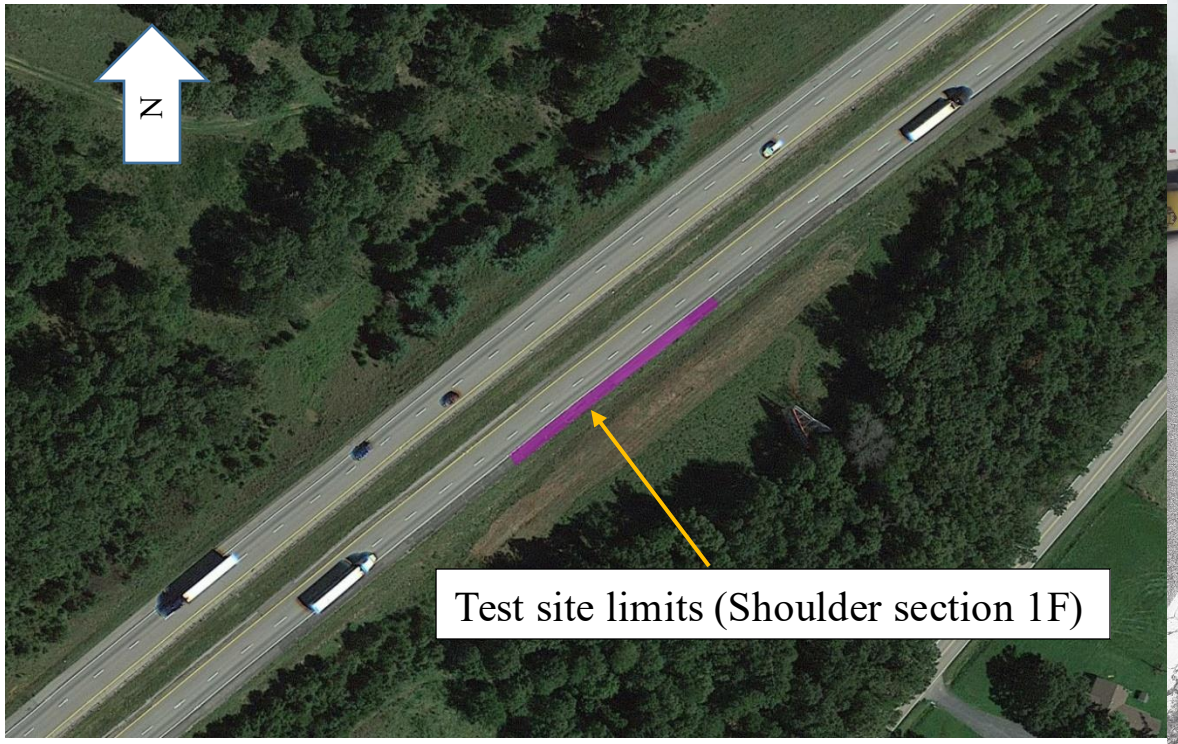
Section 1: wicking geotextile

Section 2: no wicking geotextile

Section 3: wicking geotextile

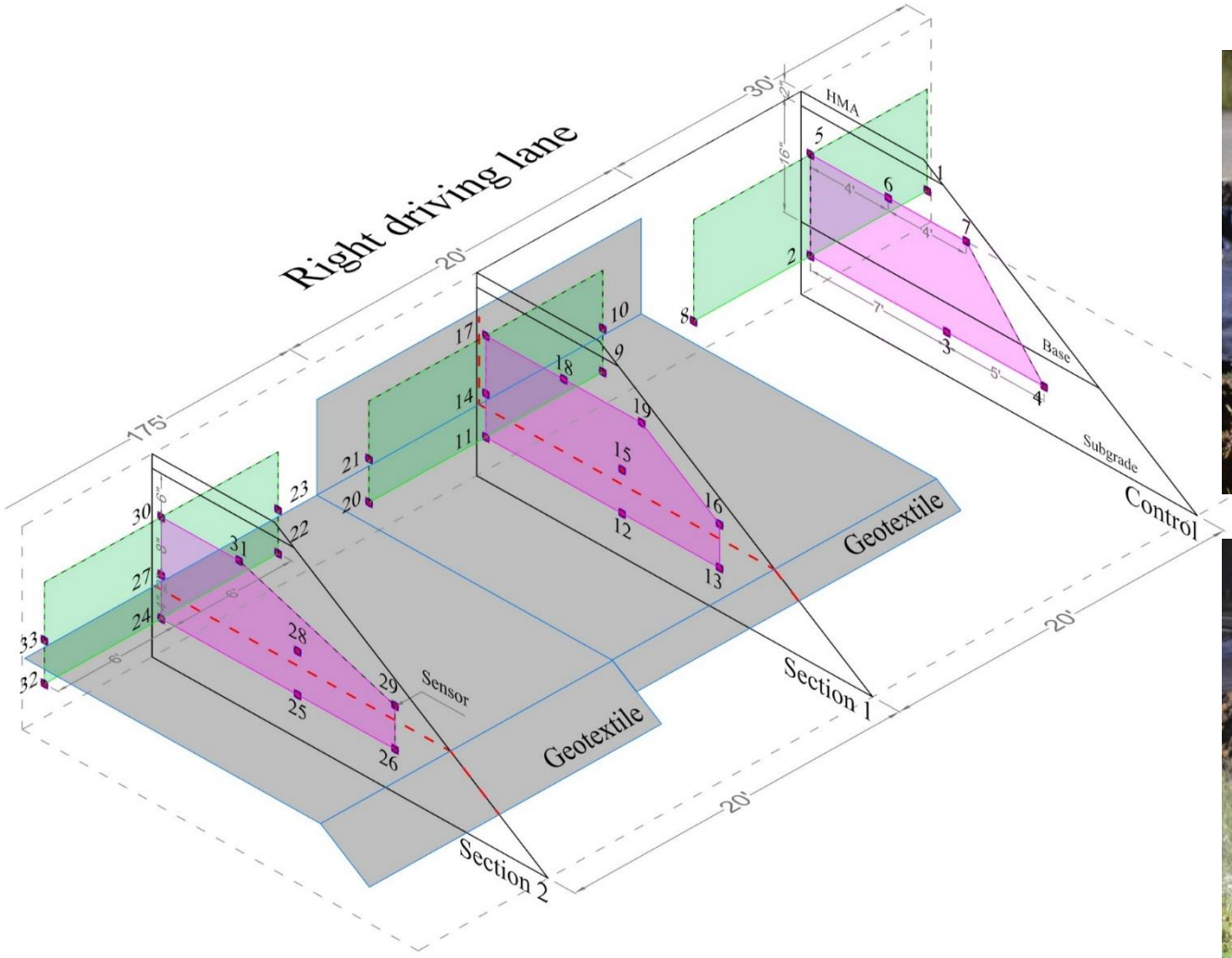
Mitigation of Moisture-Induced Damages to HMA Shoulder

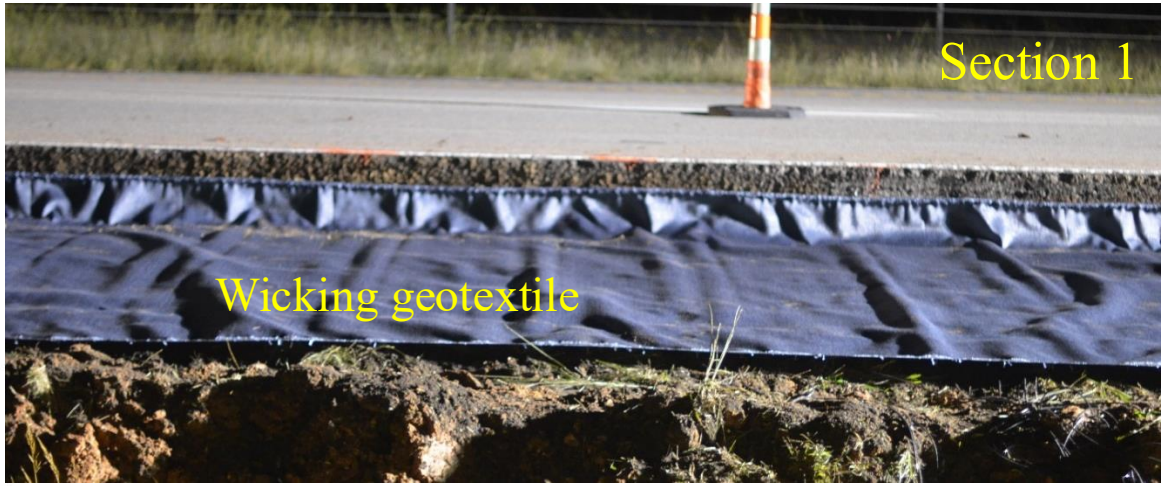
September 25, 2018



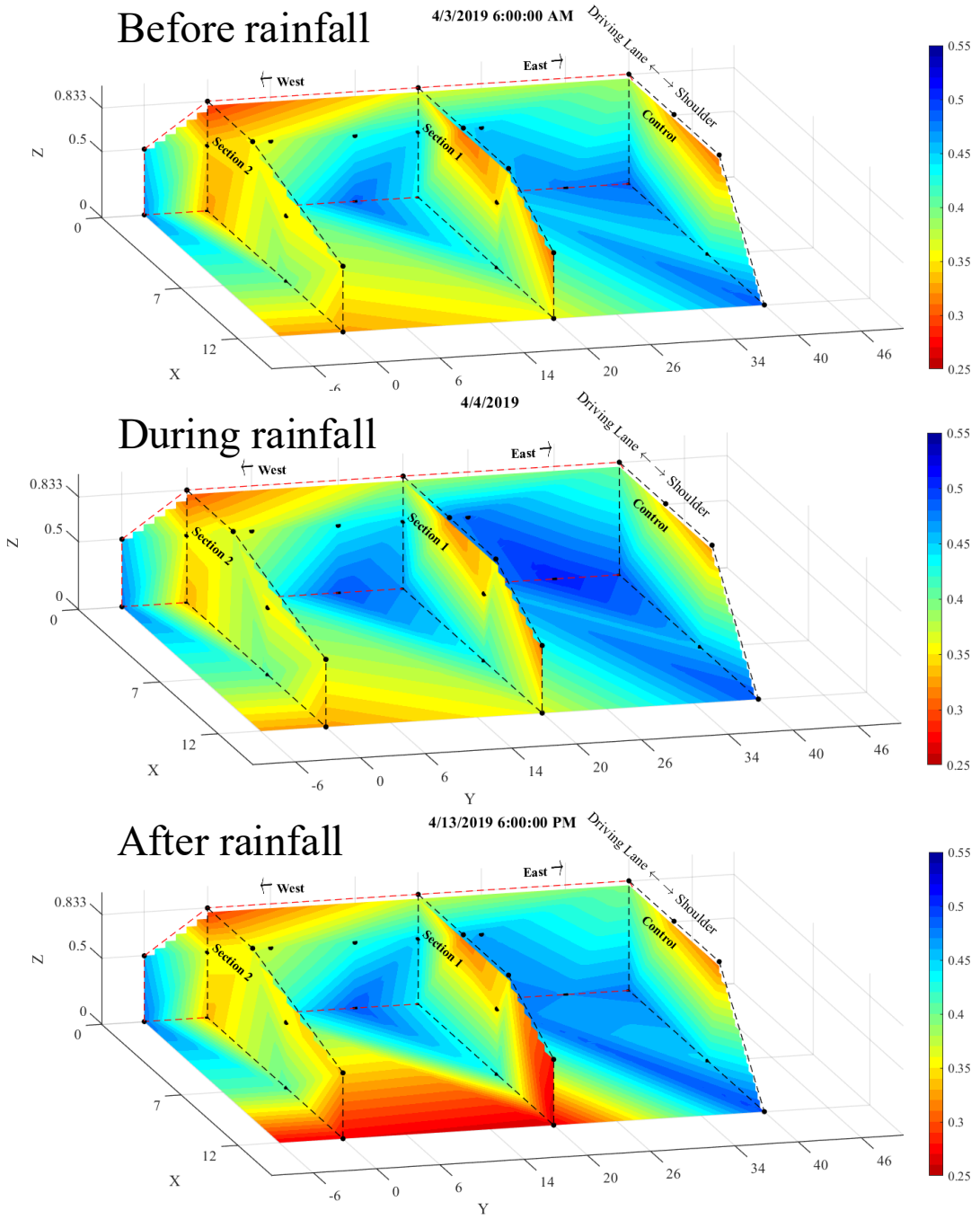
Credit: Dr. Xiong Zhang

Field Test Sections





Field Monitoring



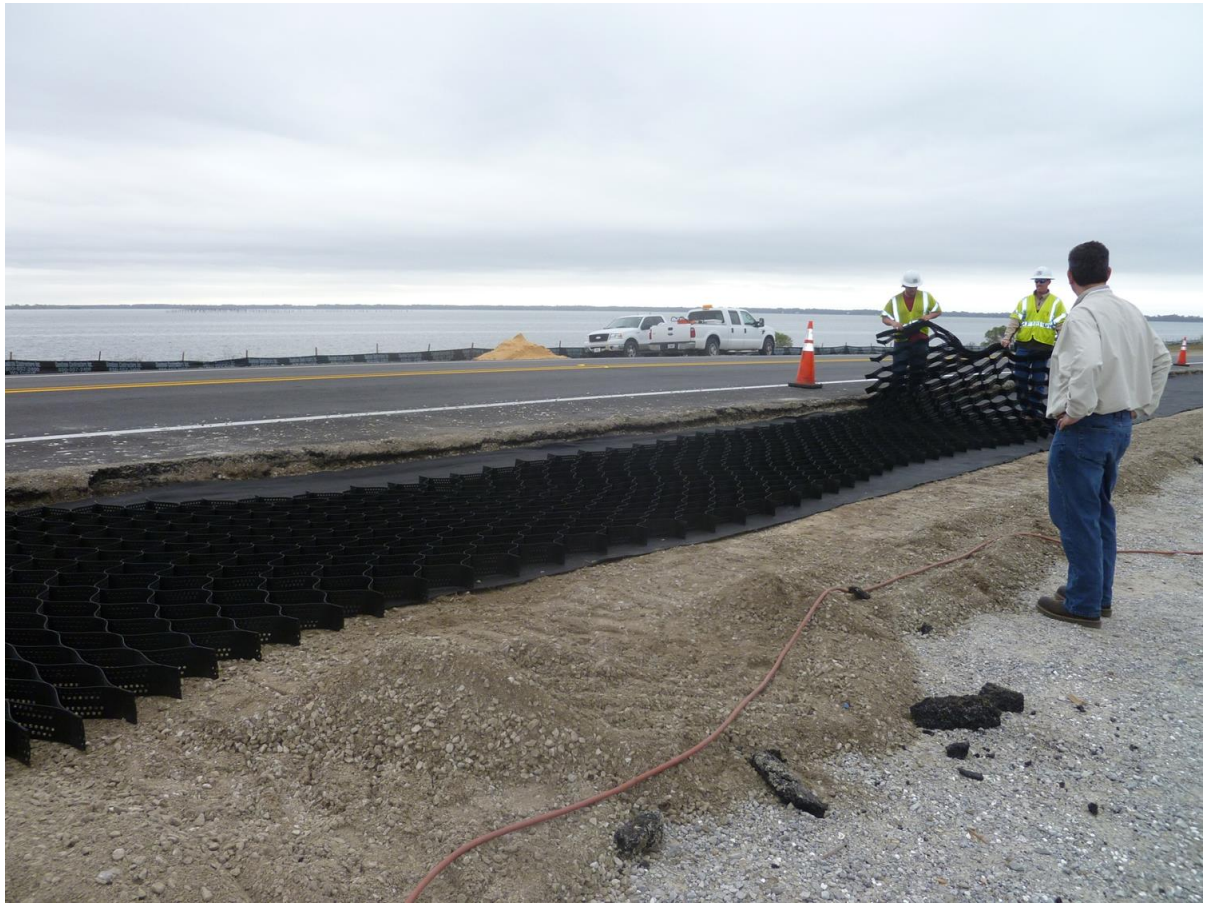
Stabilization of Unpaved Shoulder by Geocell

- Location: SR83 / US331 in Walton County, Florida
- Construction time: January 2011
- Purpose: stabilization of unpaved shoulder
- Subgrade: sandy soil
- Geocell height: 4 in.
- Infill material: crushed stone

Credit: Strata Systems, Inc.

Construction

Construction



Performance

Concluding Remarks

- There are different types of geosynthetics successfully used to improve performance of unpaved and paved shoulders.
- Selection of a geosynthetic product should consider its controlling mechanism in the application.
- Geogrid is an effective and economic solution for stabilizing granular bases if appropriate geometry compatibility between apertures and aggregate size is maintained.
- Geotextile can provide multiple functions with apparent advantages if water is a major concern (especially wicking geotextile for unsaturated soil).
- Geocell can be an economical and effective solution if used with onsite soil, recycled aggregate, or large uniform particles.

Thanks! Questions?

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