Subgrades & Subbases:
Iowa DOT Research and Next Steps

VIC

E-Construction

APLT

Outline

- Overview of challenge facing the DOT

- Background & results of research projects
  - STIC project
  - AID project

- Overview of DOT Implementation Plan

- Closing comments and questions

Challenge facing the DOT

- The primary system includes 24,534 lane miles of pavement.

- Value to replace is over $14 billion

- Half of the system's original pavement is more than 55 years old.

- 29% (6,792 miles) is 70+ years old
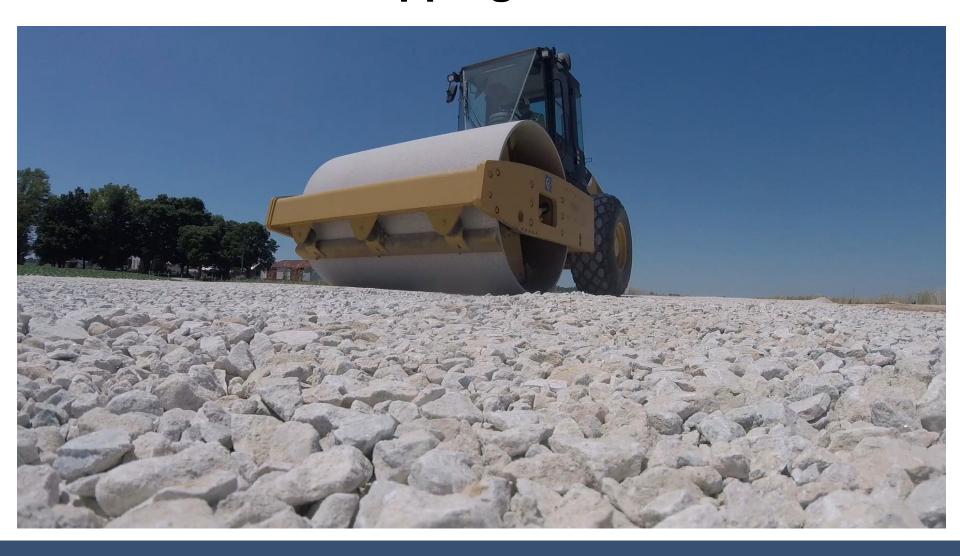
Challenge facing the DOT

- Current situation with funding.

- Need to extend pavement life.

- How?
  - Improve material performance
  - Improve foundations
  - Continually improve construction quality

Research Projects

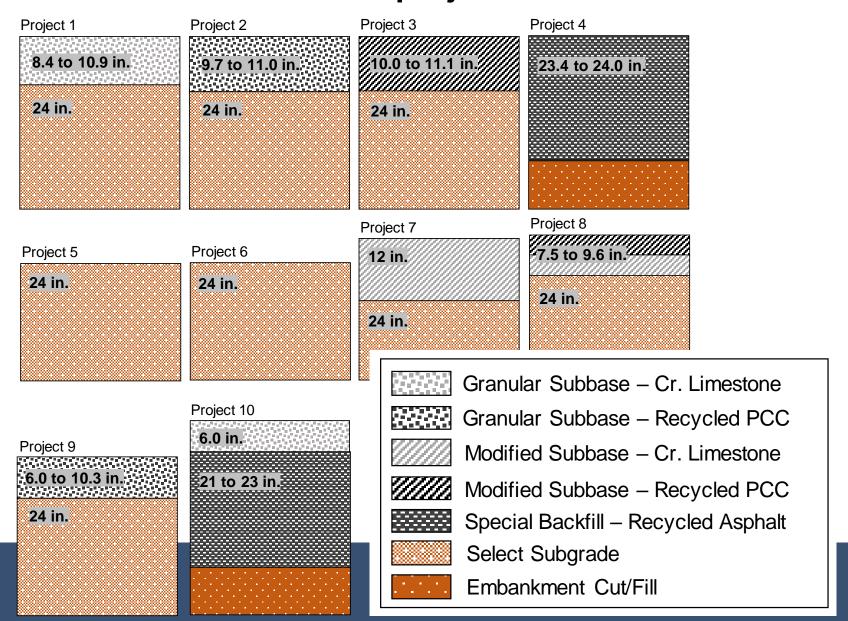- 2017 & 2018, STIC (State Transportation Innovation Council) Incentive Program: $100k

- 2019 & 2020, AID (Accelerated Innovation Deployment) Demonstration Program: $700k
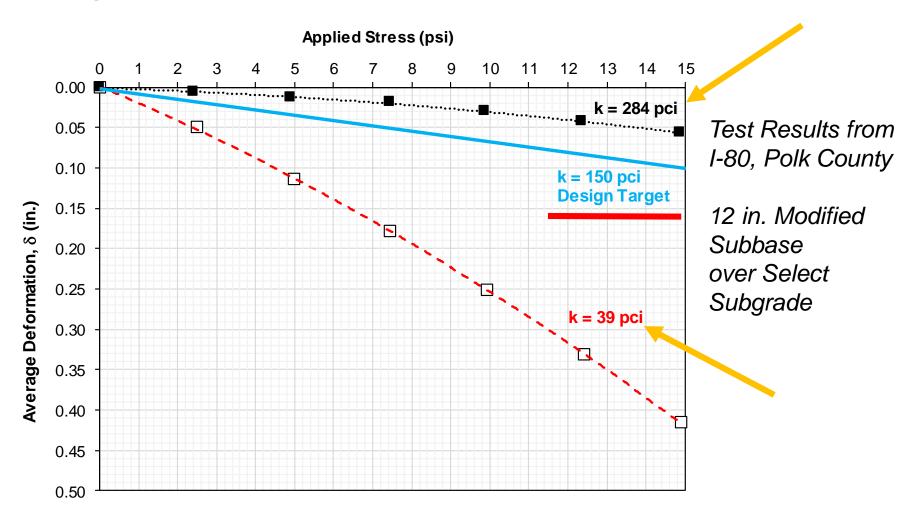
Roller Mapping of Modulus

Different typical foundation layer support conditions were evaluated at the 10 project sites.

Modulus is the most critical foundation input parameter in pavement design, and field verification of this value is important!

Applied Stress (psi)

Average Deformation, δ (in.)

k = 284 pci

k = 150 pci
Design Target

k = 39 pci

Test Results from I-80, Polk County

12 in. Modified Subbase over Select Subgrade

KEY Outcomes of this project are:

- ✓ M_r values are variable across the state and within each project site. C_v between 5% and 80% at each site.

- ✓ k-values across the site varied between 35 and 300 pci. 11 out of 14 tests showed < 150 pci.

- ✓ Sites with 2 ft of special backfill material provided higher Mr values than other sites.

- ✓ Typical values provided in the ME Design Guide based on soil classification are not reliable.

KEY Outcomes of this project are:

✓ K values over granular or modified were lower than those directly on underlying subgrade material.

✓ δ_p from static PLT varied between 0.05 and 0.4 in., with 11 out of the 14 tests > 0.05 in. critical limit.

✓ FE analysis showed that the two most important factors to reduce bending stresses in the pavement layer are pavement thickness and δ_p .

AID Project Objectives

- Continuation of APLT testing and incorporation of VIC technology

- Understand results obtained from current requirements
  - Measure modulus of foundation layers that are built with current specification requirements

- Shadow test with VIC and APLT technology

AID Project Objectives, Cont.

- Develop e-Construction system that allows near real time use of data

- Develop Implementation Plan
  - Identify improvements to current specifications (materials and construction requirements)
  - Identify changes to current pavement design procedures

AID TWG Members

Iowa DOT

- Newman Abuissa
- Ben Behnami
- Chris Brakke
- Vanessa Goetz
- John Hart
- David Heer
- Dean Herbst
- Hugh Holak
- Stephen Megivern
- Kevin Merryman
- Brian Moore
- Wes Musgrove
- Jeffrey Schmitt
- Melissa Serio
- Dustin Skogerboe

Industry Stakeholders

- Dan King (ICPA)
- Ryan Kipp (CJ Moyna)
- Adam Kos (CJ Moyna)
- Brian Manatt (Manatts)
- Greg Mulder (ICPA)
- Ron Otto (AGC Iowa)
- Cork Peterson (PCI US)
- Scott Dockstader (APAI)
- Steve Streb (Streb Construction)
- Tim Tometich (Manatts)

FHWA

- Micah Loesch
- Lisa McDaniel

Academia
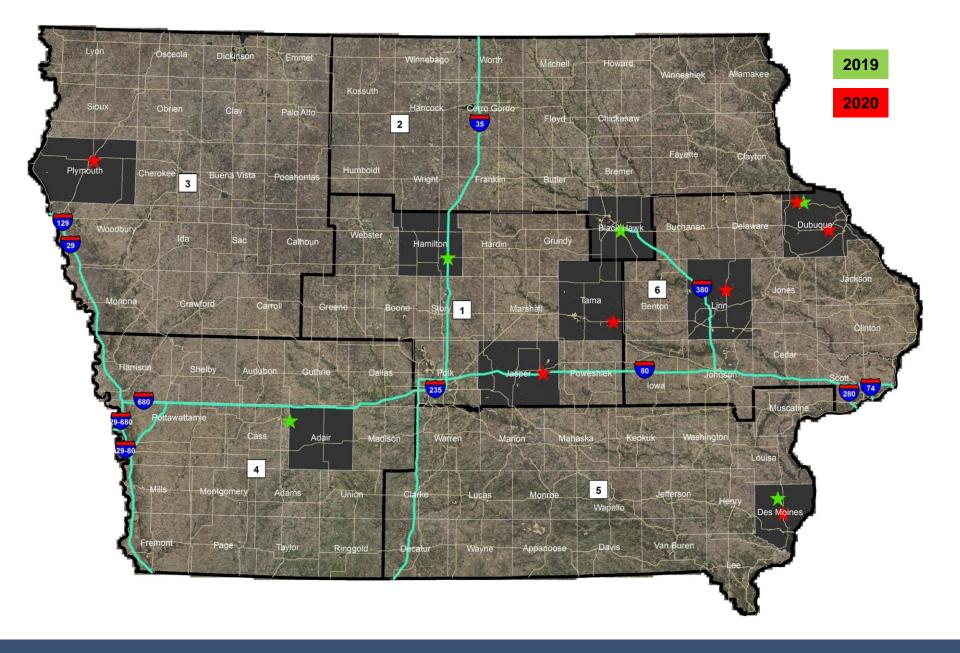
- Prof. Bora Cetin (Michigan State University)

Ingios

- Tom Cackler
- Bruce Cunningham
- Brendan Fitzpatrick
- Kera Gieselman
- LaDon Jones
- Craig Swanson
- Colby VanNimwegen
- Pavana Vennapusa
- David White

2019-2020 Scope for Mapping Verification

2020:
- No. of Projects Sites: 9
- No. of Maps Performed: 134
- No. of APLT Performed: 78

2019:
- No. of Projects Sites: 6
- No. of Maps Performed: 38
- No. of APLT Performed: 59
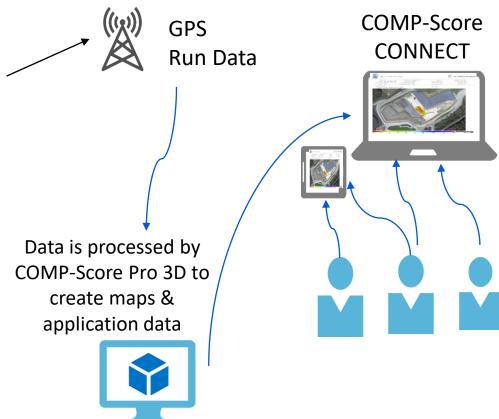
E-construction Data Flow & Processing

GPS
Run Data

COMP-Score
CONNECT

Data is processed by
COMP-Score Pro 3D to
create maps &
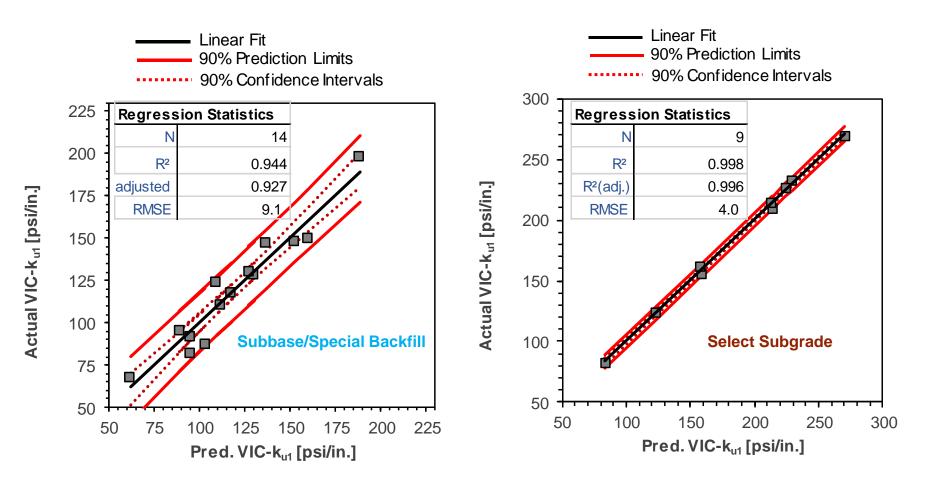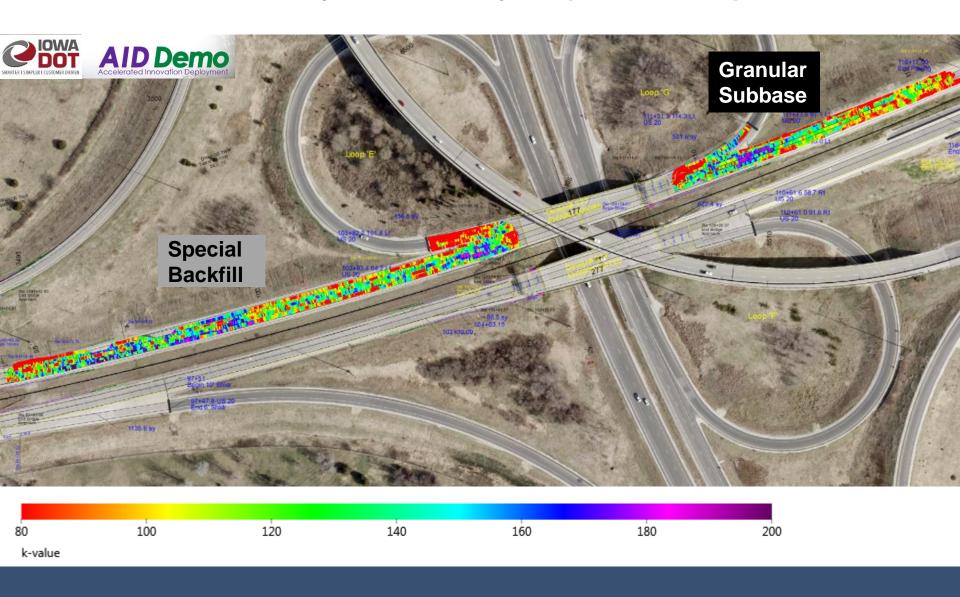application data

COMP-Score calibration of k-values on-site provides high confidence in the modulus mapping outputs.
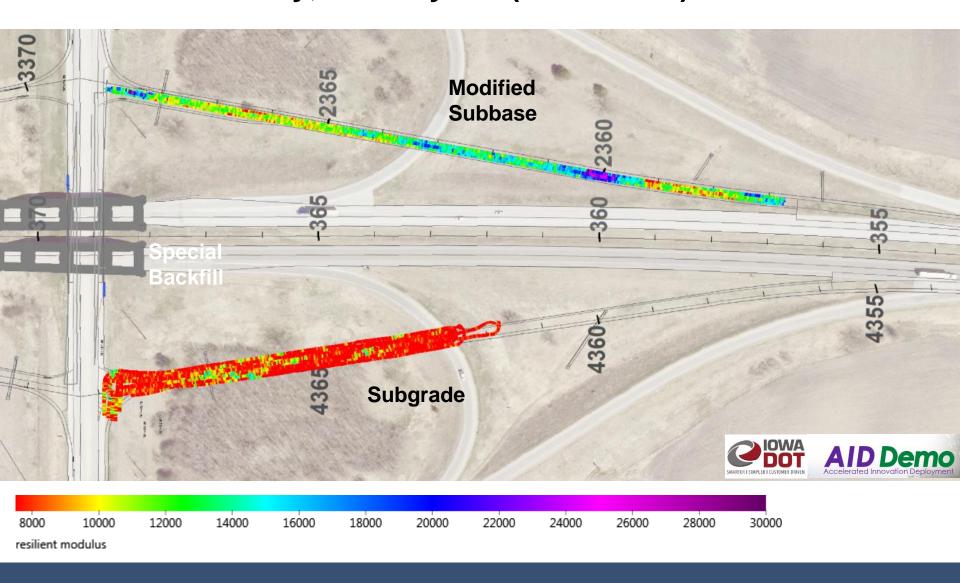
Blackhawk County, US20 Project (08/27/2019)

Hamilton County, I35/Hwy175 Ramps
Select Subgrade (TOP) and Modified Subbase (BOTTOM)
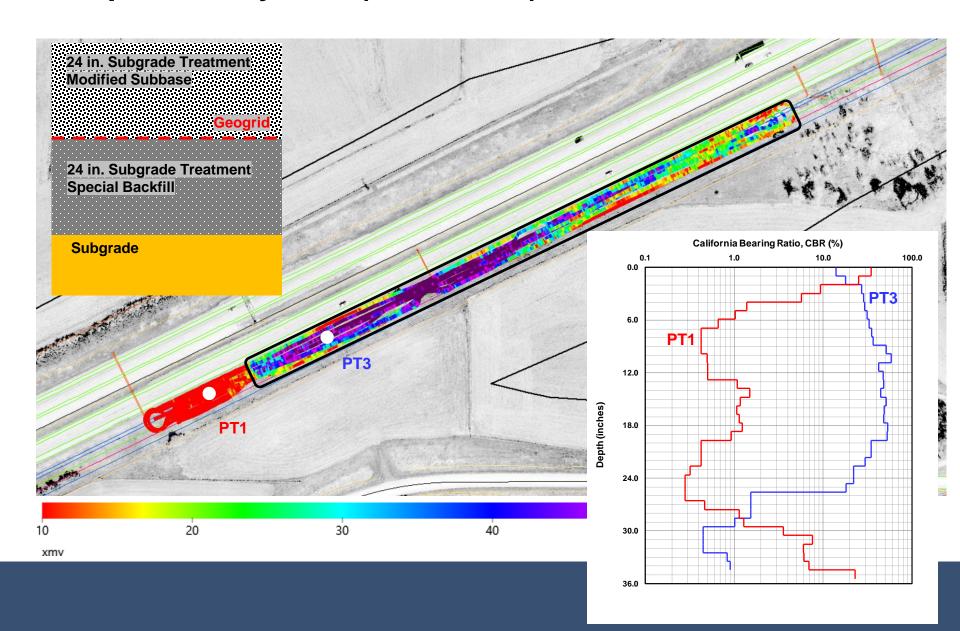
Hamilton County, I35/Hwy175 (09/03/2019)

Jasper County, I-80 (06/18/2020)

Subgrade Treatment

24 in. Subgrade Treatment Modified Subbase

Geogrid

24 in. Subgrade Treatment Special Backfill

Subgrade

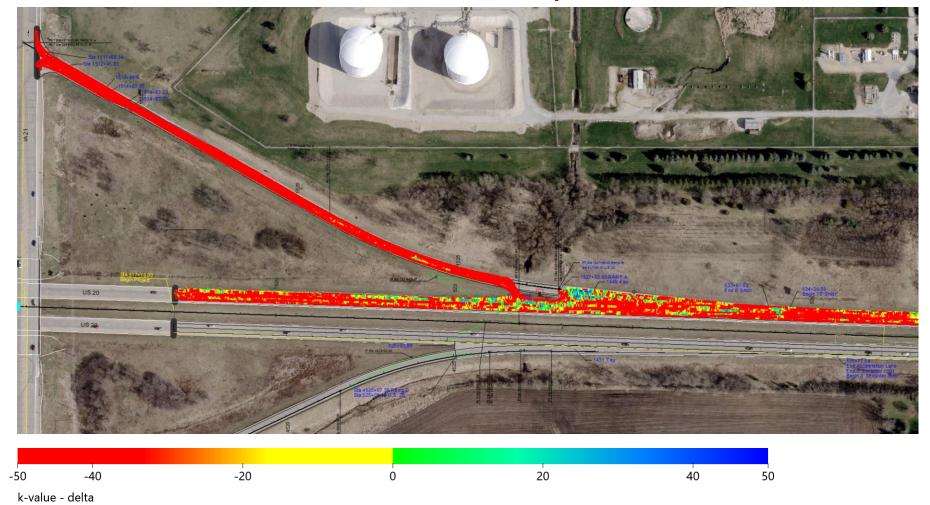**Subgrade (No treatment)**

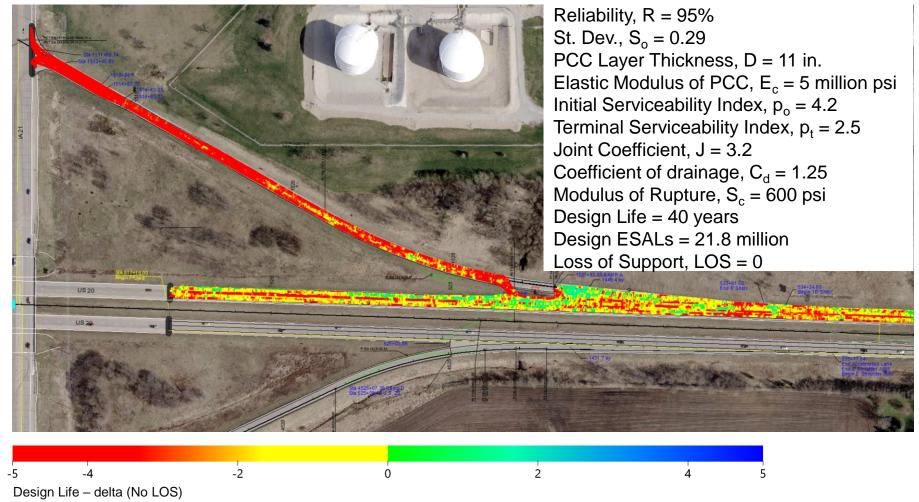# Jasper County, I-80 (06/18/2020)

Blackhawk County, US20 (09/05/2019) – Modified Subbase
Delta k-value Map

k-value - delta

Blackhawk County, US20 (09/05/2019) – Modified Subbase

Delta Design Life Map 1

Reliability, R = 95%
St. Dev., S_o = 0.29
PCC Layer Thickness, D = 11 in.
Elastic Modulus of PCC, E_c = 5 million psi
Initial Serviceability Index, p_o = 4.2
Terminal Serviceability Index, p_t = 2.5
Joint Coefficient, J = 3.2
Coefficient of drainage, C_d = 1.25
Modulus of Rupture, S_c = 600 psi
Design Life = 40 years
Design ESALs = 21.8 million
Loss of Support, LOS = 0

Design Life – delta (No LOS)

-5   -4   -2   0   2   4   5

Blackhawk County, US20 (09/05/2019) – Modified Subbase
Delta Design Life Map 2

Reliability, R = 95%
St. Dev., S_o = 0.29
PCC Layer Thickness, D = 11 in.
Elastic Modulus of PCC, E_c = 5 million psi
Initial Serviceability Index, p_o = 4.2
Terminal Serviceability Index, p_t = 2.5
Joint Coefficient, J = 3.2
Coefficient of drainage, C_d = 1.25
Modulus of Rupture, S_c = 600 psi
Design Life = 40 years
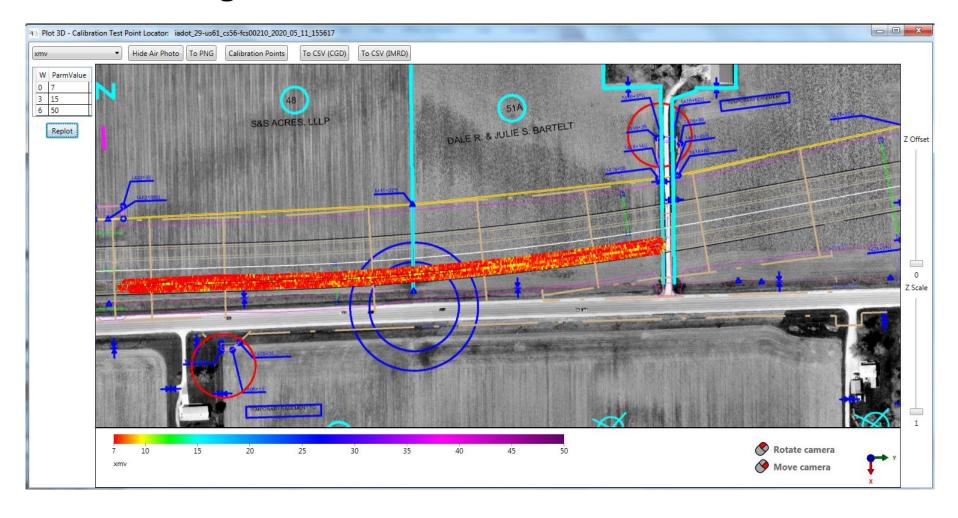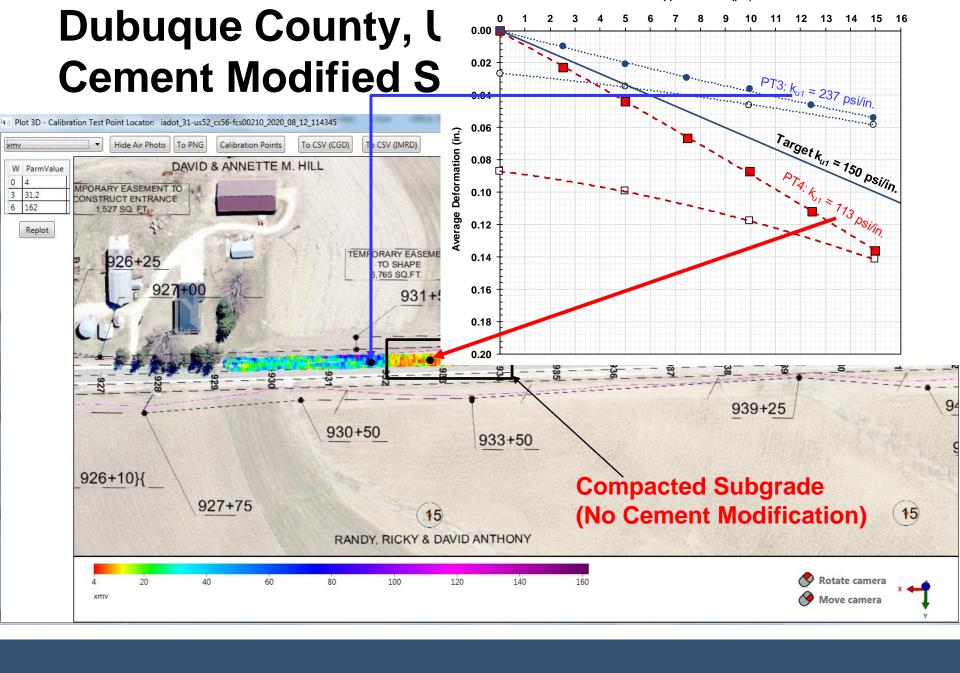Design ESALs = 21.8 million
Loss of Support, LOS = 2

Design Life – delta (LOS = 2)

Des Moines County, US61 (10/23/2019 – FALL)
Select Subgrade

Des Moines County, US61 (05/16/2020 – Spring) Select Subgrade

Dubuque County, US52
Modified Subbase

Dubuque County, L
Cement Modified S

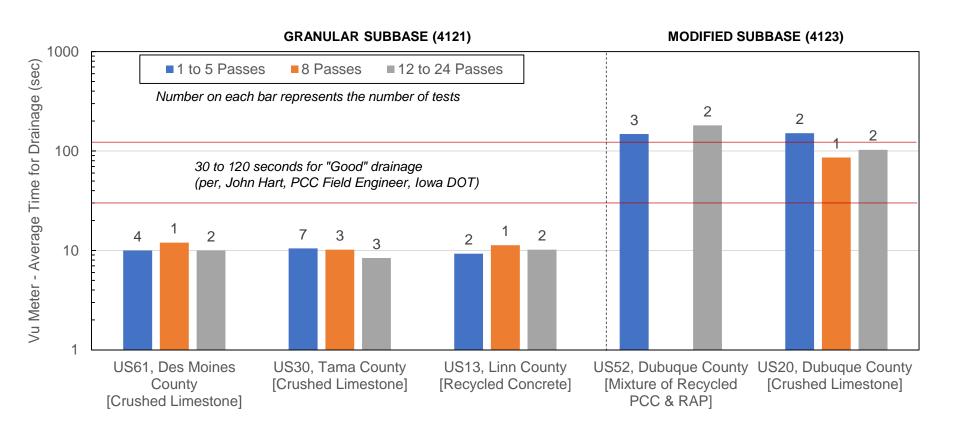**Compacted Subgrade
(No Cement Modification)**

How does current compaction specification on Granular Subbase affect Drainage Vs. Stiffness
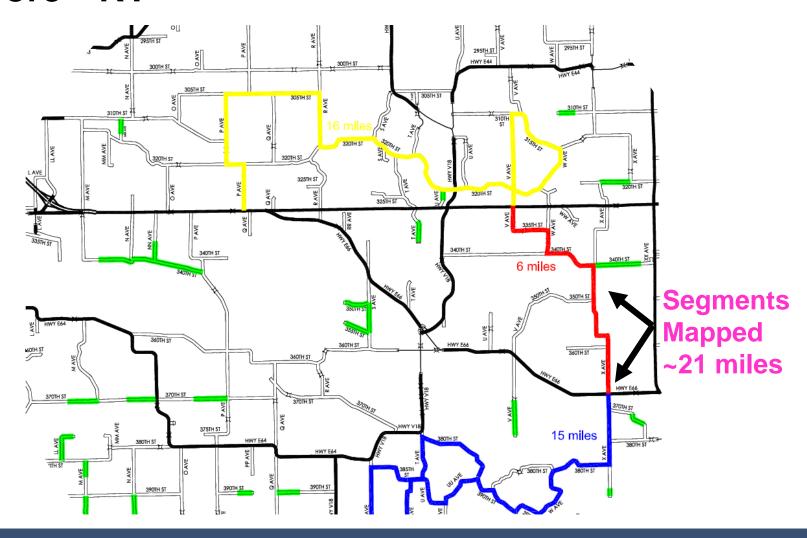

US61, Des Moines County (06/16/2020) Granular Subbase – Crushed Limestone

Summary of Vu Meter Test Results from multiple project sites

Secondary Roads Evaluation using COMP-Score™ RT

Mapping Length:

21 miles
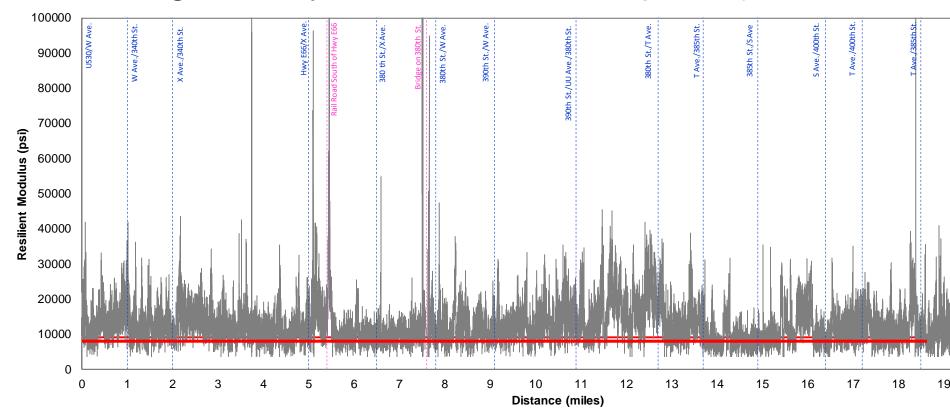
Mapping Duration:

6 hours

Number of Data Points:
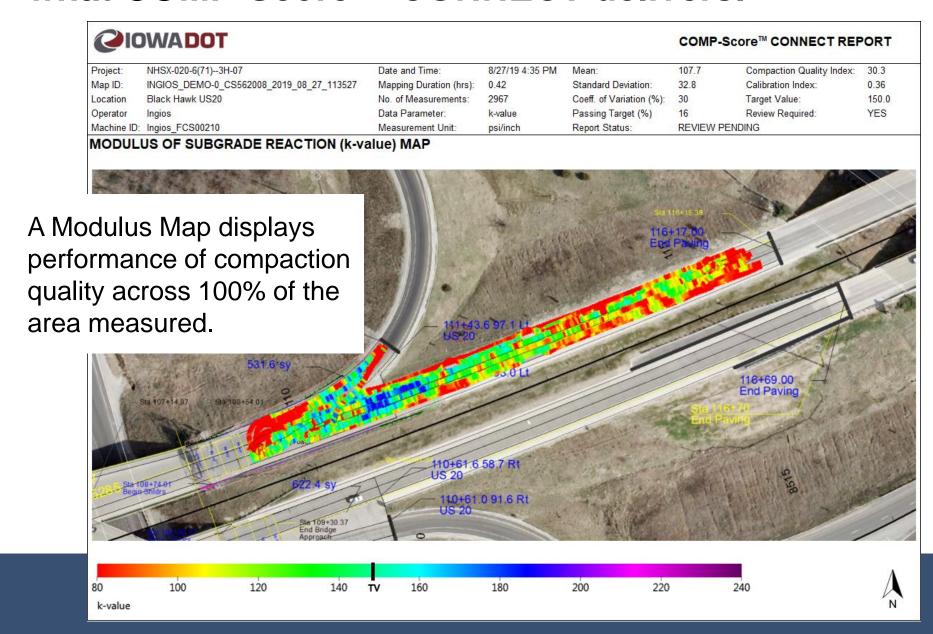
38,729

Analysis underway to assess % of roadway needing repair, with options for repair (remove/replace or thicker gravel layer or stabilization options)

Reference Target Composite Modulus Value [9,000 psi]

Compaction reports are a key component of what COMP-Score™ CONNECT delivers.

A Modulus Map displays performance of compaction quality across 100% of the area measured.

Compaction reports are a key component of what COMP-Score™ CONNECT delivers.

Quality analysis metrics give the viewer a quick glance at how the mapping performed against established targets.

IOWADOT

COMP-Score™ CONNECT REPORT

Project:	NHSX-020-6(71)--3H-07	Date and Time:	8/27/19 4:35 PM	Mean:	107.7	Compaction Quality Index:	30.3
Map ID:	INGIOS_DEMO-0_CS562008_2019_08_27_113527	Mapping Duration (hrs):	0.42	Standard Deviation:	32.8	Calibration Index:	0.36
Location:	Black Hawk US20	No. of Measurements:	2967	Coeff. of Variation (%):	30	Target Value:	150.0
Operator:	Ingios	Data Parameter:	k-value	Passing Target (%):	16	Review Required:	YES
Machine ID:	Ingios_FCS00210	Measurement Unit:	psi/inch	Report Status:	REVIEW PENDING		

QUALITY ANALYSIS SUMMARY
k-value

QUALITY VALUE	CRITERIA
30.3	CQI >= [95]
15.5	[80%] of [k-Value] MVs >= [k-value_TV]
30	COV <= [30]
46	% i-Score Blob Area >= 200 ft^2
	[80%] of [w%] >= w%_TV

Compaction Quality Index(CQI): Relative compaction quality index based on the percentage of the geospatial area that meets the minimum target values and accounts for the uniformity of compaction. The default minimum target CQI is 95 % using a uniformity weight factor of 50 %.

Percent Passing Target Values: Number of geospatial grid points from the output that meet or exceed the target value for the selected material. The default target % _Passing TV 80 %.

Coefficient of Variation (COV): Calculated from the ratio of the standard deviation to the mean based on the MVs reported at each grid point of the mapping area. The default target COV is 30%. Description of COV ranges: 20% = Low Variability; 20 to 40% = Moderate Variability; and greater than 40% = High Variability.

i-Score Blob (%): Represents the percentage of the area within the map area that has been identified from i-Score Blob Analysis as a prioritized contiguous area that is > = 200 sq. ft, with MVs < target values. Description of i-Score Blob: 0% = No rework needed; 0 to 20% = Some rework needed; 20 to 30% = Moderate rework needed; > 30% = Signficant rework needed.

Pilot Projects - 2021

- Boone County, IA 17
  - Grading
  - Approx. 0.5 miles N. of US 30 north and east approx. 3 miles
  - January 20, 2021 letting

- Black Hawk County, US 20
  - PCC Pavement – Replace
  - US 63 to IA 21 in Waterloo (EB / WB)
  - February 16, 2021 letting

Pilot Projects - 2021

- Special Provision: Modulus Verification Using Roller Mapping of Pavement Foundation Layers
  - Equipment Requirements
  - Training Requirements
  - Mapping Requirements
  - MOM & BOP

Overview of Implementation Plan

- 5 Year Plan (2021 – 2025) to transition from pilot projects to full implementation

- Plan is to have each RCE Office get project experience

- DOT considering having Ingios map completed grading projects in 2021 to support development of paving plans.

- Potential for county applications developed parallel with DOT implementation

Overview of Implementation Plan

Anticipated DOT Project Applications

- 2021 - 2 projects
- 2022 - 5 projects
- 2023 – ~10 projects
- 2024 – ~20 projects
- 2025 – Statewide implementation as standard

Overview of Implementation Plan

- Develop SPs for use in future years

- Develop training program to possibly integrate into DOT existing web-based curriculum

- Develop LCCA models

- Identify other DOTs interested in technology partnership

Closing Comments

- Additional questions/discussion?
- Thank you for attending!

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Construction & Materials Bureau, Iowa DOT

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