Subgrades & Subbases: Iowa DOT Research and Next Steps
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!

Test Results from I-80, Polk County

12 in. Modified Subbase over Select Subgrade
KEY Outcomes of this project are:

✓ Mr values are variable across the state and within each project site. Cv 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.

- $\delta_p$ 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 $\delta_p$. 
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

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Projects Sites</th>
<th>No. of Maps Performed</th>
<th>No. of APLT Performed</th>
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<tr>
<td>2020</td>
<td>9</td>
<td>134</td>
<td>78</td>
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<tr>
<td>2019</td>
<td>6</td>
<td>38</td>
<td>59</td>
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E-construction Data Flow & Processing

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.

Regression Statistics

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<tr>
<td>R²</td>
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<tr>
<td>adjusted</td>
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<td>RMSE</td>
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Regression Statistics

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<tr>
<td>RMSE</td>
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Subbase/Special Backfill

Select Subgrade
Blackhawk County, US20 Project (08/27/2019)

Granular Subbase

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

- Modified Subbase
- Special Backfill
- Subgrade
Jasper County, I-80 (06/18/2020)

Subgrade Treatment

- 24 in. Subgrade Treatment
- Modified Subbase
- Special Backfill
- Subgrade
- Geogrid

Subgrade (No treatment)
Jasper County, I-80 (06/18/2020)

- 24 in. Subgrade Treatment
- Modified Subbase
- 24 in. Subgrade Treatment
- Special Backfill
- Subgrade

![Diagram with depth and California Bearing Ratio (CBR) graph]

Depth (inches) vs. California Bearing Ratio (CBR %) for different layers, including PT1 and PT3.
Blackhawk County, US20 (09/05/2019) – Modified Subbase

Delta k-value Map

k-value - delta
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
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
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 Subgrade

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

**GRANULAR SUBBASE (4121)**

- US61, Des Moines County [Crushed Limestone]
  - 1 to 5 Passes: 4
  - 8 Passes: 1
  - 12 to 24 Passes: 2

- US30, Tama County [Crushed Limestone]
  - 1 to 5 Passes: 7
  - 8 Passes: 3
  - 12 to 24 Passes: 3

- US13, Linn County [Recycled Concrete]
  - 1 to 5 Passes: 2
  - 8 Passes: 1
  - 12 to 24 Passes: 2

**MODIFIED SUBBASE (4123)**

- US52, Dubuque County [Mixture of Recycled PCC & RAP]
  - 1 to 5 Passes: 3
  - 8 Passes: 2
  - 12 to 24 Passes: 2

- US20, Dubuque County [Crushed Limestone]
  - 1 to 5 Passes: 2
  - 8 Passes: 1
  - 12 to 24 Passes: 2

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Number on each bar represents the number of tests

30 to 120 seconds for "Good" drainage
(per, John Hart, PCC Field Engineer, Iowa DOT)
Secondary Roads Evaluation using COMP-Score™ RT

Segments Mapped ~21 miles

16 miles

6 miles

15 miles
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.
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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