IOWA STATE UNIVERSITY | WISCONSIN UNIVERSITY OF WISCONSIN–MADISON | MICHIGAN STATE UNIVERSITY

Determining Pavement Design Criteria for Recycled Aggregate Base and Large Stone Subbase

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Tuncer Edil

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MnDOT Project TPF-5(341)

Monthly Meeting

January 9, 2020

AGENCY MEMBERS

- MnDOT
- Caltrans
- MDOT
- IDOT
- LRRB
- MoDOT
- WisDOT
- NDDOT
- Iowa DOT
- Illinois Tollway

ASSOCIATE MEMBERS

- Aggregate & Ready Mix of MN
- Asphalt Pavement Alliance (APA)
- Braun Intertec
- Infrasense
- Diamond Surface Inc.
- Flint Hills Resources
- International Grooving & Grinding Association (IGGA)
- Midstate Reclamation & Trucking
- MN Asphalt Pavement Association
- Minnesota State University - Mankato
- National Concrete Pavement Technology Center
- Roadscanners
- University of Minnesota - Duluth
- University of New Hampshire
- Mathy Construction Company
- Michigan Tech Transportation Institute (MTTI)
- University of Minnesota
- National Center for Asphalt Technology (NCAT) at Auburn University
- GSE Environmental
- Helix Steel
- Ingios Geotechnics
- WSB
- Cargill
- PITT Swanson Engineering
- University of California Pavement Research Center
- Collaborative Aggregates LLC
- American Engineering Testing, Inc.
- Center for Transportation Infrastructure Systems (CTIS)
- Asphalt Recycling & Reclaiming Association (ARRA)
- First State Tire Recycling
- BASF Corporation
- Upper Great Plains Transportation Institute at North Dakota State University
- 3M
- Pavia Systems, Inc.
- All States Materials Group
- Payne & Dolan, Inc.
- Caterpillar
- The Dow Chemical Company
- The Transtec Group
- Testquip LLC
- Hardrives, Inc.
- Husky Energy
- Asphalt Materials & Pavements Program (AMPP)
- Concrete Paving Association of MN (CPAM)
- MOBA Mobile Automation
- Geophysical Survey Systems
- Leica Geosystems
- University of St. Thomas
- Trimble

OUTLINE

- Follow-up
- Test cells & materials
- Tasks 5 & 6

FOLLOW-UP

- **Task 1** – Literature review and recommendations
- **Task 2** – Tech transfer "state of practice"
- **Task 3** – Construction monitoring and reporting
- **Task 4** – Laboratory testing
- **Task 5** – Performance monitoring and reporting
- **Task 6** – Instrumentation
- **Task 7** – Pavement design criteria
- **Task 8 & 9** – Draft/final report

Green – Completed
Red – In Progress

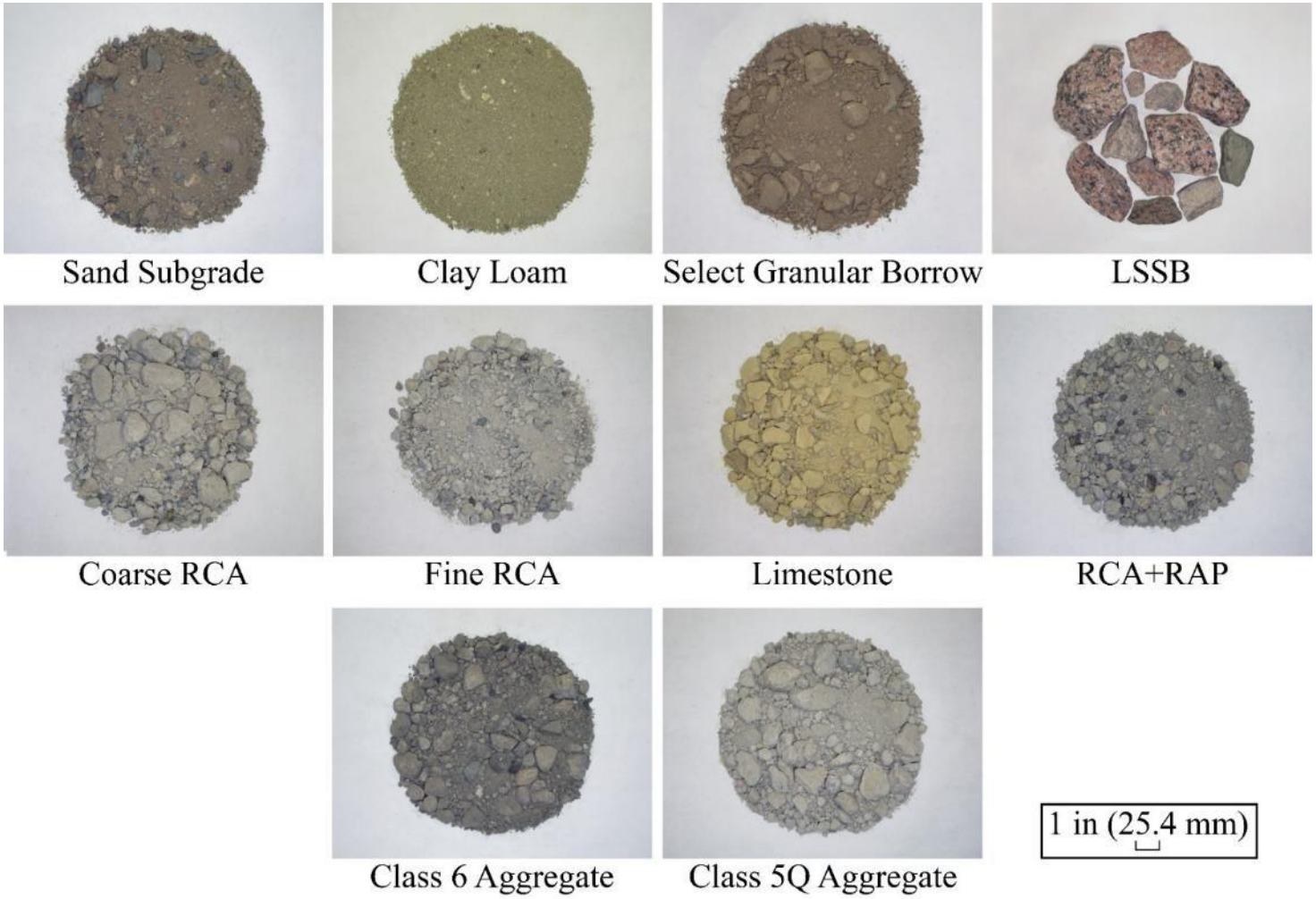
TEST CELLS

Recycled Aggregate Base				Large Stone Subbase		Large Stone Subbase with Geosynthetics				
185	186	188	189	127	227	328	428	528	628	728
3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave	3.5 in Superpave
12 in Coarse RCA	12 in Fine RCA	12 in Limestone	12 in RCA+RAP	6 in Class 6 Aggregate	6 in Class 6 Aggregate	6 in Class 5Q Aggregate	6 in Class 5Q Aggregate	6 in Class 5Q Aggregate	6 in Class 5Q Aggregate	6 in Class 5Q Aggregate
3.5 in S. Granular Borrow	3.5 in S. Granular Borrow	3.5 in S. Granular Borrow	3.5 in S. Granular Borrow	18 in LSSB (1 lift)	18 in LSSB (1 lift)	9 in LSSB TX	9 in LSSB TX+GT	9 in LSSB BX+GT	9 in LSSB BX	9 in LSSB
Sand	Sand	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam

S. Granular Borrow = Select Granular Borrow

TX = Triaxial Geogrid
BX = Biaxial Geogrid
GT = Nonwoven Geotextile

MATERIALS

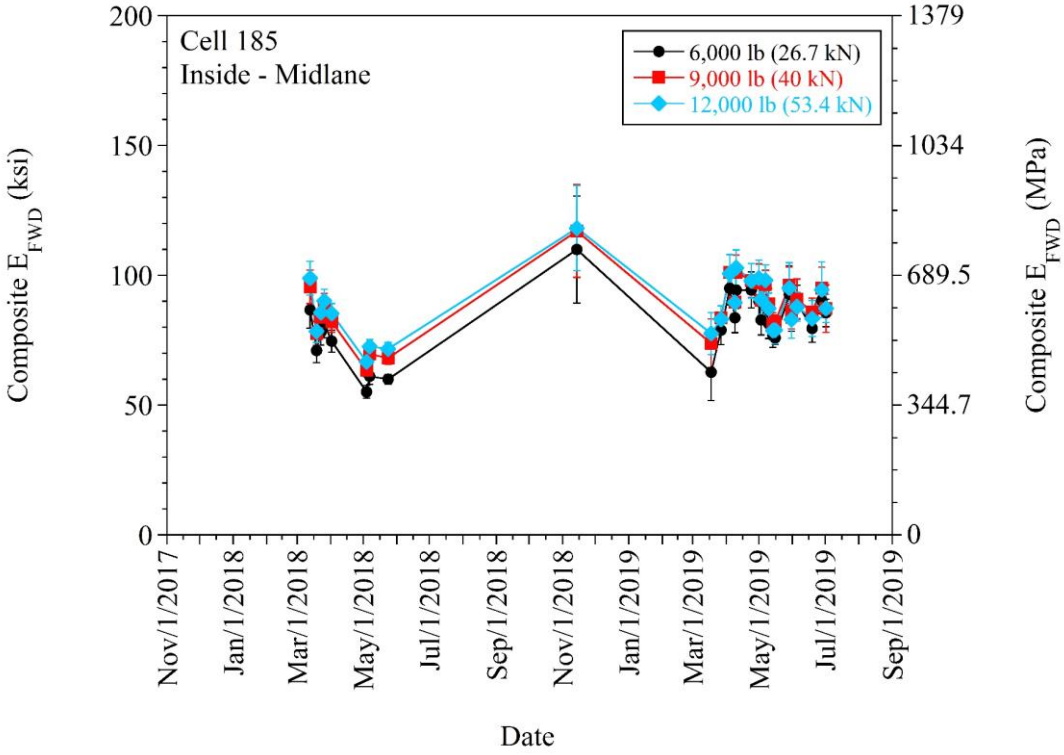

Sand Subgrade
Clay Loam
Select Granular Borrow
LSSB
Coarse RCA
Fine RCA
Limestone
RCA+RAP
Class 6 Aggregate
Class 5Q Aggregate
1 in (25.4 mm)

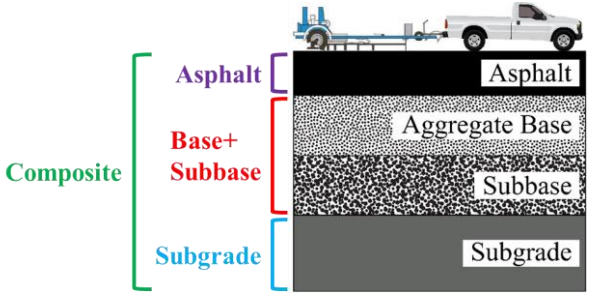
TASKS 5 & 6

- Falling weight deflectometer (FWD)
- Frost heave
- International roughness index (IRI)
- Rutting
- Environmental monitoring
  - Weather data
  - Temperature sensors
  - Moisture sensors
  - Frost depth
  - Number of freeze-thaw cycles
- Pavement distresses

Green – Completed
Red – In Progress

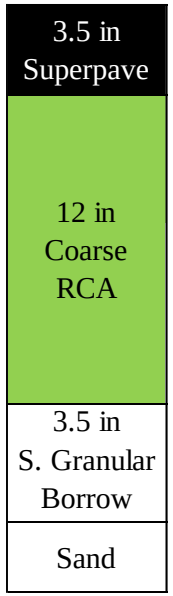
FWD



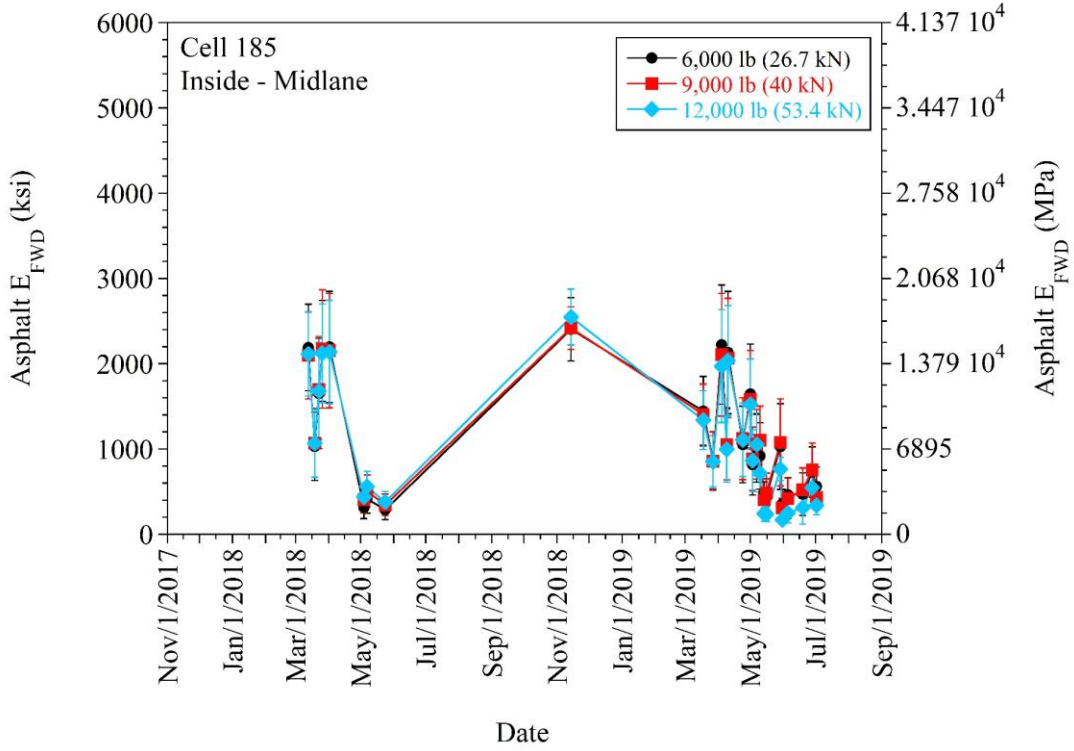


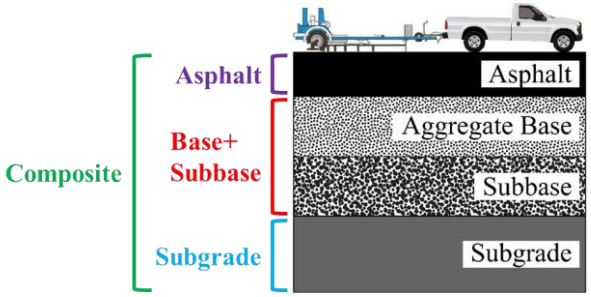
Cell Number	Station	Test Points	OUTSIDE LANE (+)			INSIDE LANE (-)		
			OWP	MID	IWP	IWP	MID	OWP
185 *12 in. Coarse RCA*	16368	Start						
	16379	1	o					o
	16409	2		o			o	
	16439	3	o					o
	16469	4		o			o	
	16499	5	o					o
	16529	6		o			o	
	16559	7	o					o
	16569	End						

185



FWD





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185 *12 in. Coarse RCA*	16368	Start						
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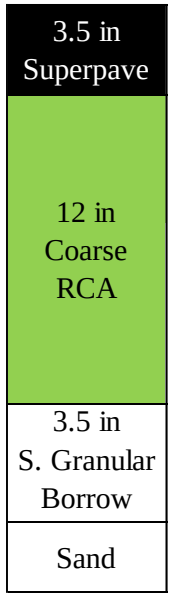
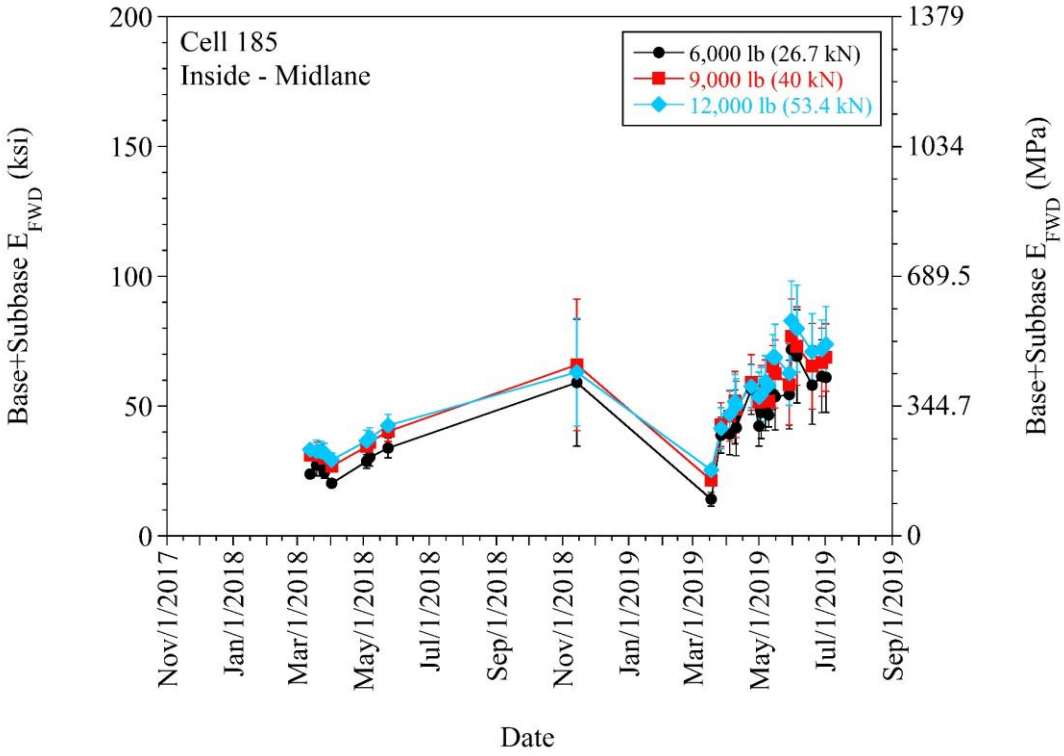
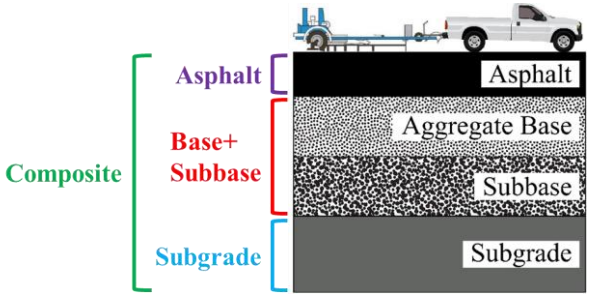
	16469	4		o			o	
	16499	5	o					o
	16529	6		o			o	
	16559	7	o					o
	16569	End						

185



FWD





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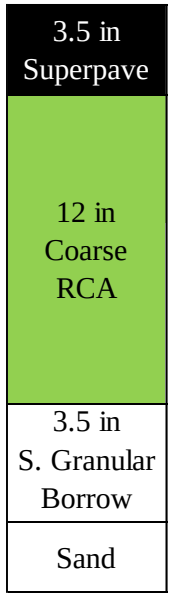
	16469	4		o			o	
	16499	5	o					o
	16529	6		o			o	
	16559	7	o					o
	16569	End						

185



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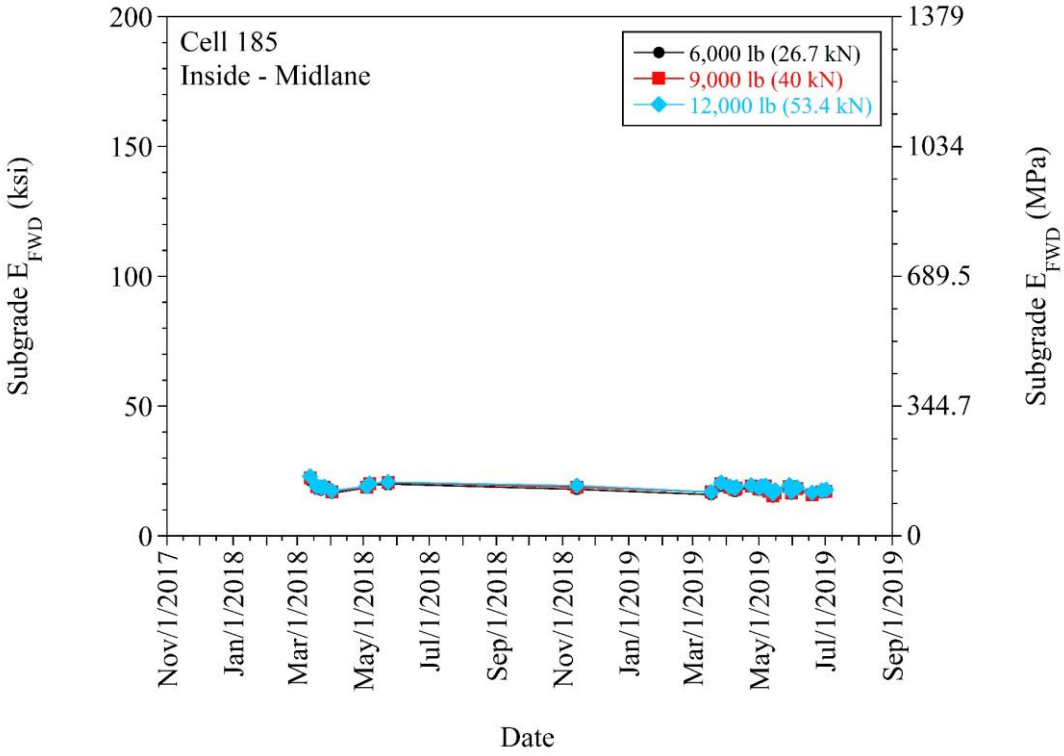

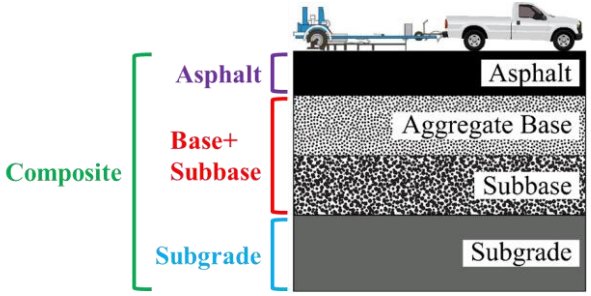

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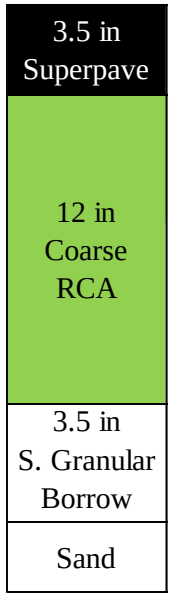
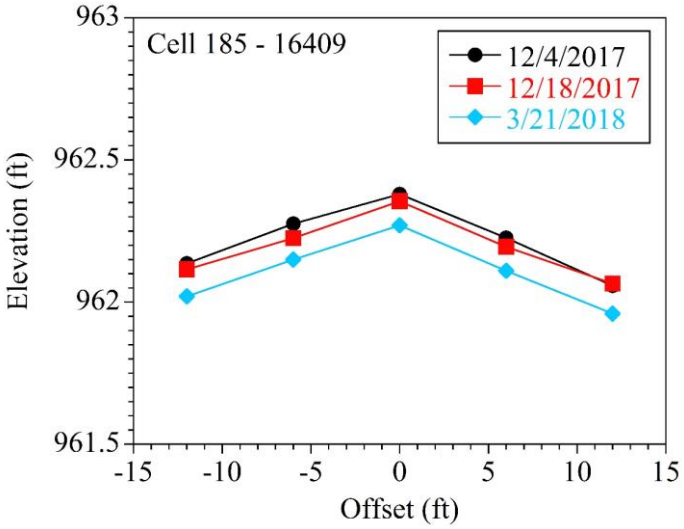
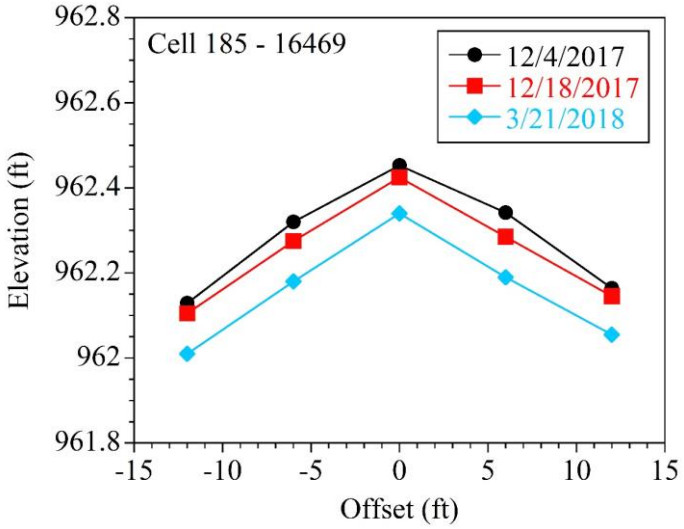
	16499	5	o					o
	16529	6		o			o	
	16559	7	o					o
	16569	End						

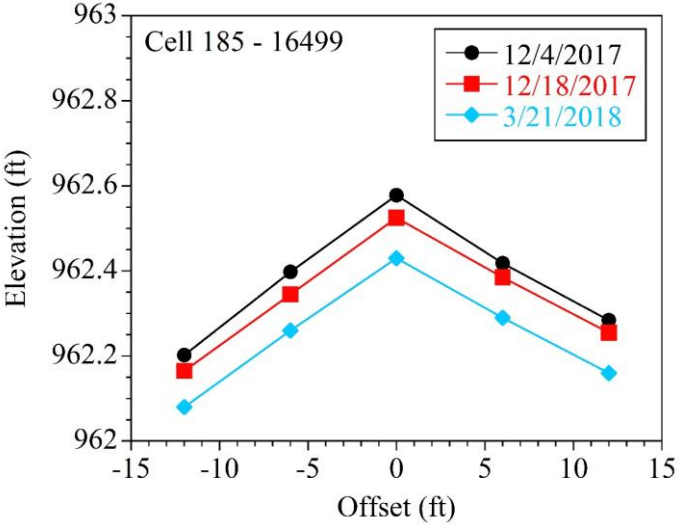
185

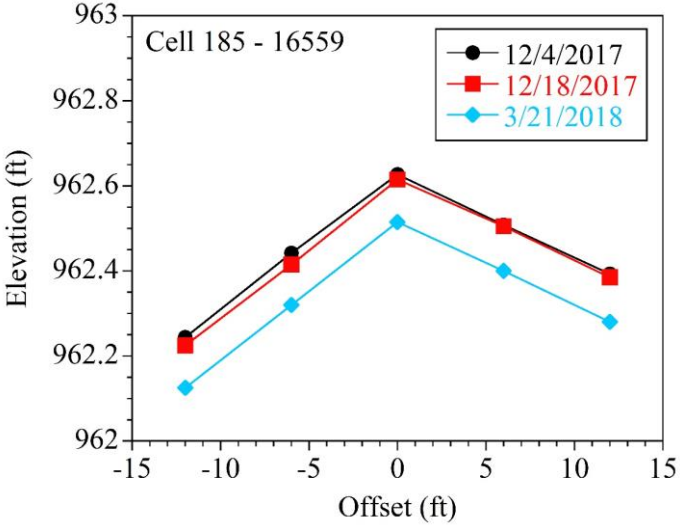


FROST HEAVE





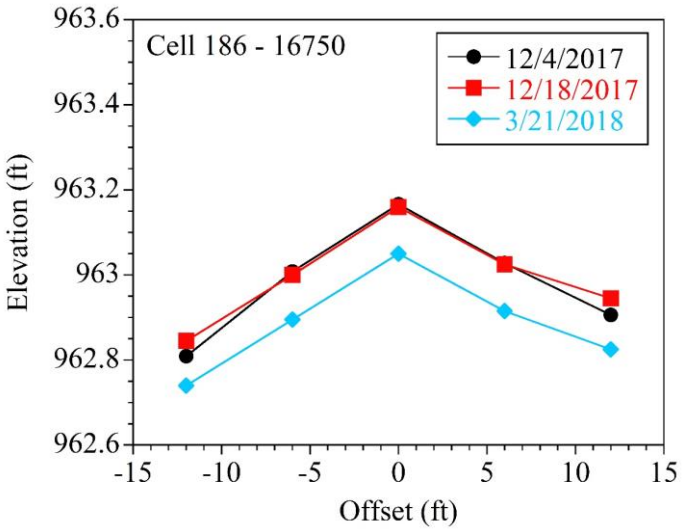


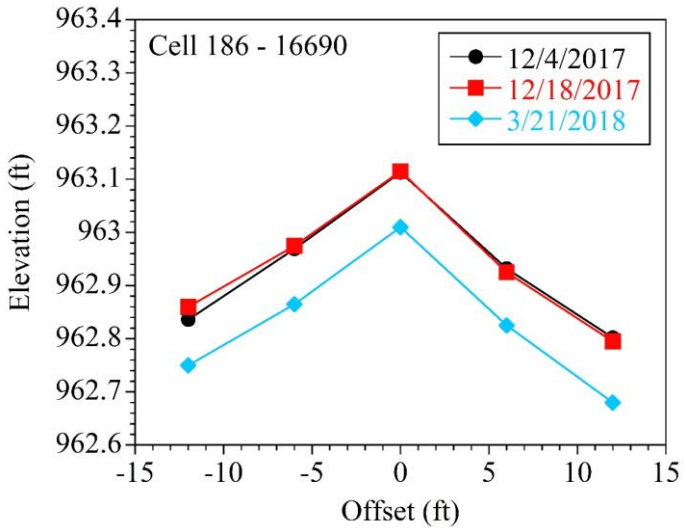


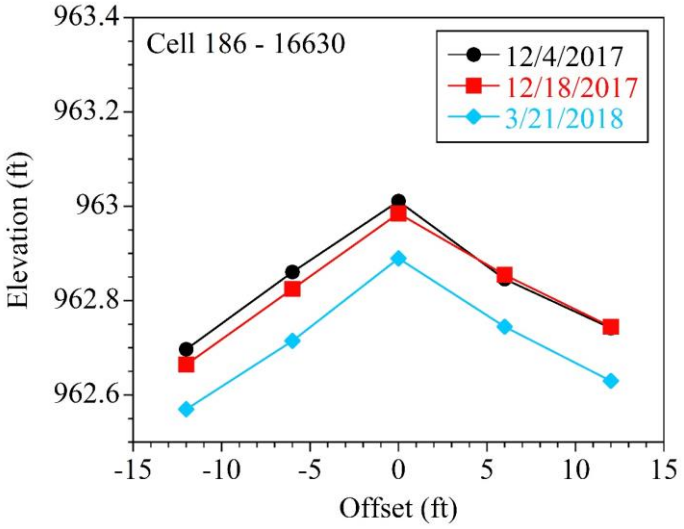
185

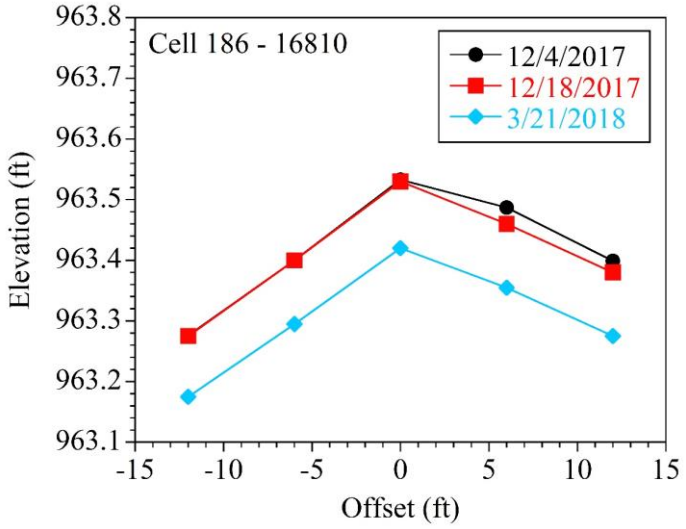
3.5 in Superpave
12 in Coarse RCA
3.5 in S. Granular Borrow
Sand

FROST HEAVE





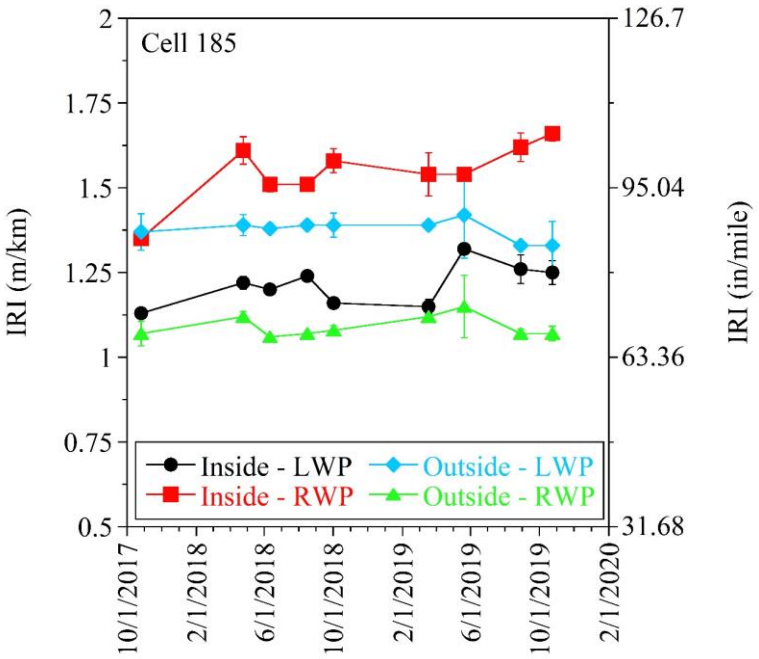


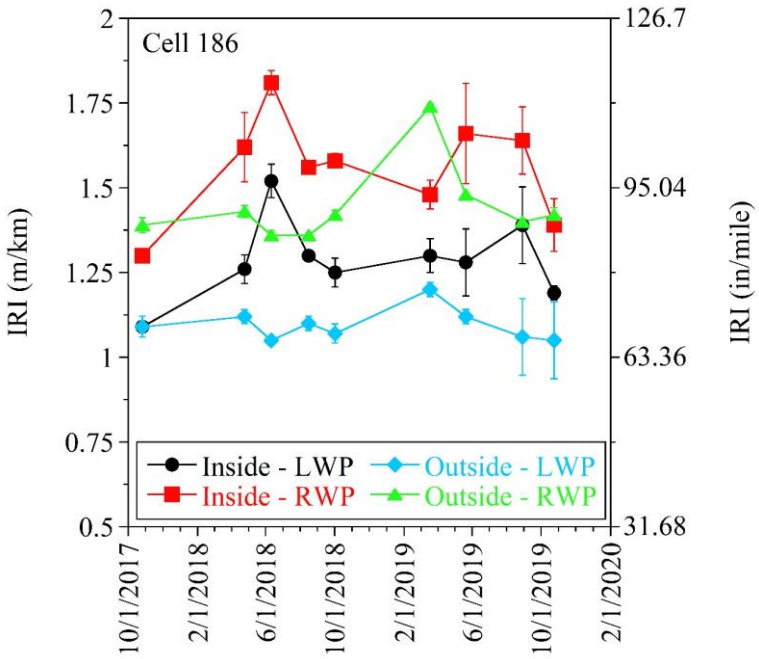


186

3.5 in Superpave
12 in Fine RCA
3.5 in S. Granular Borrow
Sand

IRI

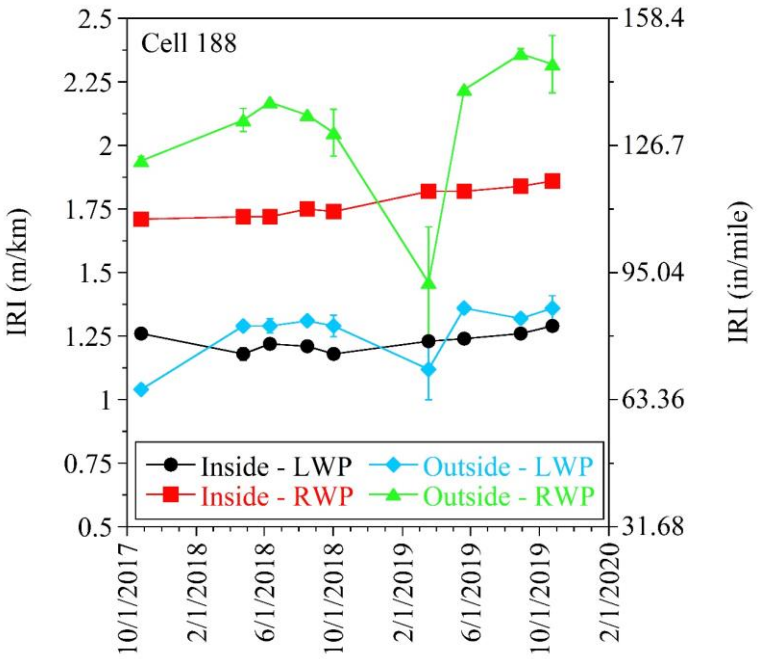


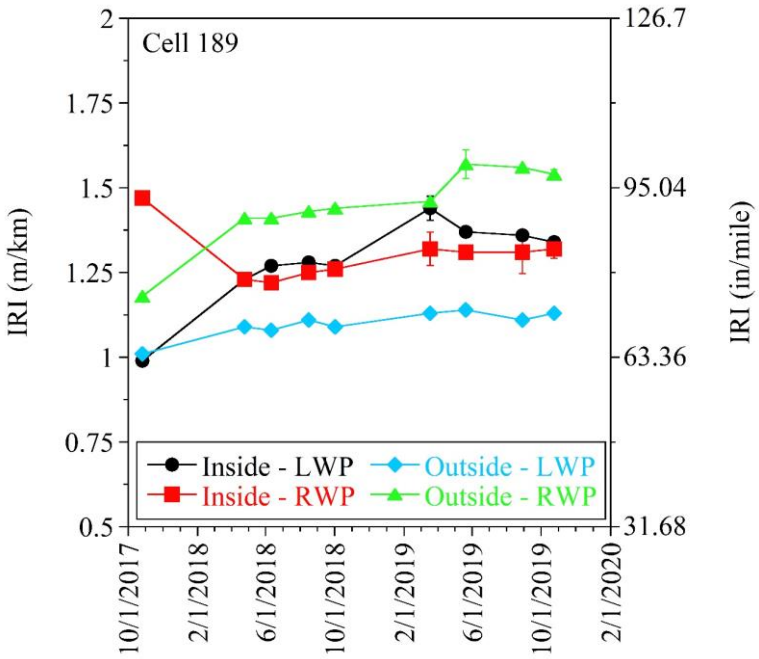


185	186
3.5 in Superpave	3.5 in Superpave
12 in Coarse RCA	12 in Fine RCA
3.5 in S. Granular Borrow	3.5 in S. Granular Borrow
Sand	Sand

LWP = Left Wheel Path
RWP = Right Wheel Path

IRI





188	189
3.5 in Superpave	3.5 in Superpave
12 in Limestone	12 in RCA+RAP
3.5 in S. Granular Borrow	3.5 in S. Granular Borrow
Clay Loam	Clay Loam

LWP = Left Wheel Path
RWP = Right Wheel Path

FROST DEPTH

Laboratory and field performance of recycled aggregate base in a seasonally cold region

Tuncer B. Edil, Bora Cetin, Ali Soleimanbeigi (2017)

- Freeze-point depression
  - Temperature at which water would begin to freeze in the materials
- Complete freezing
  - Lower temperature than the freeze-point depression

Table 2 Freezing-point depressions and freezing temperatures of materials (Rosa *et al.*, 2016).

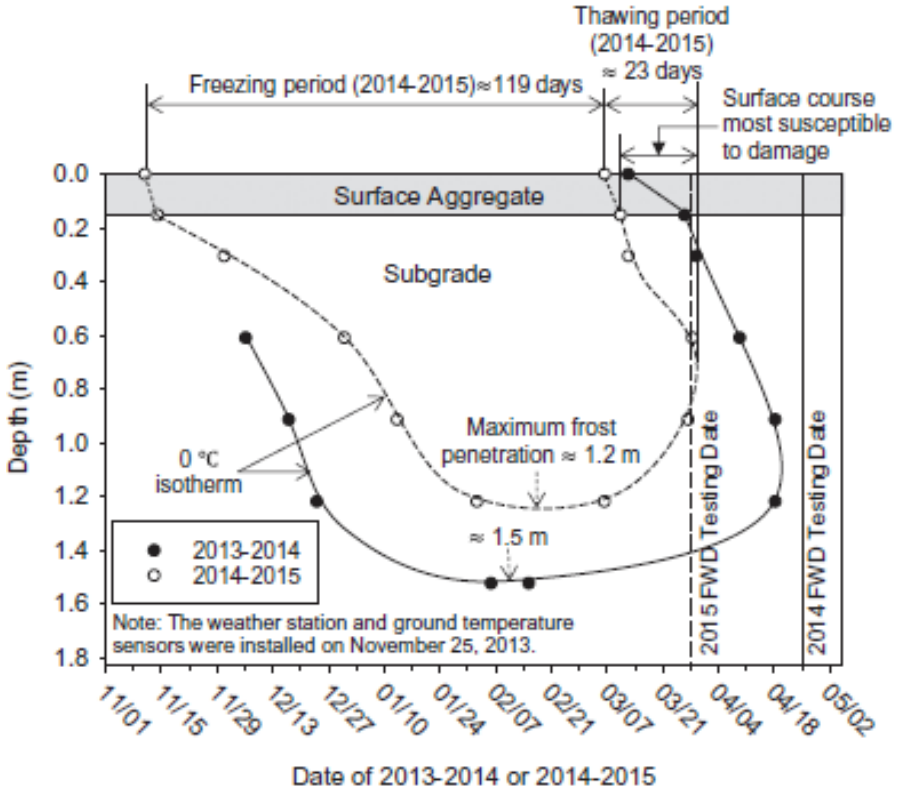
Materials	Freezing-point depression (°C)	Freezing temperature (°C)
RCA	–	−12
50% RCA~50% Aggregate	–	−12
RAP	−10	−15
Natural aggregate	−5.2	−12

FROST DEPTH

Mechanistic-based comparisons for freeze-thaw performance of stabilized unpaved roads

Cheng Li, Pavana K.R. Vennapusa, Jeramy Ashlock, David J. White (2017)

- 0°C isotherm lines

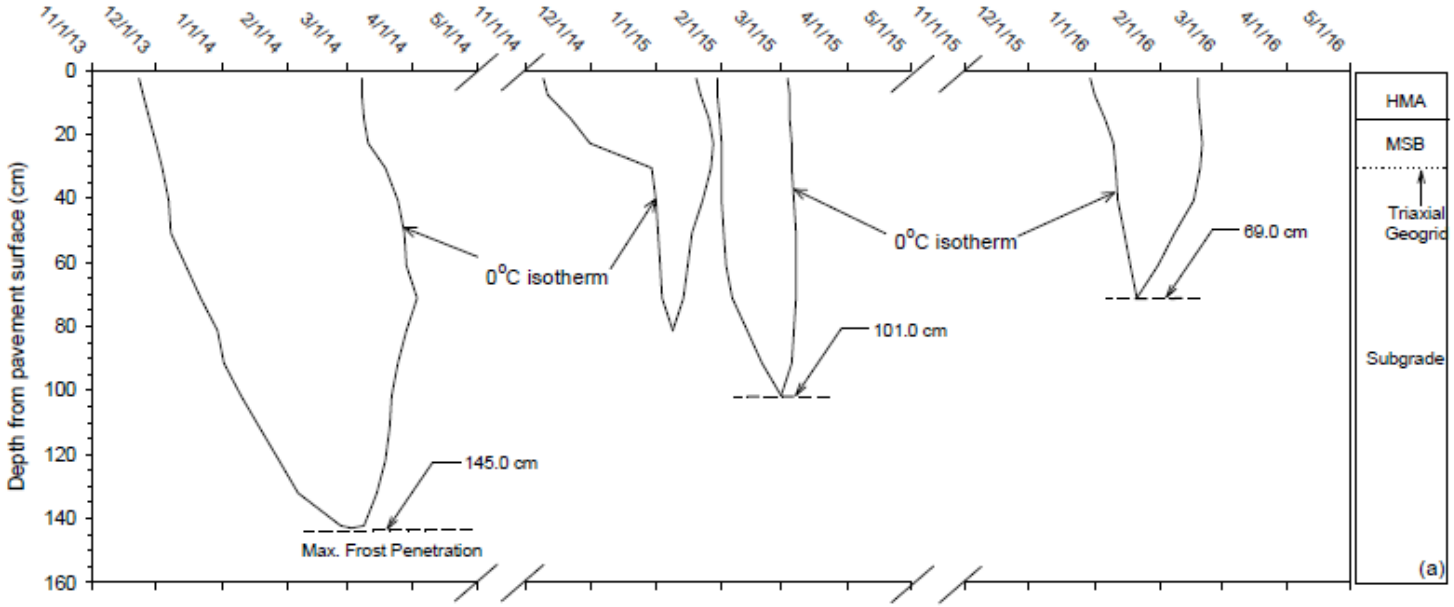


FROST DEPTH

Assessing seasonal performance, stiffness, and support conditions of pavement foundations

Yang Zhang (2016)

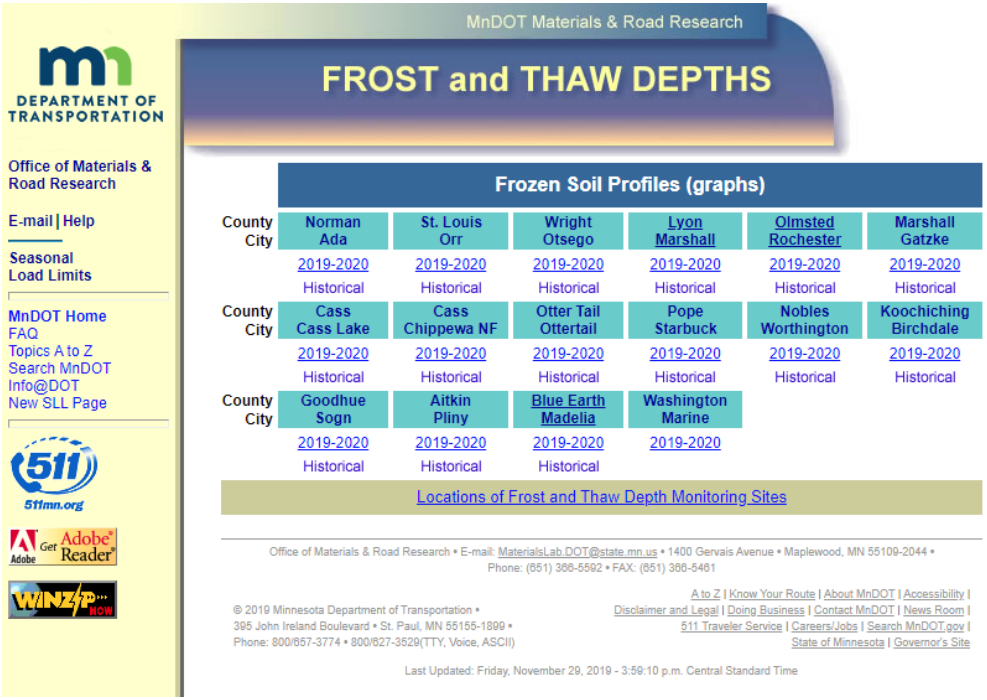
- 0°C isotherm lines
- ±0.5°C to determine the number of freeze-thaw cycles

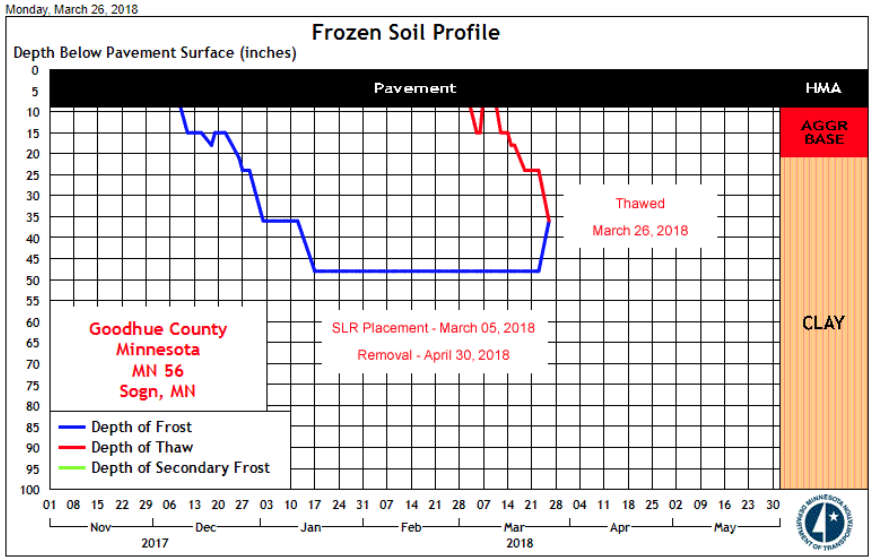


FROST DEPTH

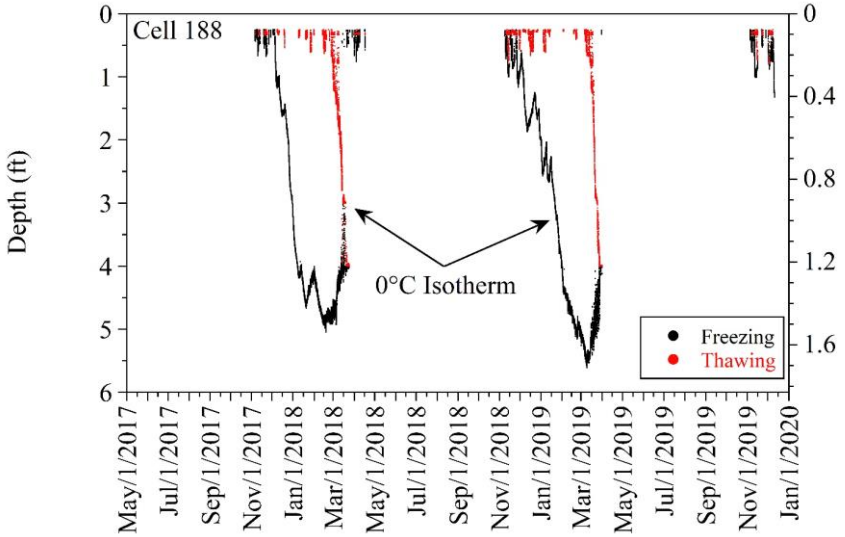
MnDOT Method

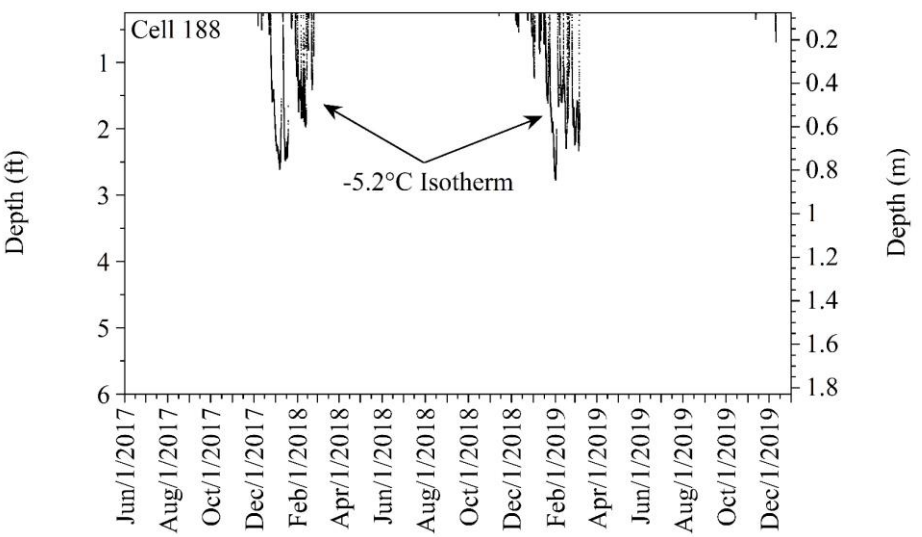
- 23 hours in a day is below 0°C – freezing
- More than 4 hours in a day higher than 0°C – thawing

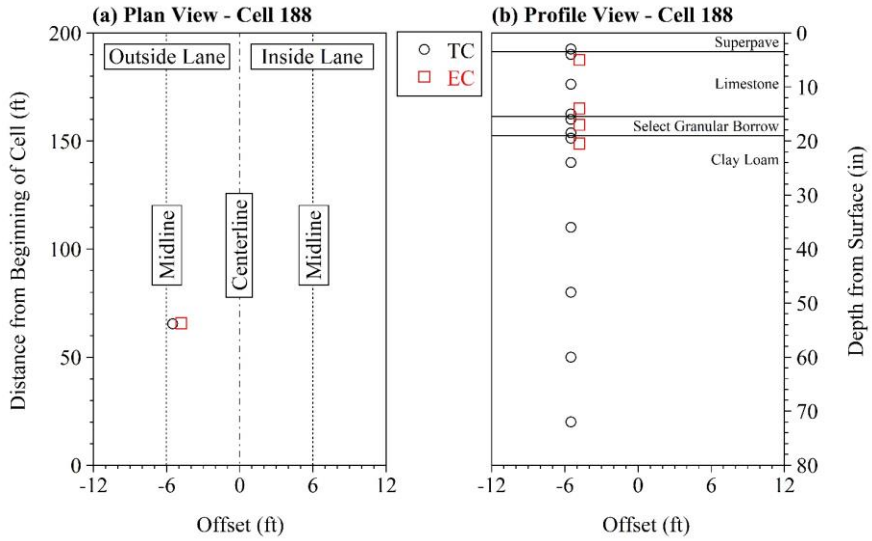


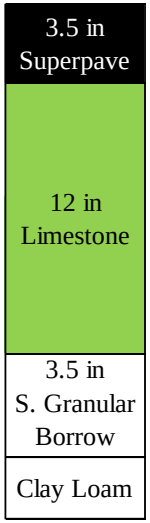


FROST DEPTH


Cell 188
0°C Isotherm
Freezing
Thawing
Depth (ft)
Depth (m)
May/1/2017
Jul/1/2017
Sep/1/2017
Nov/1/2017
Jan/1/2018
Mar/1/2018
May/1/2018
Jul/1/2018
Sep/1/2018
Nov/1/2018
Jan/1/2019
Mar/1/2019
May/1/2019
Jul/1/2019
Sep/1/2019
Nov/1/2019
Jan/1/2020


Cell 188
-5.2°C Isotherm
Depth (ft)
Depth (m)
Jun/1/2017
Aug/1/2017
Oct/1/2017
Dec/1/2017
Feb/1/2018
Apr/1/2018
Jun/1/2018
Aug/1/2018
Oct/1/2018
Dec/1/2018
Feb/1/2019
Apr/1/2019
Jun/1/2019
Aug/1/2019
Oct/1/2019
Dec/1/2019


(a) Plan View - Cell 188
Outside Lane
Inside Lane
Midline
Centerline
Midline
TC
EC
Distance from Beginning of Cell (ft)
Offset (ft)
(b) Profile View - Cell 188
Superpave
Limestone
Select Granular Borrow
Clay Loam
Depth from Surface (in)
Offset (ft)


188
3.5 in Superpave
12 in Limestone
3.5 in S. Granular Borrow
Clay Loam

Thank You!

QUESTIONS??

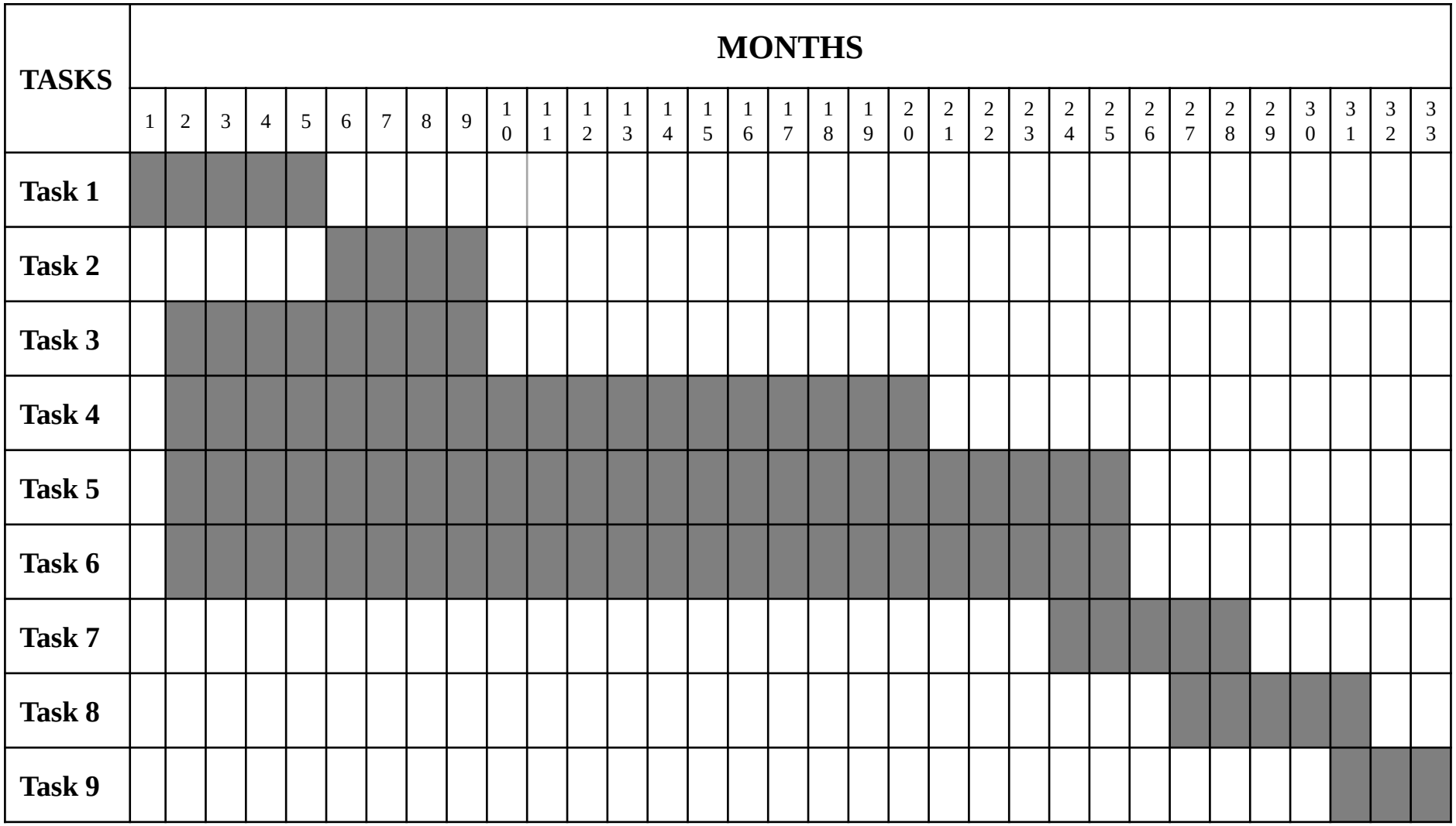
IOWA STATE UNIVERSITY

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

MICHIGAN STATE
UNIVERSITY

Iowa State University | University of Wisconsin-Madison | Michigan State University

SCHEDULE


TASKS
MONTHS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Task 7
Task 8
Task 9