Innovations in Subgrade & Subbase Construction for Iowa’s Highways

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PRESENTERS
Chris Brakke
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Outline

- Overview of challenge facing the DOT (Chris)
- Background & Results of Research Projects (Chris)
- Overview of DOT Implementation Plan & DOT Pilot Projects (Melissa)
Challenge facing the Iowa DOT

• Inadequate funding for the size of the system
  • Pavements will need to last 100+ years before replacement

• Need to extend pavement life & maintain cost effectiveness

• How to extend pavement life?
  • Improve pavement material performance
  • Improve foundation longevity, uniformity
  • Improve construction quality

• Construct long life/permanent foundations
  • Remain in-place during future pavement replacement
## Our annual investment

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>5 year total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subbase</strong></td>
<td>$16,797,382</td>
<td>$23,775,714</td>
<td>$23,775,714</td>
<td>$39,534,746</td>
<td>$13,293,528</td>
<td>$140,148,529</td>
</tr>
<tr>
<td><strong>Earthwork</strong></td>
<td>$23,559,157</td>
<td>$46,025,950</td>
<td>$39,177,551</td>
<td>$30,486,240</td>
<td>$13,822,561</td>
<td>$153,071,461</td>
</tr>
<tr>
<td><strong>Pavement</strong></td>
<td>$79,252,321</td>
<td>$142,667,820</td>
<td>$176,990,516</td>
<td>$218,134,096</td>
<td>$80,554,583</td>
<td>$697,599,338</td>
</tr>
</tbody>
</table>
~40 year lifespan = state of practice for pavement design life

100+ year lifespan = engineering requirement for sustainable pavement systems

Improved pavement foundations extend pavement life and decrease project costs over time.
Research/Implementation Projects

• 2017 & 2018, STIC (State Transportation Innovation Council) Incentive Program: $100k
  ❖ Focused on obtaining in-situ foundation properties for Pavement-ME Design input
  ❖ Highlighted deficiencies in our current foundation design process

• 2019, 2020 & 2021 AID (Accelerated Innovation Deployment) Demonstration Program: $700k
  ❖ Implementation of Pavement foundation modulus verification and construction quality monitoring
FHWA’s Report to Congress on the AID-PT program

AID-PT SHORT TAKE

Pavement Foundation Research
Foundation design is a key aspect of pavements structural design that needs to be considered in design processes. The basis of design in current mechanistic-empirical (ME) design procedures are pavement responses such as stresses, strains, and deflections. Because the stiffness of unbound base layers is significantly less than that of surface layers, foundation layers have a relatively minor impact on pavement response. Thus, the benefits of a good foundation are not adequately reflected in the ME design process. While fundamentally, the ME design concept is sound, the ME designs do not consider the effects of any deterioration or spatial variability in the foundation layers. Over time, the conditions of the foundation layers can degrade and deform under the influence of repeated heavy loads, leading to non-uniform support conditions and localized failures. Thus, the principal role of a robust pavement foundation is ensuring the foundation layers retain their integrity throughout the pavement life.

Improving pavement foundation design is a focus area for FHWA. A pavement foundation that does not degrade over time does not need to be replaced, which may translate to significant sustainability benefits in environmental impact and costs. In congested areas, eliminating the need to replace the foundation could be highly advantageous by expediting pavement rehabilitation.
“I’m a believer now and you can’t cheat with this stuff.”

(Trained contractor operator, May 2021)
COMP-Score RT Technology

Computer screen showing spatial color-coded data overlain on georeferenced aerial image.

Position Sensors

Sensor

Sensor

Vibrating Drum

Layer 1

Layer 2

Layer 3

Vibrations transmitted into ground
e-Construction

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

COMP-Score CONNECT

GPS
Run Data
Subgrade Composite
$M_r = 3,293$ psi

Subbase/Subgrade Composite
$M_r = 25,162$ psi
125 tests: 31% meet the minimum design requirement for foundation support

- k = 150 psi/in (Assumed in Design by IADOT)

- N = 10 (US20 Blackhawk Cty 2021)
- N = 100 (IA-AID Project)
- N = 15 (FHWA-STIC Project)

31% of measurements > k = 150 psi/in.

- Power (All Data)

- y = 23.372x^{-1.161}
- R² = 0.9026
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

(1) Variability field conditions, and
(2) Potential for large permanent deformation (LOS).
= Reduced ride quality
KEY Outcomes of the projects are:

1. k-value tests reveal ~70% of the measurements do not meet the current assumed value in the design.

2. COMP-Score RT modulus mapping provides high degree of confidence in providing k-value and $M_r$-value maps – $R^2$ values > 0.90

3. Modulus calibration records produced for different materials across State.

4. COMP-Score RT mapping identifies “weak” areas.
Overview of Implementation Plan

- 5 Year Plan (2021 – 2025) to transition from pilot projects to full implementation
  - 2021 - 2 projects
  - 2022 – 4-5 projects
  - 2023 – ~10 projects
  - 2024 – ~20 projects
  - 2025?? – Statewide implementation as std.
2021 Pilot Project
Black Hawk US 20

• 3 miles of reconstruction of 4 lane (EB/WB) divided highway
• Mapping on subgrade, modified & granular subbase
• 176 e-Compaction Reports.
• Geogrid stabilization recommendations based on review of mapping results
2021 Pilot Project
Black Hawk County US 20
2021 Pilot Project
Black Hawk County US 20

Initial Map
6/11/2021 [08:02 AM]

Re-Map after rework
6/15/2021 [12:08 PM]
• Grading only
• Mapping required on 6 compacted soil layers
• 61 e-Compaction Reports
• Cement stabilization recommendations based on review of mapping results
2021 Pilot Project
Boone County IA 17
Lessons Learned from or during 2021 Pilot Projects

- Adjustments to target values and blob sizes during projects
- Showed how “great” material does not always meet design values
- Increase estimated quantities for stabilization
- Modifications to e-Construction dashboard & reports
Lessons Learned from or during 2021 Pilot Projects

- Update to training materials
- Need for additional testing on stabilization methods, such as best location for geogrid
2022 Pilot Projects

• December 21, 2021, letting
  – Jasper I-80
    • Marshalltown RCE
    • Grid
  – Boone IA 17
    • Jefferson RCE
    • Cement stabilization (including areas from previous grading project)

• All 2022 pilot projects provide for additional quantity of mapping for additional compaction pass
2022 Pilot Projects

• March 15, 2022, letting
  – Dubuque IA 3
    • Manchester RCE
    • Cement stabilization

• Previously let project
  – Benton US 30
    • Cedar Rapids RCE
    • Stabilization TBD
Overview of Implementation Plan – Next Steps

• Identify & evaluate specification and design changes to cost effectively deliver better performing pavement foundations

• Quantify value proposition of longer performing foundations

• Develop SPs for use in future years

• Determine best contracting arrangement to continue this work (changes likely for 2023 projects)

• Continue work with TWG
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
Questions/Comments?

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