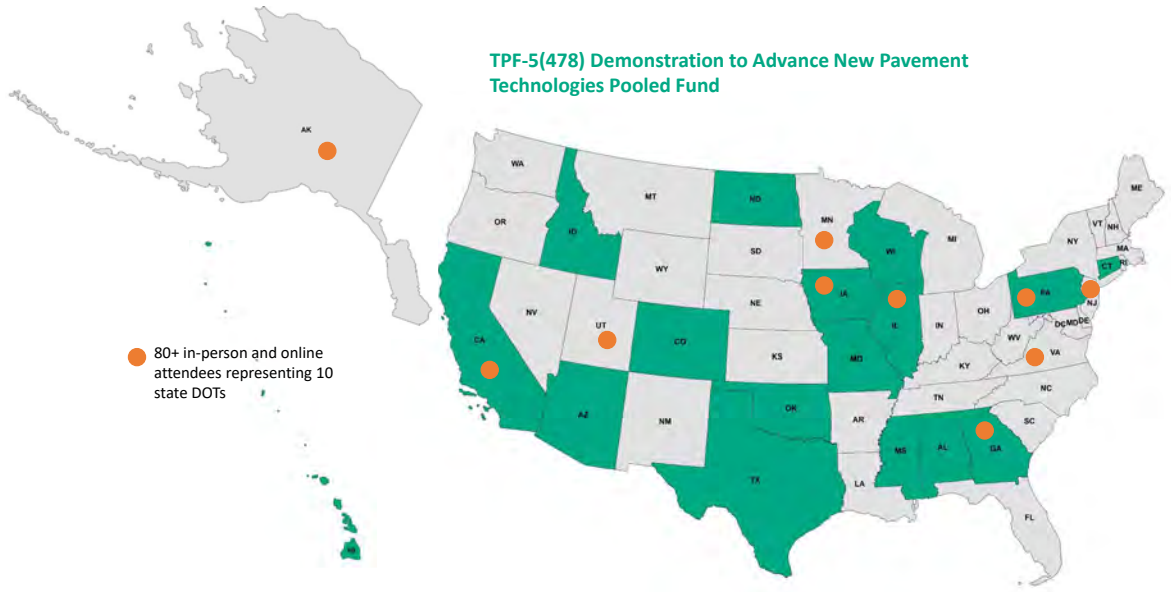
Demonstration of Innovative Technologies for Pavement Foundation Layer Construction: Iowa DOT Open House (October 28, 2022)



Interim Report for Open House

January 24, 2023

TPF-5(478) OHR

Sponsored by the Iowa Department of Transportation and Federal Highway Administration

SUBMITTED BY
INGIOS GEOTECHNICS, INC

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16. Abstract

The Iowa Department of Transportation has recognized that the current level of performance from their pavements is not financially sustainable which has motivated the Iowa DOT to develop practical steps that will result in a lower ownership cost for their pavement infrastructure and increase their level of service to the public. The Iowa Department of Transportation believes that the next step forward in pavement foundation construction quality as well as optimized pavement designs will be realized by implementing design-value, modulus-based assessment and ensuring that the pavement design assumptions are met during construction. The FHWA has also recognized the need to improve the quality of pavement foundations nationally and has identified this need as a focus area in their 2019/2020 annual report to Congress on the Accelerated Implementation and Deployment of Pavement Technologies, AID-PT program. In recognition of this need the FHWA established Transportation Pooled Fund Project TPF-5(478) entitled: Demonstration to Advance New Pavement Technologies Pooled Fund. In 2022, The Iowa DOT joined the study and submitted a proposed project "Support for Pavement Foundation Design Modulus Verification and Construction Quality Monitoring" which was accepted to provide support for piloting and implementing modulus-based pavement foundation construction. To meet the project objectives, a technology field open house was completed on October 28, 2022. The open house was hosted jointly by The Iowa Department of Transportation, Ingios Geotechnics, Inc. (Ingios), and The Federal Highway Administration. This report documents the background and presentation activities of the open house.

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Demonstration of Innovative Technologies for Pavement Foundation Layer Construction: Iowa DOT Open House (October 28, 2022)

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Sponsored by the Iowa Department of Transportation and Federal Highway Administration TPF -5(478)

Submitted by Ingios Geotechnics, Inc.

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Sincere thanks to the following individuals for their support of this open house:

Presenters

FHWA ■ Thomas Yu
Iowa Department of Transportation ■ Wes Musgrove, Chris Brakke, Melissa Serio
Ingios Geotechnics, Inc. ■ Dr. David White, John Puls, Craig Swanson, Kera Gieselman, Colby VanNimwegen

Moderators

Ingios Geotechnics, Inc. ■ John Puls, Kera Gieselman

Planning Committee

Iowa Department of Transportation ■ Chris Brakke, Melissa Serio
Ingios Geotechnics, Inc. ■ John Puls, Kera Gieselman, Sue Ann Peters, Dr. David White, Ells T. Cackler

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Introduction

The Iowa Department of Transportation has recognized that the current level of performance from their pavements is not financially sustainable. Disinvestment in the lower end of the roadway network has been occurring for many years to address needs on the higher traffic routes. Current and anticipated future funding levels will require pavements to perform two- or three-times their current service life in order to maintain their system at an acceptable level of service. This disparity has motivated the Iowa DOT to develop practical steps that will result in a lower ownership cost for their pavement infrastructure and increase their level of service to the public.

The Iowa DOT is in the 3rd year of an implementation plan to move from their current method specifications to modulus-based requirements and field processes that will ensure the intended foundation support values assumed during pavement design are achieved. Also being evaluated are workflow processes to ensure design, material selection, and construction requirements are harmonized to achieve organization efficiency and maximum value.

The Iowa Department of Transportation believes that the next step forward in pavement foundation construction quality as well as optimized pavement designs will be realized by implementing design-value, modulus-based assessment and ensuring that the pavement design assumptions are met during construction. Field measurements of foundation support values obtained by plate load testing from a variety of foundation treatments across the state, indicate that the results of current design and construction requirements has resulted in only 30% of the locations tested meeting the support values assumed in design. This data set was generated from automated plate load testing (APLT) at over 130 locations under FHWA sponsored STIC and AID projects during 2017 – 2022 and is summarized in Figure 1.

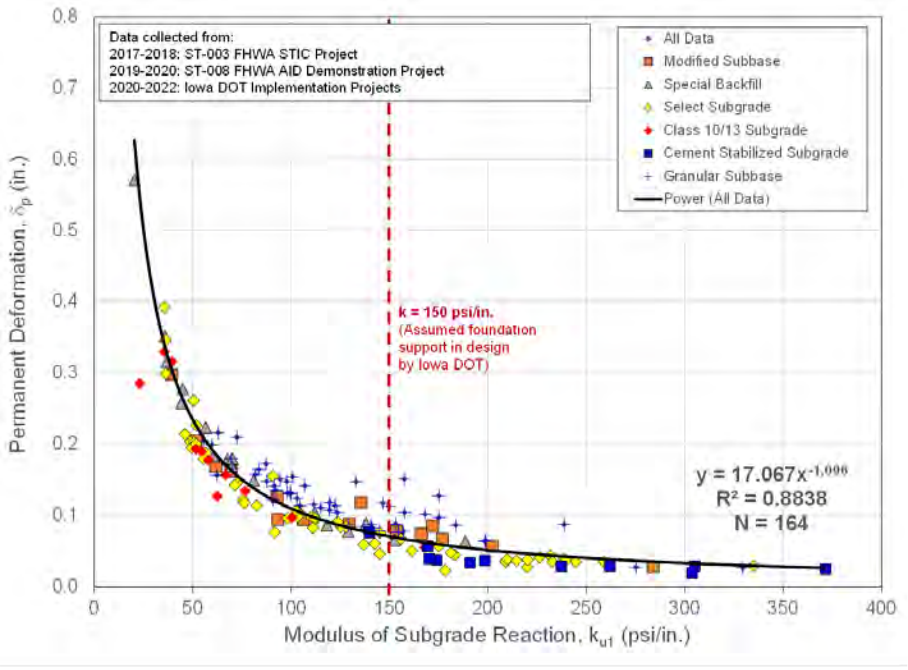


Figure 1: Modulus of subgrade reaction (k-value) versus permanent deformation at the end of test from field static plate load test measurements (164 tests from multiple project sites across Iowa from 2017 to 2022).

This realization was the culmination of a focused effort by the Iowa DOT to understand overall pavement performance and develop strategies that can achieve longer-life pavements with less required maintenance and built-in defects. A particularly helpful project that the Iowa DOT led was TPF-5(183) *Improving the Foundation Layers for Concrete Pavements; Lessons Learned and a Framework for Mechanistic Assessment of Pavement Foundations.* The Iowa DOT's current implementation plan builds upon the key findings and lessons learned from the detailed pavement foundation test programs in the participating states of California, Iowa, Michigan, Pennsylvania, and Wisconsin. Through this study, it was determined that current practices for pavement foundation quality inspection, specifically mechanistic characterization, are limited by the methods of measurement and frequency of testing. Ultimately, important pavement foundation parameters are not being measured in practice or controlled in situ, and therefore their impact on pavement performance is not well understood or accounted for in modern pavement design.

The key challenges regarding current practices were documented as follows:

- The geomaterials used in pavement foundations construction are variable and complex.
- No field verification of the engineering parameters used in the mechanistic design of pavement foundations is being used for quality acceptance during construction.
- While parametric studies of pavement design have shown that pavement performance has a low sensitivity to the support provided by the foundation materials, poor support conditions are well documented as affecting the long-term field performance of pavements.
- Substantial spatial variability (nonuniformity) exists in newly constructed pavement foundations for the range of materials tested.
- If the subgrade layer is nonuniform, the overlying aggregate base layer will be nonuniform.
- Uniformity of support is an important characteristic of pavement foundation systems. New finite element analyses quantify the effects of this characteristic on pavement performance.
- Loss of support due to irreversible plastic deformation in the foundation layer can significantly decrease the fatigue life of the pavement.
- Permanent (irreversible) deformation of the pavement foundation layers is not considered in modern pavement design or measured as part of the construction verification process.
- Limited geotechnical testing (covering less than 1% of a given work area) is used to accept the engineering support values of pavement foundations, resulting in low reliability.
- Constructed pavement foundation layers often show isolated areas of poor quality that contribute to localized pavement performance issues.
- Limited technology is available to help earthwork and paving contractors improve the field control of pavement foundation layers during construction.
- Modern laboratory testing to determine the stress-dependent resilient moduli of foundation materials does not accurately represent/replicate field boundary conditions.
- More frost heave and thaw testing is needed to characterize complex pavement foundation geomaterials, especially stabilized materials. In addition, the impact of wetting and drying cycles on these materials should be evaluated and characterized in terms of changes in volume, stiffness, and strength.
- Characterizing the soil water characteristics curves (SWCCs) of foundation layer materials is important, especially if the new mechanistic-empirical design procedure used in AASHTOWare Pavement ME Design is followed, because SWCCs have a direct impact on modeling the post-construction variations in the resilient moduli of these materials over the design life of the pavement.
- The current practice for selecting design input parameters for pavement foundation geomaterials (e.g., modulus, post-construction changes in modulus) is still largely empirical.
- Most methods for quality inspection testing do not qualify as direct mechanistic measurements.

Further the report identified the following key features of a performance-based construction specification.

- Measurement technologies that provide near 100% sampling coverage

- Acceptance and verification testing procedures that measure the performance-related parameters that are relevant to the mechanistic design inputs
- Protocols for establishing target values for acceptance based on design
- Quality statements that require achievement of spatial uniformity
- Protocols for data analysis and reporting that ensure that the construction process is field controlled in an efficient manner

The FHWA has also recognized the need to improve the quality of pavement foundations nationally and has identified this need as a focus area in their 2019/2020 annual report to Congress on the Accelerated Implementation and Deployment of Pavement Technologies, AID-PT program: *"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."*

In recognition of this need the FHWA established Transportation Pooled Fund Project TPF-5(478) entitled: Demonstration to Advance New Pavement Technologies Pooled Fund. The objective of this study is to support and showcase the implementation of innovative pavement technologies, products, and processes by State DOTs by leveraging of Federal investments with State DOT partnerships. DOTs are encouraged to submit topics of interest.

In 2022, The Iowa DOT joined the study and submitted a proposed project "*Support for Pavement Foundation Design Modulus Verification and Construction Quality Monitoring"* which was accepted and had the following objectives identified:

- Begin to develop a state specific library of the pavement foundation material properties for use as input values in Pavement ME Design (PMED).
- Provide direct support to interested states for piloting and implementing modulus-based pavement foundation construction.

To meet these objectives, the following tasks were identified:

1) Generate modulus maps on five selected projects in addition to IA DOT pilot projects.
2) Develop training programs for Engineers, inspectors, and contractors and assist the DOT with integrating them into the current web-based training classes.
3) Develop model specifications to be used on future projects.
4) Develop workflow process and contractual documents for transitioning QC/QA processes from methods to performance specifications.
5) Field open house (For Iowa public agencies, contractors, and other DOTs with interest in technology partnerships)
6) Develop educational and technology transfer materials.
7) Develop a technology brief on the value proposition of improving pavement foundation performance using data from 2022 projects and LCCA modeling completed using 2021 pilot project data

Task 5 was completed on October 28, 2022, with the *Iowa DOT Open House: Demonstration of Innovative Technologies for Pavement Foundation Layer Construction*. The open house was hosted jointly by The Iowa Department of Transportation, Ingios Geotechnics, Inc. (Ingios), and The Federal Highway Administration.

Open House Objectives

The following were the key objectives of the open house:

- Raise awareness of the importance of pavement foundations to pavement performance
- Share knowledge of current state of e-compaction technologies
- Demonstrate outcomes from use of e-compaction technologies on Iowa DOT projects
- Foster collaboration within Iowa DOT and with other state DOTS/FHWA
- Receive feedback from industry partners on needs for implementation
- Identify next steps for further development of e-compaction information system

Agenda

The open house was held from 8:30 am to 3:30 pm (CDT) at the Central Iowa Expo Administration Building in Boone, Iowa. The morning sessions focused on why there is a need for modulus-based pavement foundation construction, and highlighted the challenges experienced in increasing pavement performance and the need to increase pavement longevity through improved foundation construction. The lunch break took participants outdoors for an equipment tour. In person and virtual participants (through live stream) viewed an Automated Plate Load Test (APLT) in action and the COMP-Score RT system installed on a roller. The afternoon session focused on how roller mapping is used by the Iowa DOT for modulus verification of pavement foundation layers and how the resulting data is used to make real time, in-field decisions on pavement foundation improvements. The afternoon session included a live demonstration of roller mapping on site, with the immediate generation of an e-Compaction report and subsequent viewing of the data in COMP-Score CONNECT. A full agenda is included in Appendix A. The open house included many questions and discussions and because attendance was both in-person and virtual, a process was used to involve all participants in the conversation. In-person questions and discussions were communicated to virtual participants via the presenter and moderator through the webinar microphone. Virtual participants asked questions and provided feedback online through the webinar platform, and as time allowed the questions and comments were announced live to all participants. A full list of questions and answers in included in Appendix B. At the conclusion of the open house, a feedback survey was provided to both in-person and virtual participants. The results of the survey can be found in Appendix C.

Figure 2: Roller Equipment Tour.

Figure 3: APLT Equipment Tour.

Presenters

The open house included presentations by the Iowa DOT, FHWA, and Ingios. Presenters were as follows:

- Wes Musgrove, P.E. – Iowa DOT Director, Construction and Materials Bureau
- Chris Brakke, P.E. – Iowa DOT Pavement Design & Pavement Management Engineer, Construction & Materials Bureau
- Thomas Yu, P.E. – FHWA Program Manager, Pavement Design
- Melissa Serio, P.E. - Iowa DOT Earthwork Field Engineer Construction & Materials Bureau
- John Puls, P.E. – Engineering Business Manager, Ingios Geotechnics, Inc.
- Kera Gieselman – Project Manager, Ingios Geotechnics, Inc.
- Craig Swanson – Data Manager, Ingios Geotechnics, Inc.
- David White, P.E. – President, Ingios Geotechnics, Inc.

A copy of slides from each presentation can be found in Appendix F.

Figure 4: Wes Musgrove (Iowa DOT) Presenting.

Figure 5: Chris Brakke (Iowa DOT) Presenting.

Figure 6: Tom Yu (FHWA) Presenting.

Figure 7: Melissa Serio (Iowa DOT) Presenting.

Figure 8: John Puls (Ingios) Presenting.

Figure 9: Craig Swanson (Ingios) Presenting.

Figure 10: Dr. David White (Ingios) Presenting.

Attendees

The open house was attended by 84 people: 31 in-person and 53 virtual. Ten state DOTs were represented: Alaska, California, Georgia, Indiana, Iowa, Minnesota, New Jersey, Pennsylvania, Utah, and Virginia. Additional organizations represented were Association of General Contractors of IA, Cherokee County-Iowa Engineer, Federal Highway Administration, Army National Guard, Iowa Concrete Paving Association, Iowa Ready Mixed Concrete Association, IRMCA/ICPA, JB Holland Construction, National Center for Asphalt Technology, Snyder and Associates, Inc., Stanley Consultants, Taylor County-Iowa Secondary Roads Engineer, University of Illinois at Urbana-Champaign, Washington County-Iowa Engineer. A full list of in-person attendees is included in Appendix D and a full list of virtual attendees is included in Appendix E.

Figure 11: In person attendees listening to a presentation.

Figure 12: In person attendees during a break.

Key Outcomes

The following were identified as the key outcomes of the open house:

- Awareness of e-Compaction.com as the resource for information and collaboration
- Awareness of pavement modulus verification technologies throughout Iowa DOT and other states
- Feedback from attendees regarding training needs (e.g., inspector training)
- Collaboration with Iowa DOT and other states regarding implementation of modulus verification using roller mapping
- Identification of states interested in partnering on implementation of modulus verification using roller mapping
- Feedback from Iowa DOT Resident Construction Engineers (RCEs) on best practices for implementation

REFERENCES

Iowa Department of Transportation. (2021*). Improving the Foundation Layers for Concrete Pavements: Lessons Learned and a Framework for Mechanistic Assessment of Pavement Foundations - TPF-5(183).* https://publications.iowa.gov/35176/

Federal Highway Administration. (2021, March 23). *ACCELERATED IMPLEMENTATION AND DEPLOYMENT OF PAVEMENT TECHNOLOGIES 2019-2020 Annual Report*. https://www.fhwa.dot.gov/pavement/pubs/hif21024.pdf

APPENDICES

Appendix A: Open House Agenda

Appendix B: Open House Questions and Answers

Appendix C: Open House Feedback Survey Responses

Appendix D: Open House In-Person Attendees

Appendix E: Open House Virtual Attendees

Appendix F: Presentation Slides

Iowa DOT Open House -- Demonstration of Innovative Technologies for Pavement Foundation Layer Construction

Date: Friday October 28th, 2022
Where: In-person (Central Iowa Expo in Boone County, Iowa) and Virtually

Overview: The open house will provide information on the Iowa DOT's participation in a new FHWA pooled fund *TPF-5(478) Demonstration to Advance New Pavement Technologies*. The open house will showcase how the Iowa DOT is using roller mapping and automated plate load testing technologies to increase pavement performance though pavement foundation design modulus verification and construction quality monitoring.

Agenda:

8:30	**Welcome and Introductions** – Wes Musgrove, P.E. – Iowa DOT Director, Construction and Materials Bureau
8:40	**Overview of Challenge Facing the DOT**- Chris Brakke, P.E. – Iowa DOT Pavement Design & Pavement Management Engineer, Construction & Materials Bureau
9:05	Introduction to TPF-5(478) **Demonstration to Advance New Pavement Technologies Pooled Fund** – Thomas Yu, P.E. – FHWA Program Manager, Pavement Design
9:20	**An Information System for Pavement Foundation Quality and Findings from STIC/AID Demonstrations** – David White, Ph.D., P.E. – Ingios Geotechnics, Inc.
10:00	**Break**
10:10	**Iowa DOT Implementation Plan and Pilot Projects** - Melissa Serio, P.E. - Iowa DOT Earthwork Field Engineer Construction & Materials Bureau
10:30	**Collaborative Session: Vision for the Future** – John Puls, P.E. – Engineering Business Manager, Ingios Geotechnics, Inc., and Kera Gieselman – Project Manager, Ingios Geotechnics, Inc.
11:15	**Equipment Tour and Lunch (Automated Plate Load Test and COMP-Score RT Roller)** –Break for virtual participants
12:45	**Learn how Advanced Technology and Automated Digital Workflow is used for Pavement Foundation Verification**. Craig Swanson – Data Manager; David White, P.E. – President, Ingios Geotechnics, Inc.
1:20	**Engineering and Inspection Examples for e-Compaction Reports** – Melissa Serio, P.E. - Iowa DOT Earthwork Field Engineer, Construction & Materials Bureau, and Kera Gieselman – Project Manager, Ingios Geotechnics, Inc.
2:00	**Break**
2:15	**Field Demonstration of Live Mapping** – John Puls, P.E. – Engineering Business Manager, Ingios Geotechnics, Inc., and Colby VanNimwegen - Project Engineer, Ingios Geotechnics, Inc.
2:50	**Value of Pavement Foundation Verification: Leverage Power of Data and Moving forward in a Measured Way! -** David White, Ph.D., P.E. – Ingios Geotechnics, Inc.
3:10	**Pavement Foundations Moving Forward: Collaborate for project news, workflows, specification development, and training.** www.e-compaction.com John Puls, P.E. – Engineering Business Manager, Ingios Geotechnics, Inc.
3:25	**Closing and feedback survey**– Wes Musgrove, P.E. – Iowa DOT Director, Construction and Materials Bureau

APPENDIX B: OPEN HOUSE QUESTIONS AND ANSWERS

Question or Comment	Response
Once the deficient subgrade areas are identified via the mapping, what are the specific methods used to correct the deficiencies? Beyond additional roller passes, what are the preferred/typical options and unit costs?	This will be covered in later sessions, with specific data collected during 2021-2022 Iowa DOT pilot projects
Any thought as to the modulus/stiffness response measured during construction vs. the long-term in-service performance the subgrade actually delivers? Post-construction, once the ground moisture levels stabilize, does the modulus/stiffness change significantly?	
3% would be 1 state? Which state was that and what does it mean that pavement parameters are directly measured?	Direct, in field measurement of pavement design inputs. Later sessions will address in more detail.
Measure what you treasure!	Great quote! Thank you!
If the soil still changes with freeze thaw, when spot improvements are done, does it improve uniformity after freeze thaw, or does it create non uniform areas after some FT cycles?	Answered live. Thank you!
Melissa mentioned 'management pumping brakes due to increased costs' but Chris' slides showed 30% was base vs 70% pavement costs. Why not add substantial cost to the 30% to stretch the life??	Eaxactly!
Instantly adjust based on data. Cross reference the as built data with maintenance data to build that a.i. dataset so we can add that into cost decisions live.	Announced live. Thank you!
Use smaller safety factor in design.	Announced live. Thank you!
Less inspection, more responsibility on the contractor	Yes!
Need buy-in. It's hard to convince people without that 20 year record. How do you make this day of education 15 minutes for those decision makers?	Maybe an hour? How would that look for your agency? Do they need to understand the challenge first?
1000s ft blobs seem huge. Wouldn't a 100sft soft spot fail a PCC panel and less for HMA?	We orginally had it set to 200sf. IA DOT asked us to incease to 1000sf
Can Colby zoom in?	He can't
Can a contractor lease eqpt for a single project?	

APPENDIX B: OPEN HOUSE QUESTIONS AND ANSWERS

Question or Comment	Response
What is the oldest pavement where you have used this process? Have you been able to check performance vs expectation?	Answered live. Thank you!
Glad to hear the comment on Operator engagement and importance	It is very important and we have seen time after time where inspectors begin to take pride and ownership in their work
when you retrofit Ingios System into Contractor Roller, does it include camera too?	We can, it that is something the DOT wants.
For cement stabilized subgrade, we require the 7-day compressive strength (with no correction for the length-to-diameter ratio) to be from 200 – 350 psi. How does that relate to psi/in? What tests would be required, and how much cost per test?	
What does CAGR stand for?	Compound Annual Growth Rate
Do you consider degradation over time for a drainage layer under a flexible pavement?	
Alaska DOT specifies a low Micro-Deval loss for Crushed aggregate drainage layer under thin (2-4") asphalt pavements to minimize breakdown.	Thank you!
We have seen crushed aggregate base course gradation made frost susceptible by over compaction. Worst case was <6% minus 200 material changed to 18% minus 200 material.	Thank you. We would be interested in your research on this. Do you have a report you could send to webinars@ingios.com?
it allows correction of deficiencies in real time	Announced live. Thank you!
No potholes left behind!	Nice!
empowers field staff to make a better product	Very important!
empowers field staff to make a better product	Varies by project and material. Typically will need 12 tests on a new material where we have no prior data
Fullfills Donald Burmister's 1948 vision often quoted by Dr. White. "The primary problem is not so much to determine the average conditions, as it is to make reasonably certain that possible the most unfavorable conditions ar know over a given area that may give rise to soft spots."	Thank you!
How deep did you mill the cement into the subgrade?	Answered live. Thank you!

APPENDIX B: OPEN HOUSE QUESTIONS AND ANSWERS

Question or Comment	Response
It looks like the gravel pad location from the arerial photo is a bit off from the mapped area.	
Very nice interface from field to report!	Thank you
To get longer life	Yes!
Introduce dynamic corrective actions	Announced live. Thank you!
Come up with "What if " plans	Announced live. Thank you!
Lack of sufficient knowledge to test.	Announced live. Thank you!
Non availability of simple tests to say the foundation is compacted enough	Announced live. Thank you!
We have to wait and see how it reduces maitenance	Yes, true value will be determined over time
We get better validated foundation	Announced live. Thank you!
Increase in Confidence level while designing	Yes!
Get support from Contractors and field inpsectors	Announced live. Thank you!
for a successful implementation	We originally set the blob size at 200sf for the reason you stated, however the DOT asked us to increase the blob size because the data was indicating too many small areas that needed to be addressed
for a successful implementation	Announced live. Thank you!
Contractor's acceptance for IC	Yes!
We also need to establish data storage and database maintenance	Yes
How many plate load tests are needed per Lane Mile or SY ?	varies by material, typically 12 on a new project for each new material
Thanks	

APPENDIX B: OPEN HOUSE QUESTIONS AND ANSWERS

Question or Comment	Response
What is the cost difference between Cement treatment and the 12" Subbase? Sorry if I had missed.	One would not replace the other. Would need cement treatment and also modified subbase
Have you got into a situation where after compaction you had to cut for utility and after refill did you test again?	Contractor has only been asked to map subgrade when it was ready for the next lift
30.6 % Passing means ?	30% of the area meets or exceeds target K value of 150pci
Re- roll needed?	
70 % is not compacted.. that's why	
I mean compacted enough	Correct. So it has not met the design value (if this were a roadway)
Do you have any sweet spot for Frequesncy and Amplitude?	There is a requirement for this stated in the spec
It is very difficult to quantify Economic loss if we take out a lane for repair	not much data available in that area
How will the industry react to bonus or penalty for IC?	Will have to be a partnership between agency and industry. Change is hard, but necessary
Hope they cooperate. Good luck.	
How do you contorl moisture content during this real-time monitoring process?	Answered live. Thank you!

APPENDIX C: OPEN HOUSE FEEDBACK SURVEY RESPONSES

Survey Question	Survey Answer
What was your primary goal in attending this open house?	To become familiar with new technology across the board.
	To learn about intelligent compaction, see how it is being used
	learn about subgrade mapping
	Learning more about the technology
	Learning about the system
	Learn how subgrade foundation is constructed in Wisconsin. How pavement last longer
	Gain additional insight into Ingios IC mapping system and new QA framework
	MnDOT continues to try to move forward with various intelligent construction technologies. We have tabled intelligent compaction on earthwork related items for a while now until further research could be completed (as being presented today), but instead moved forward with IC on reclamation and paving activities.
	To get up to date on the compaction mapping technology that Ingios has been advancing for the last 8 years or so.
	learn the benefits of Intelligent compaction over current specifications
	learning more about other states best practices
	Learn about APLT and intelligent compaction control devices.
	To see new technology in compaction control
	I wanted to learn about Intelligent Compaction and how successfully it is being implemented
	Seeing how the specifications are working
	Gaining more knowledge on the subject
	gaining more knowledge on the subject and networking
	Gaining more knowledge on the subject
	Gaining more knowledge on the subject
What aspects of the open house did you like the most?	I enjoyed every part as I believe it was organized pretty well. Theory, in-site showcase, QA, etc.

APPENDIX C: OPEN HOUSE FEEDBACK SURVEY RESPONSES

Survey Question	Survey Answer
	good technical presentations, good live stream of equipment
	Option to participate virtually
	Open forum multiple presenters
	In situ testing and design calibration
	Workflow discussion and quantification of benefits of using IC for pavement foundation. Also, the Iowa DOT case histories.
	Updates on data collection, correlations, specifications
	The streamlining from data collection to reporting has been remarkable! Kudos to the Ingios team for the R&D work and to Tom Yu, and Iowa DOT for the institutional support.
	Results of the projects
	It was a great crash course in "how to transfer research into practice?"
	Presentation and interactions with the participants
	The practical aspects.
	Seeing the equipment and demonstration
	Plenty of opportunity and encouragmement for discussion
	presentations and tech demo
	presentations, side conversations, equipment demo
	enjoy climbing in the cab and seeing the equipment, see live demo and how it works
Would you be interested in future webinars or training opportunities? If yes, what topics would want to have covered?	I am interested in emerging technologies in Asphalt and Concrete pavements.
	Yes, FWD testing
	NDT and test at the failed location
	Yes. Verification of the performance of mapped roads and quantification of benefits.
	Yes. Topics related to intelligent construction technologies, automated machine guidance, geospatial statistics, etc.
	Yes, I like all aspects of Intelligent Construction from design to construction and LCCA.
	Possibly
	pavement recycling

APPENDIX C: OPEN HOUSE FEEDBACK SURVEY RESPONSES

Survey Question	Survey Answer
	Yes, anything pertaining to pavement geotechnics, transportation soil stabilization, etc.
	Yes
	Intelligent Compaction used for Re-surfacing and Infra-Red Thermal profiling behind paver
	yes. Digging into the data analysis. I see opportunities to use this data with other systems
	yes. Additional informational webinars. I would like to have more FHWA people attend
	yes. Presentations of the pilot projects would be good to follow
	Yes. Interpreting data to make foundation decision in construction
Please let us know if you have any follow-up questions:	I like to thank you folks taking pavement foundation issue.
	Information on rollers for compaction such as sheep foot work on clay what the depth of influence of foot.
	Granular soils are compacted with setting up adequate frequency such as aggregate is smaller frequency whereas higher frequency is required for sand.
	Non at this time. THanks!
	Would like to know more about soft spots that were identified and how it was fixed and whether it was re-tested
Would you be interested in more information on how to implement modulus-based specification requirements in your state?	Yes
	Yes
	Yes
	Yes
	No
	Yes
	Yes
	Yes
	Yes
	Yes
	Yes
	Yes

APPENDIX C: OPEN HOUSE FEEDBACK SURVEY RESPONSES

Survey Question	Survey Answer
	Yes
	yes
	yes

APPENDIX D: OPEN HOUSE IN PERSON ATTENDEES

Last Name	First Name	Organization	Title
Daghighi	Amin	Iowa DOT	Materials Engineer Assistant
Moore	Brian	Iowa DOT	Secondary Roads Research Engineer
Puls	John	Ingios Geotechnics	Business Unit Leader
Swanson	Craig	Ingios Geotechnics	Data Manager
Van Nimwegen	Colby	ingios geotechnics	Project Engineer
Brakke	Chris	Iowa DOT	Pavement Design & Pavement Management Engineer
Cackler	Tom	Ingios Geotechnics	General Manager
Clute	Khyle	Iowa DOT	SPR Research and Pooled Fund Programs Manager
Cooper	Stephen	FHWA, RC	Senior Pavement & Materials Engineer
Dell	Mark	Iowa Department of Transportation	Transportation Engineer Specialist
Gieselman	Kera	Ingios Geotechnics, Inc	Project Manager
Jackson	Ryan	Iowa DOT District 1 Materials	Highway Technician Senior - Materials Inspector
Johnsen	Eric	Iowa DOT	Specifications Engineer
Kjolhede	Aaron	IRMCA/ICPA	Regional Services Manager
Lamping	John	Iowa DOT	Cedar Rapids RCE
McDaniel	Lisa	Federal Highway Administration	Pavements & Materials Engineer
Miller	Matthew	Iowa DOT	E-construction Coordinator
Musgrove	Wes	Iowa DOT	Construction and Materials Bureau Director
Nelson	Gabe	Snyder & Associates, Inc.	Civil Engineer
Neuhaus	Shane	IDOT	District Materials Engineer
Otto	Ronald	ASSOC. GENERAL CONTRACTORS of IA	Technical Director
Perkins	John	Iowa Army National Guard	Construction and Facility Management Officer
Peters	Sue Ann	Ingios	Staff Engineer
Savage	Justin	Taylor County Secondary Roads	County Engineer
Serio	Melissa	Iowa Department of Transportation	Earthwork Engineer

APPENDIX D: OPEN HOUSE IN PERSON ATTENDEES

Last Name	First Name	Organization	Title
Shepard	Lee	Iowa Concrete Paving Association	Concrete Promotions Director
Simonson	Adrian	Iowa DOT	RCE
Smith	Brian	Iowa DOT	Resident Construction Engineer Creston
White	David	Ingios Geotechnics, Inc.	President
Wilkinson	Cedric	Iowa DOT	Eng. Tech. Senior
Yu	Tom	FHWA	Pavement-Design Program Manager

APPENDIX E: OPEN HOUSE VIRTUAL ATTENDEES

Last Name	First Name	Organization	Title
Ayotte	Matthew	VirginiaDOT	Pavement Managers
BLIGHT	ROBERT	NJDOT	Manager, Pavement & Drainage Management & Technology Bureau
Bautista	Emil	MnDOT	MnROAD Project Engineer
Becker	Peter	Indiana Department of Transportation	Research Civil Engineer
Bitewlign	Helina	NJDOT	Assistant Engineer
Bohart	Charles	AK DOT	Western Region Construction Manager
Cahoon	Rich	Ingios Geotechnics	Business Manager
Collins	Lauriane	UDOT	State Pavement Design Engineer
Cosenza	Nicholas	INDOT	Pavement Engineering
Crandol	Rob	VDOT	Assistant State Maintenance Engineer
Dongo	Joseph	Caltrans	Chief, Office of Construction Standards
Embacher	Rebecca	Minnesota Department of Transportation	Advanced Materials and Technology Engineer
GANARAJAN	VASUDEVAN	NJDOT	Senior Engineer
GORJACKOVSKI	OLGA	Iowa DOT	DESIGN TECHNICIAN
Garcia	Reimond	Caltrans - Office of Concrete Pavements	Senior Transportation Engineer
Gelhaus	Roy	Iowa Department of Transportation	District Construction Engineer
Giessel	Richard	Alaska DOT&PF	State Quality Assurance Engineer
Grabau	Garrett	JB Holland Construction, Inc.	Project Manager
Husain	Syed Faizan	University of Illinois at Urbana-Champaign	Graduate Research Assistant
Jerman	Renee	Iowa DOT	
Jia	Yanxiao	Iowa DOT	Transportation Engineer Manager
Kettleson	William	NJDOT	Principal Engineer - Pavement Designer
Kim	Wansoo	VDOT	Materials Program Manager
Lauritsen	Mike	Iowa DOT District 1	District Materials Engineer
Liberatore	Rob	Virginia Department of Transportation	Quality Assurance Manager - Staunton District

APPENDIX E: OPEN HOUSE VIRTUAL ATTENDEES

Last Name	First Name	Organization	Title
MAHARJAN	RUKESH	Caltrans-HQ Pavement Program	Contract Manager
Mallicoat	Steven	Iowa Ready Mixed Concrete Association	Director of Engineering and Education
Matulac	Donna	Iowa DOT	Assistant Specifications Engineer
McGee	Mike	mike.mcgee@dot.gov	Pavement Engineer - FHWA
Mokhtari	Ali	Caltrans	Transportation Engineer
Morshed	Nusrat	NJDOT	Project Engineer
Nabizadeh	Hadi	Caltrans	
Najafi	Shahriar	VDOT	District Pavement Management Engineer
Nantung	Tommy	Indiana Department of Transportation	Assistant Director of Research and Development Division
Neff	Dennis	PennDOT	Geotechnical Engineer
Patterson	David	Washington County	Assistant Engineer
Podolsky	Joseph	Minnesota Department of Transportation	MnROAD Research Implementation Engineer
Reis	Thomas	Stanley Consultants	Resident Project Representative
Saboundjian	Steve	ADOT&PF	SPE
Schuler	John	Virginia DOT	Assistant State Materials Engineer
Shu	Xiang	Caltrans	Transportation Engineer
Siddiki	Nayyar	INDOT	Geotechnical Operation
Simmons	Jason	UDOT	Statewide Pavement Engineer
Stone	Jewell	GA DOT	State Pavement Design Engineer
Tracy	Sarah	Cherokee County	County Engineer
Tran	Nam	National Center for Asphalt Technology	Assistant Director
Tutumluer	Erol	UIUC	Abel Bliss Professor
Velasquez	Raul	MnDOT	Geomechanics Research Engineer
Wipper	Jenna	Ingios	Lab Manager
YOON	SUNG MIN	INDOT	engineer
Younie	Robert	Iowa DOT	District Engineer

APPENDIX E: OPEN HOUSE VIRTUAL ATTENDEES

Last Name	First Name	Organization	Title
Zeimen	Danny	Iowa Department of Transportation	Engineering Specialist
habib	affan	VDOT	Assistant State Materials Engineer

APPENDIX F: OPEN HOUSE PRESENTATIONS

The following presentations were made at the open house and are provided herein in that order:

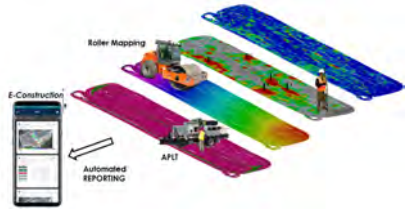
1. **Welcome and Introductions** – Wes Musgrove, P.E. – Iowa DOT Director, Construction and Materials Bureau
2. **Overview of Challenge Facing the DOT**- Chris Brakke, P.E. – Iowa DOT Pavement Design & Pavement Management Engineer, Construction & Materials Bureau
3. **Introduction to TPF-5(478) Demonstration to Advance New Pavement Technologies Pooled Fund** – Thomas Yu, P.E. – FHWA Program Manager, Pavement Design
4. **An Information System for Pavement Foundation Quality and Findings from STIC/AID Demonstrations** – David White, Ph.D., P.E. – Ingios Geotechnics, Inc.
5. **Iowa DOT Implementation Plan and Pilot Projects** - Melissa Serio, P.E. - Iowa DOT Earthwork Field Engineer Construction & Materials Bureau
6. **Collaborative Session: Vision for the Future** – John Puls, P.E. – Engineering Business Manager, Ingios Geotechnics, Inc., and Kera Gieselman – Project Manager, Ingios Geotechnics, Inc.
7. **Learn how Advanced Technology and Automated Digital Workflow is used for Pavement Foundation Verification**. Craig Swanson – Data Manager; David White, P.E. – President, Ingios Geotechnics, Inc.
8. **Engineering and Inspection Examples for e-Compaction Reports** – Melissa Serio, P.E. - Iowa DOT Earthwork Field Engineer, Construction & Materials Bureau, and Kera Gieselman – Project Manager, Ingios Geotechnics, Inc.
9. **Value of Pavement Foundation Verification: Leverage Power of Data and Moving forward in a Measured Way! -** David White, Ph.D., P.E. – Ingios Geotechnics, Inc.
10. **Pavement Foundations Moving Forward: Collaborate for project news, workflows, specification development, and training. www.e-compaction.com** John Puls, P.E. – Engineering Business Manager, Ingios Geotechnics, Inc.
11. **Closing and feedback survey**– Wes Musgrove, P.E. – Iowa DOT Director, Construction and Materials Bureau

Welcome to the Iowa DOT Open House -- Demonstration of Innovative Technologies for Pavement Foundation Layer Construction

We will start promptly at 8:30 AM (CDT).

1

Iowa DOT Open House – Demonstration of Innovative Technologies for Pavement Foundation Layer Construction



2

Introduction

- Welcome
- Plan for open house
  - Morning: Focus on Iowa DOT challenges and pavement foundation advancements and technologies to meet those challenges.
  - Mid-day: Field demonstration with lunch
  - Afternoon: Back at 12:45 PM to get into nuts and bolts of the technologies and data analytics for real-time modulus mapping
- Goals for open house
- Moderator introduction who will go over technical logistics

3

Important Information for Attendees

- Online and in-person attendees
  - All online attendees will remain muted for today's sessions
  - In person attendees please leave the room for conversations or phone calls
  - Protocol for questions
- We must remain on schedule for the day
  - Agendas provided for in-person audience
  - Agenda emailed/provided in webinar for virtual audience
- We will be monitoring comments so please let us know if there are audio or video issues
- Field demo livestream starting at 11:45 CDT-link in webinar chat

4

Asking Questions

- In-person and online questions will be addressed at presentation, as time allows
- Online attendees:
  - Please utilize chat feature of webinar to ask your questi

5

Asking Questions

- If we do not get to your question today, please send it to: webinars@ingios.com and we will respond to you

6

Challenge facing the Iowa DOT

- While current funding can meet our target condition level on the system, the long-term needs are out-pacing our level of investment in pavement reconstruction……
- Inadequate funding to replace a system of this size
  - Pavements will not last for hundreds of years.
- Even funding a 100 year life, by replacing 1% of the system each year, is unachievable at current investment levels.

1

Pavement Inventory

2

Challenge facing the Iowa DOT

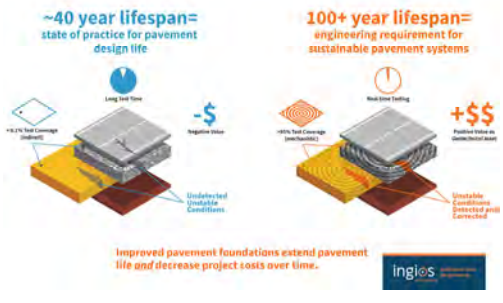
- Need to extend pavement life & maintain cost effectiveness
  - Construct long life/permanent foundations
    - Remain in-place during future pavement replacement
- How to extend pavement life?
  - Improve pavement material performance ✓
  - Improve foundation longevity, uniformity
  - Continually improve construction quality

3

Our annual investment

	2017	2018	2019	2020	2021(partial year)	5 year total
Subbase	$16,797,382	$23,775,714	$23,775,714	$39,534,746	$13,293,528	$140,148,529
Earthwork	$23,559,157	$46,025,950	$39,177,551	$30,486,240	$13,822,561	$153,071,461
Pavement	$79,252,321	$142,667,820	$176,990,516	$218,134,096	$80,554,583	$697,599,338

4



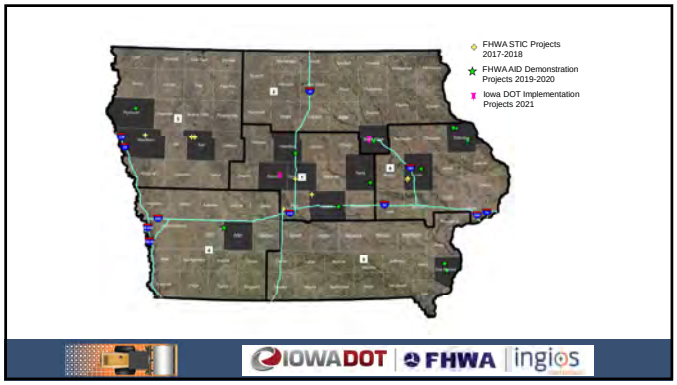
5

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

6

2. Overview of Challenge



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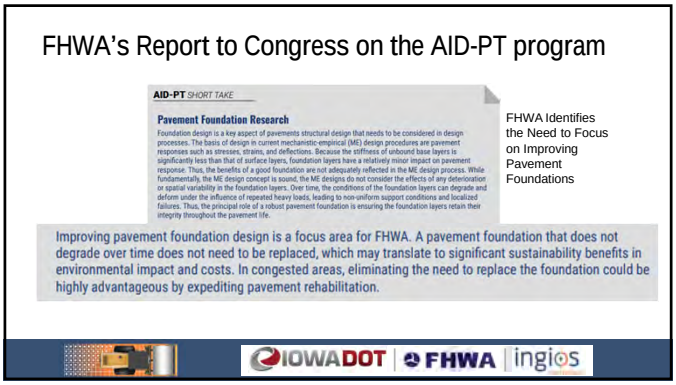

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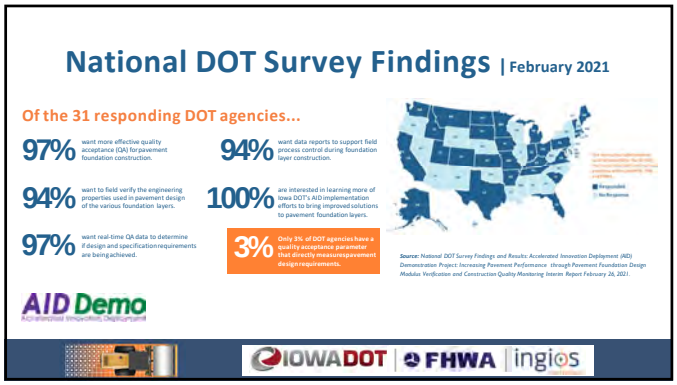


9

Pavement-Design

Program Objectives and Priorities

Image Source: FHWA

H. Thomas Yu, P.E.
Program Manager, Pavement Design
Federal Highway Administration
Office of Infrastructure

October 2022

1

Disclaimer

Except for any statutes or regulations cited, the contents of this presentation do not have the force and effect of law and are not meant to bind the public in any way. This presentation is intended only to provide information to the public regarding existing requirements under the law or agency policies.

2

Pavement-Design Program

Vision

FHWA should lead the way to providing durable, long-life pavements that remain in excellent condition throughout their service lives

Approach

- Demonstrate performance and sustainability advantages of long-life, distress-free pavements
- Provide technical resources needed to improve long-term, pavement performance

3

Vision

US DOT Mission Statement
FY2022-26 Strategic Plan

"To deliver the world's leading transportation system, serving the American people and economy through the safe, efficient, sustainable, and equitable movement of people and goods."
(emphasis added)

4

Keys to achieving well-performing pavement

- Effective structural design
  - Good foundation
  - Adequate structural section
  - Appropriate design features
- Durable material
  - Durable surface
  - No material-related problems
- Quality construction

5

Structural Model

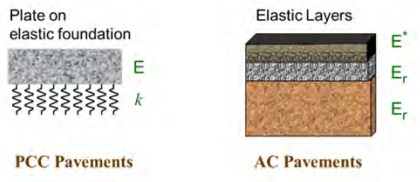


Image Source: FHWA

6

Foundation

- More emphasis should be given to foundation design in the U.S., especially for concrete pavements
  - Greater emphasis on the structural analysis
  - Difficult to quantify the benefit
- Good foundation design is essential to good pavement performance
  - Foundation performs important functions, which cannot be provided by the surface layer
  - The foundation layers must remain in good condition throughout the life of the pavement

7

Roman Road

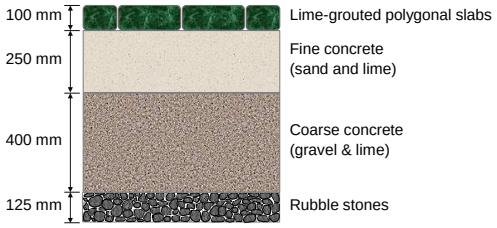


Image Source: FHWA

8

Pavement-Design Program

Strategic Objectives

- Improve pavement design and construction practices and promote transition to long-life pavements
- Provide resources for effective pavement rehabilitation
- Enhance resiliency of pavement structures

9

Thank you!

Tom Yu
tom.yu@dot.gov
202-366-1198

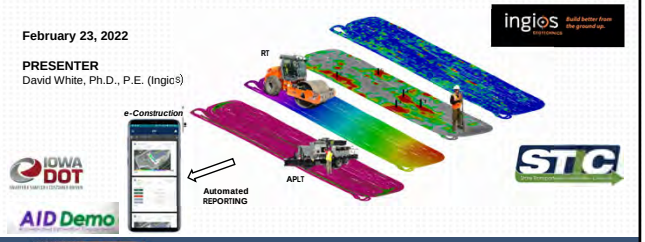
10

4. An Information System

An Information System for Pavement Foundation Quality and Findings from STIC/AID Demonstrations

February 23, 2022

PRESENTER
David White, Ph.D., P.E. (Ingios)



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1

The ideas presented are Radically Different compared to current practice!

1. Digital Transformation is Underway!
2. Field Information positions us to Attack the Root of the Problem.
3. Transitioning to 100% Inspection versus < 0.1%.
4. Remote Inspection is Real. (CAGR for construction (pavements) is projected to outpace available workforce, particularly field staff.)
5. Real-time Data-Driven Workflow.
6. Must build Sustainable, Resilient, High Performing Systems.
7. QC/QA Shifting to Design and Performance Verification.
8. New Information System emerging with New People Responsibilities.
9. Recognizing Different Investment Allocations are Needed.
10. People are excited about Pavements Foundations! ☺

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2

Sustainable Pavement Systems

Foundations are Critical to Performance *and* to Achieving Sustainable Pavements

The foundation layer is largely ignored in modern day road construction techniques. This results in shorter project life-spans and expensive maintenance and repair cycles in the millions of dollars. 95% of these defects can be detected and remediated in real-time during the initial construction process.

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3

The 1-10-100 rule for pavement foundations is concerned with quality and the cost of correction.

Do it right
Verification of design values costs
1 unit – labor, dollars, time, safety

Correction Cost
Rework later costs 10 units of resources

Failure Cost
Repair later costs 100 units of resources

****Do Nothing Cost****
Impacts beyond pavement costs 1,000 units of resources

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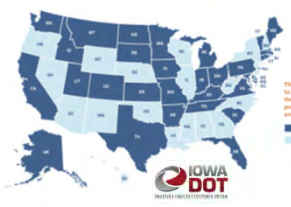
4

National DOT Survey Findings | February 2021



Federal Highway Administration

AID Demo
Accelerated Innovation Deployment

97% of state DOTs want more effective quality acceptance (QA) technologies.

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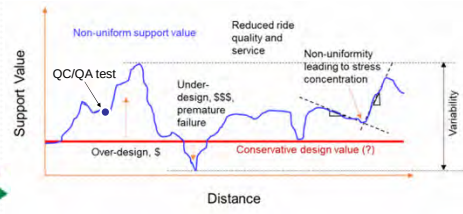
5

What design value would you select...?

Traditional Methods



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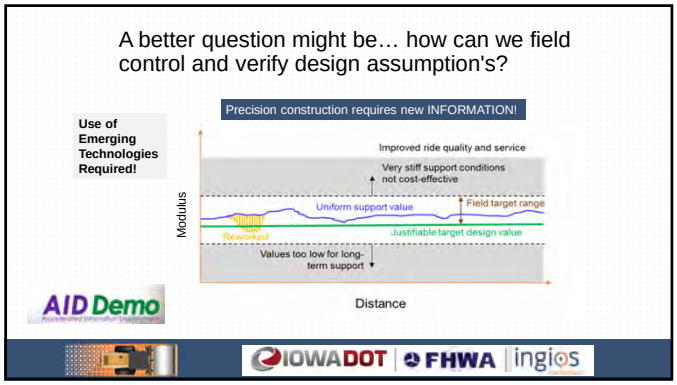
A better question might be… how can we field control and verify design assumption's?
Use of Emerging Technologies Required!
Precision construction requires new INFORMATION!
Improved ride quality and service
Very stiff support conditions not cost-effective
Uniform support value
Field target range
Justifiable target design value
Values too low for long-term support
Modulus
Distance
AID Demo
IOWA DOT
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7


IMPROVING THE FOUNDATION LAYERS FOR CONCRETE PAVEMENTS:
Lessons Learned and a Framework for Mechanistic Assessment of Pavement Foundations
Final Report | January 2021
"…current practices for pavement foundation quality inspection, specifically mechanistic characterization, are limited by the methods of measurement and frequency of testing. Ultimately, important pavement foundation parameters are not being measured or controlled…"
David J. White, Ph.D., P.E.
CEER
IOWA STATE UNIVERSITY
IOWA DOT
FHWA
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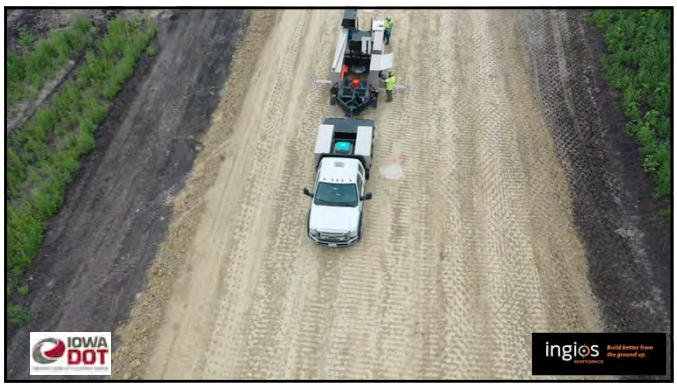
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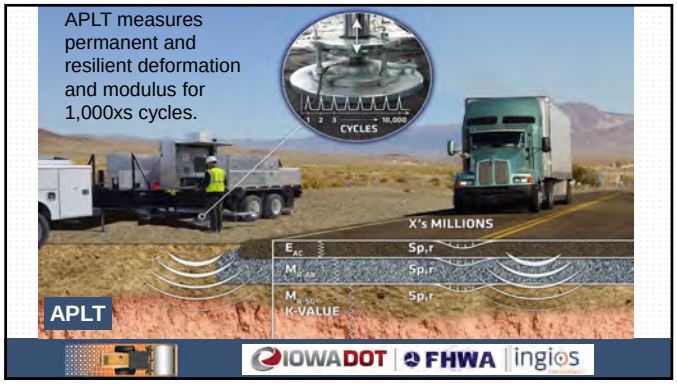
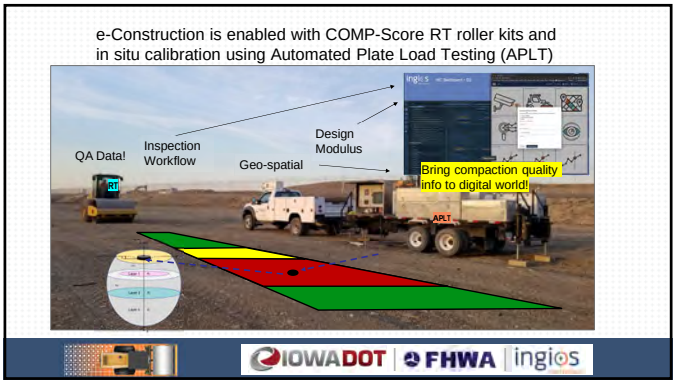

APLT measures permanent and resilient deformation and modulus for 1,000xs cycles.
CYCLES
X's MILLIONS
K-VALUE
APLT
IOWA DOT
FHWA
ingios

11


e-Construction is enabled with COMP-Score RT roller kits and in situ calibration using Automated Plate Load Testing (APLT)
QA Data!
Inspection Workflow
Geo-spatial
Design Modulus
Bring compaction quality info to digital world!
RT
APLT
IOWA DOT
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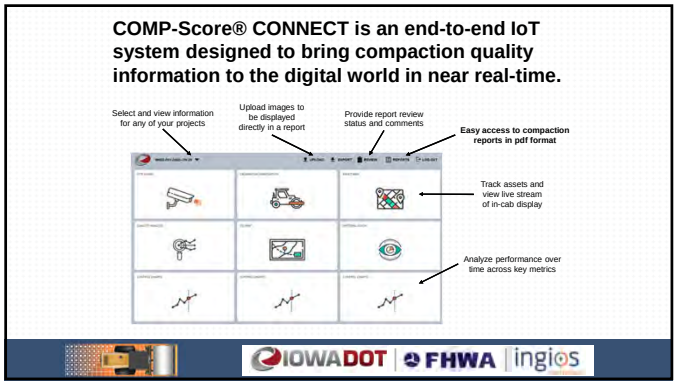
12



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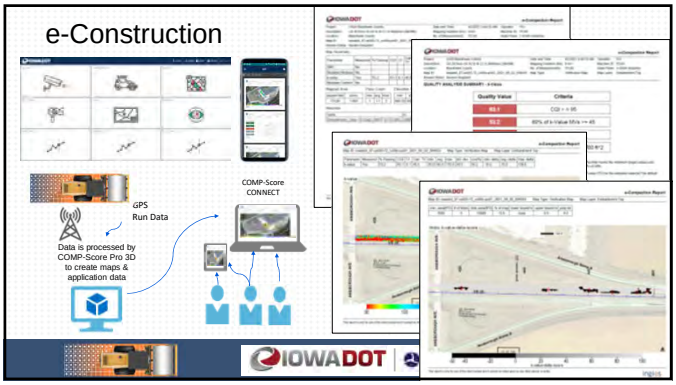

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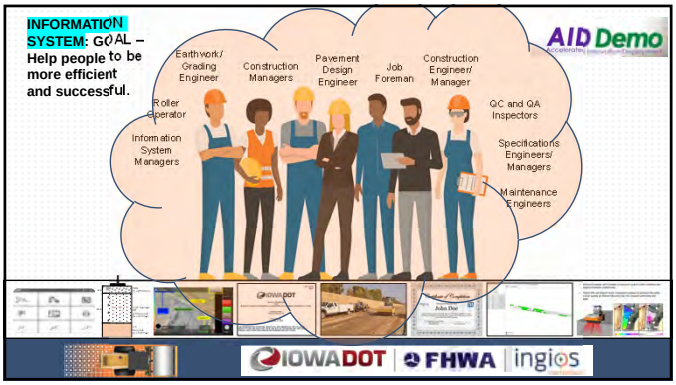

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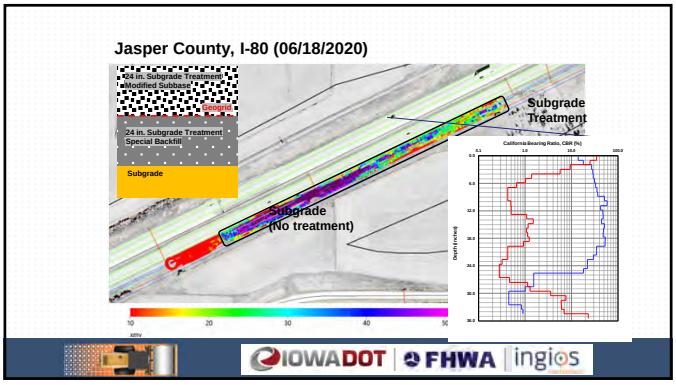
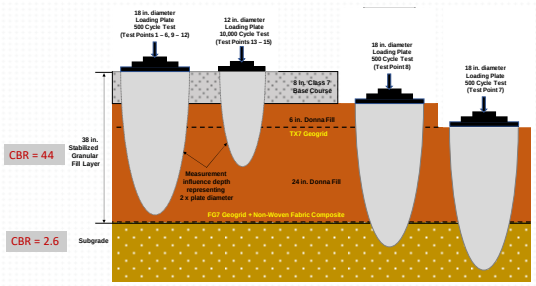


18

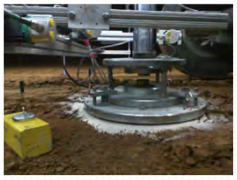
Example…APLT Experimental Plan



19

What does modulus look like …? ☺

Subgrade Composite
M_r = 3,293 psi



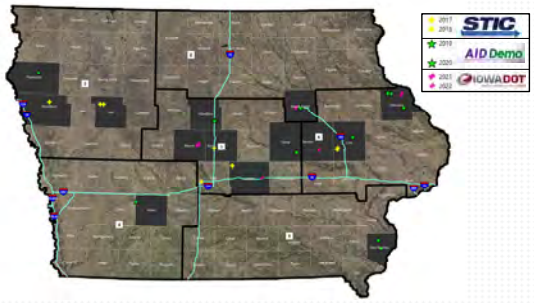
Subbase/Subgrade Composite
M_r = 25,162 psi

20

STIC and AID Projects

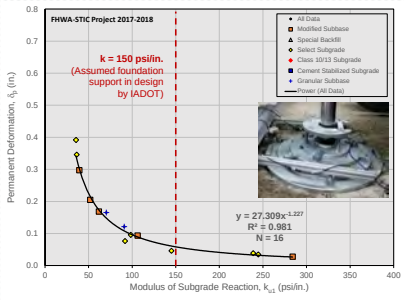
Overview and Key Findings

21



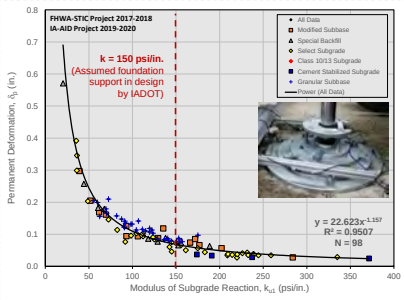
22

N = 16 tests: 21% of measurements meet the minimum design requirement for foundation support



23

N = 98 tests: 37% of measurements meet the minimum design requirement for foundation support



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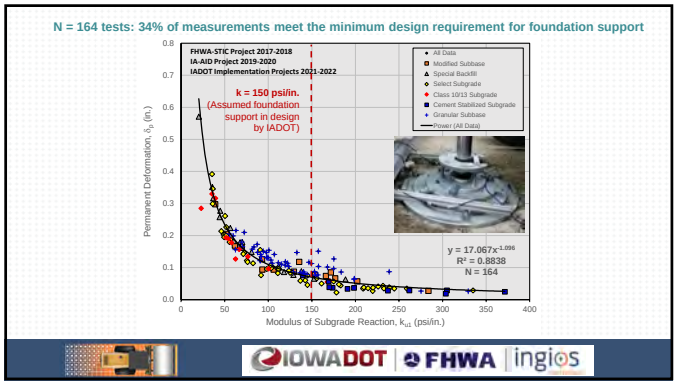

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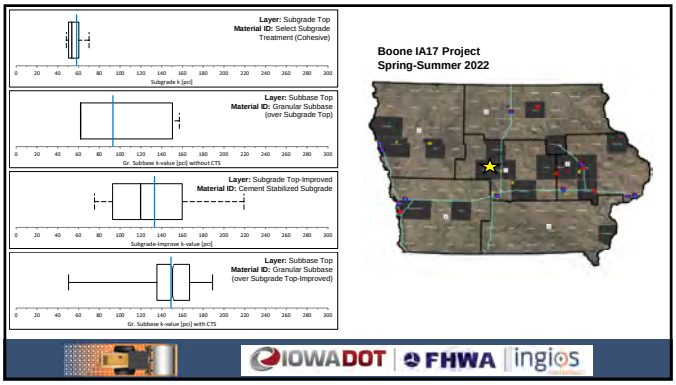

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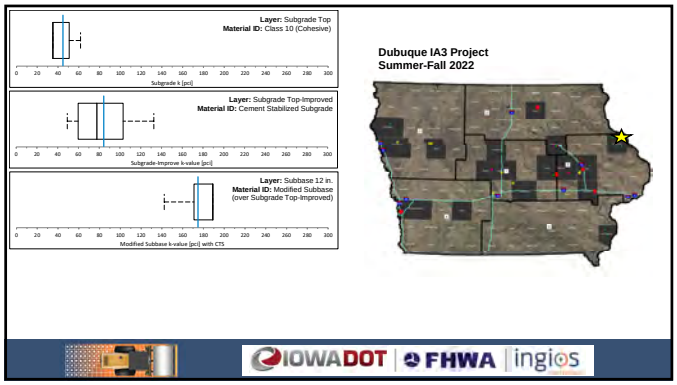

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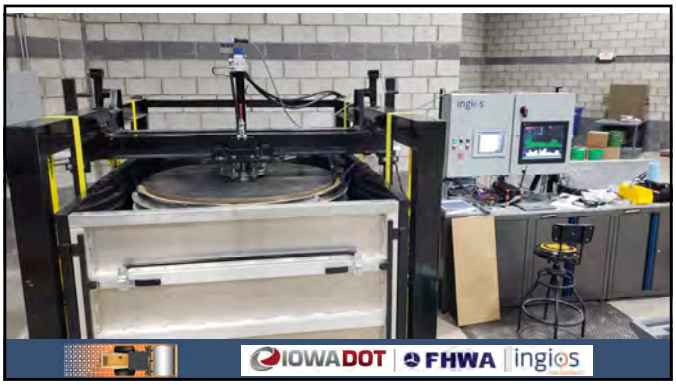

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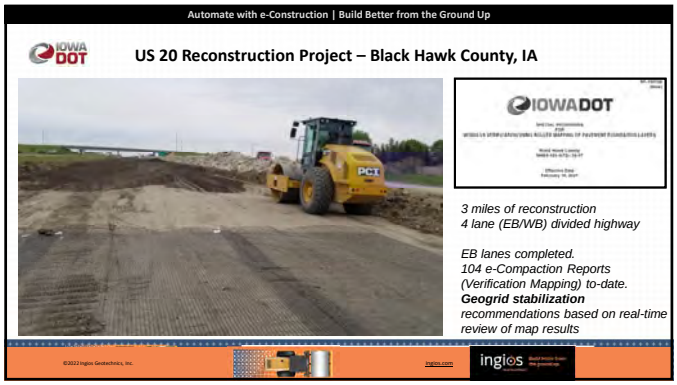

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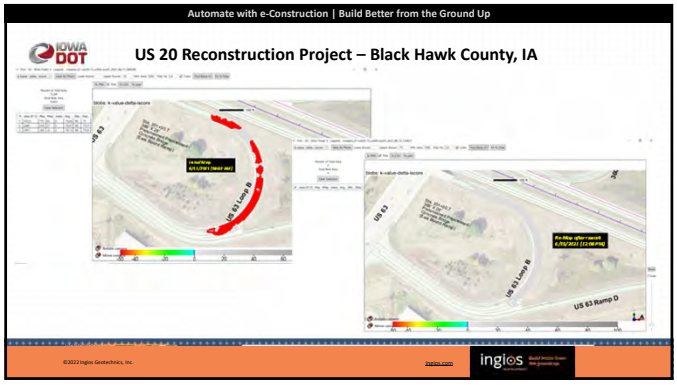

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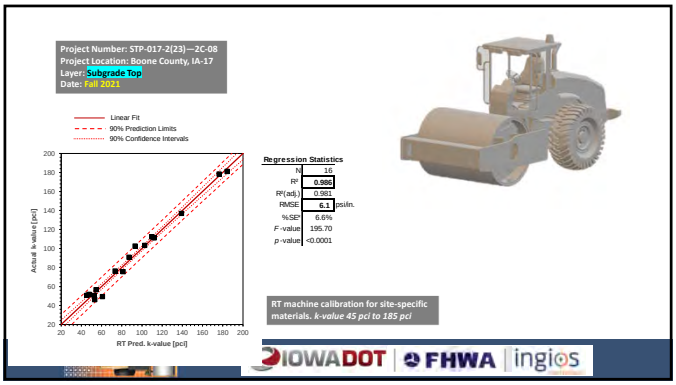

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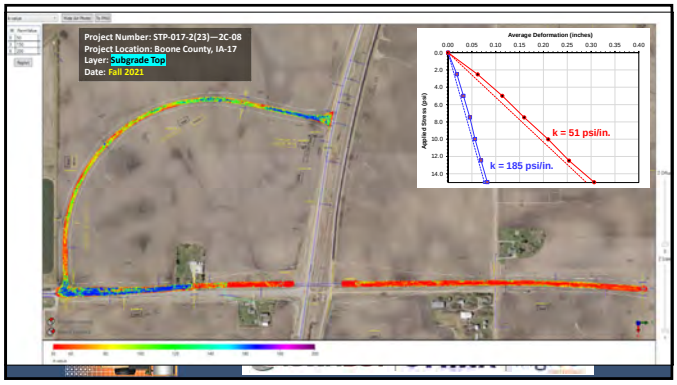

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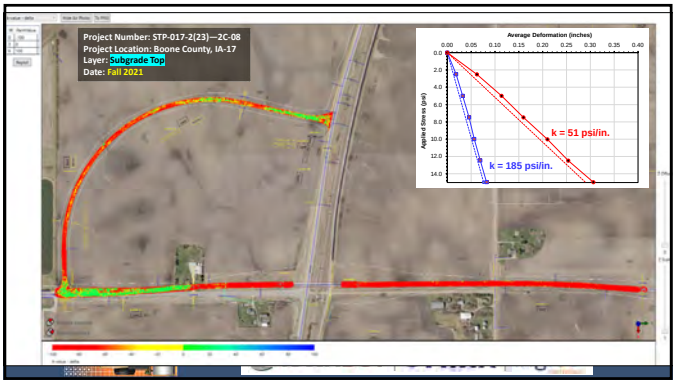

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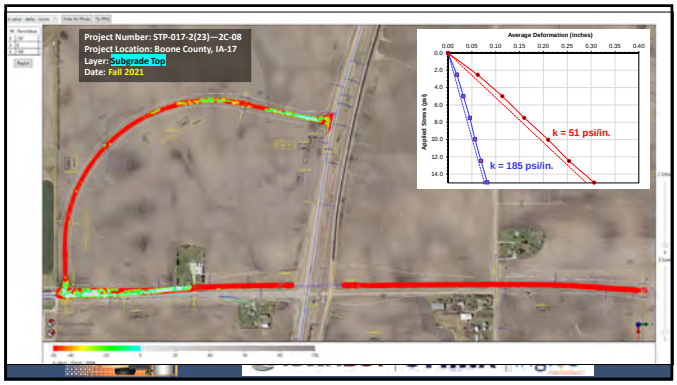

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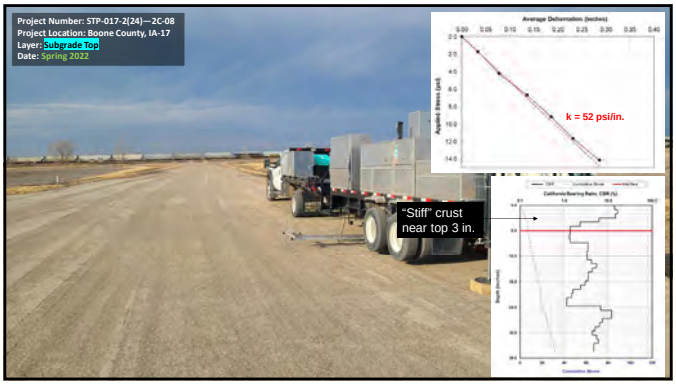

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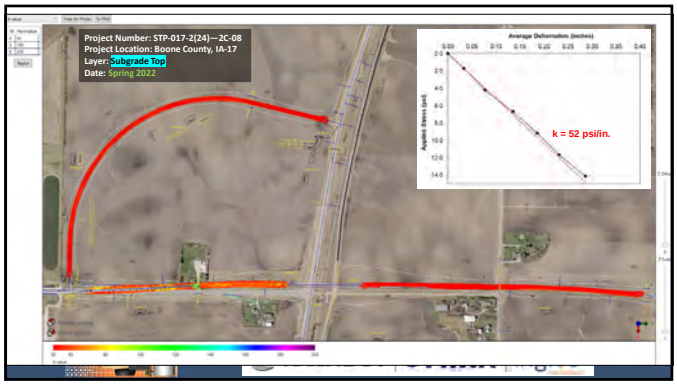

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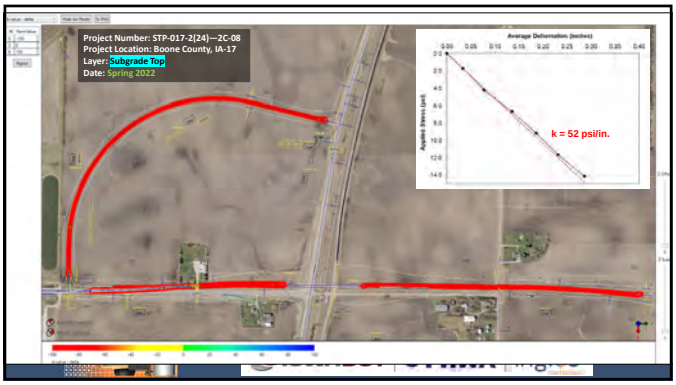

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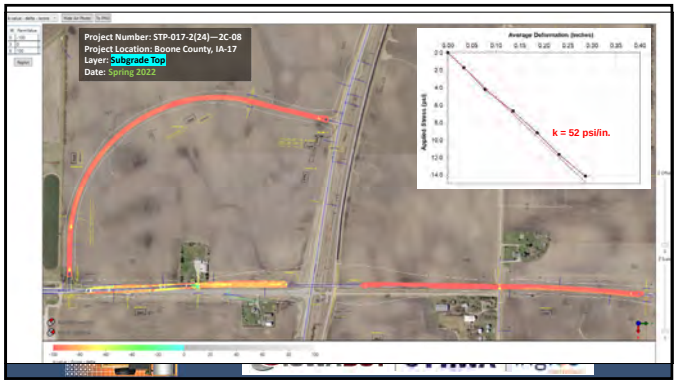

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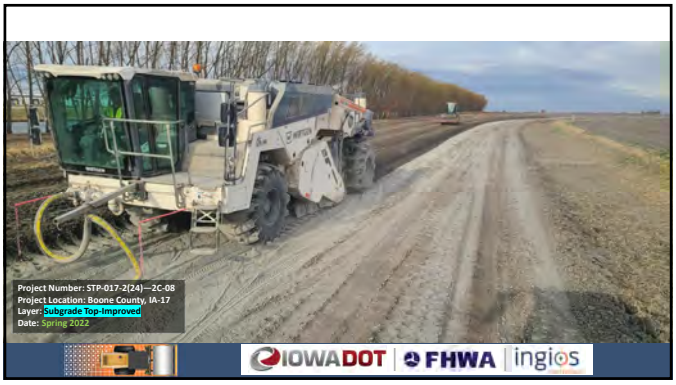

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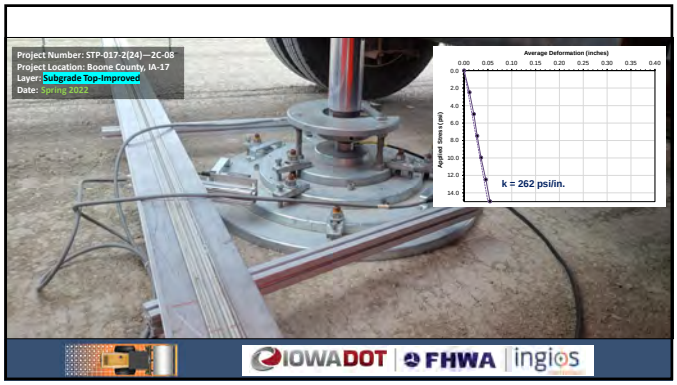

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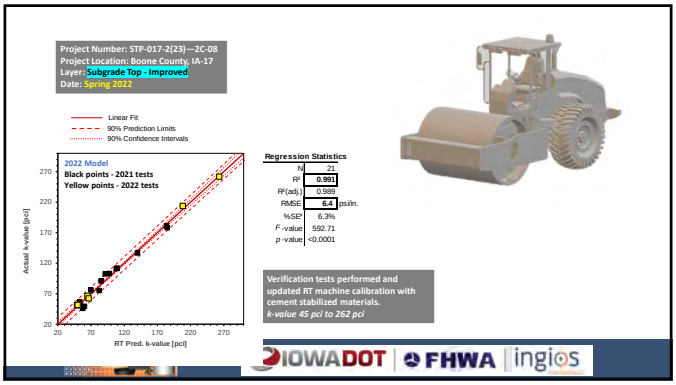

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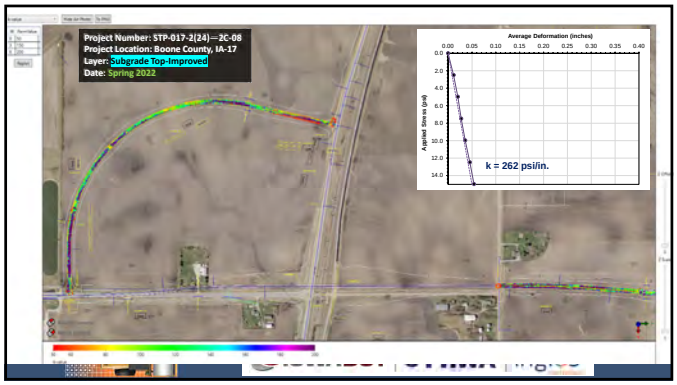

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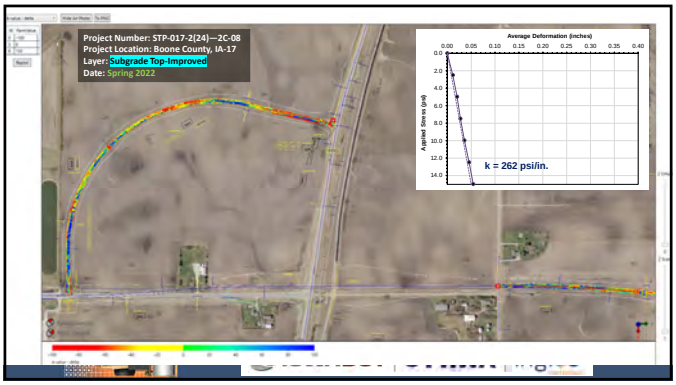

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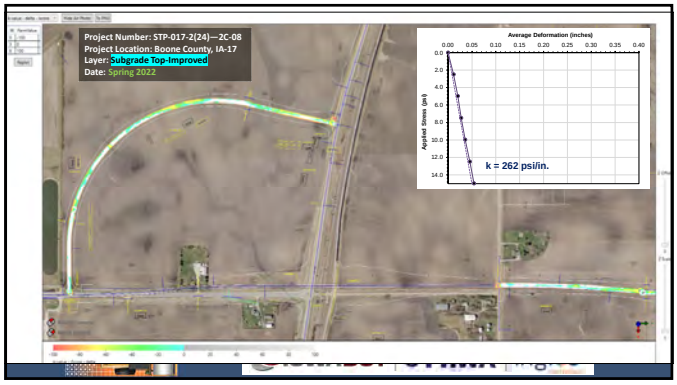

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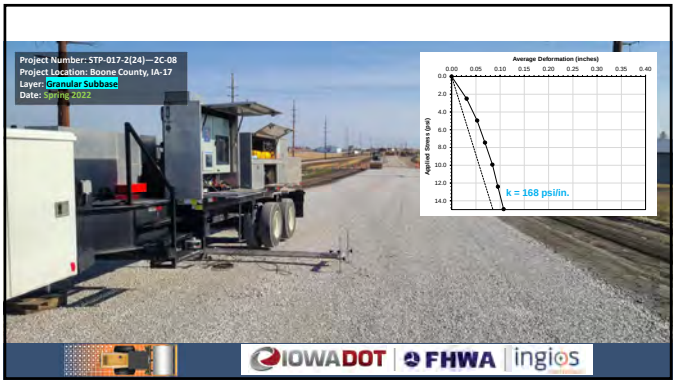

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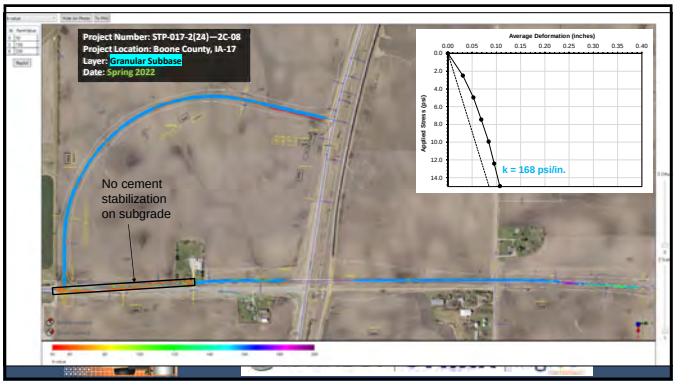

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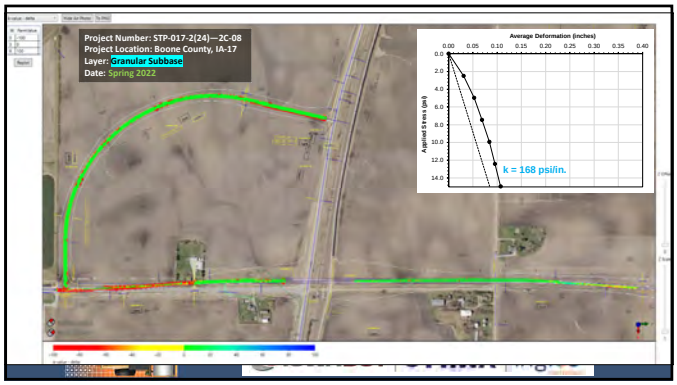

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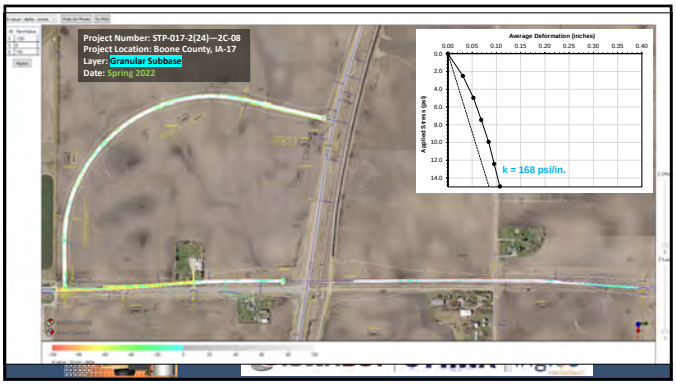

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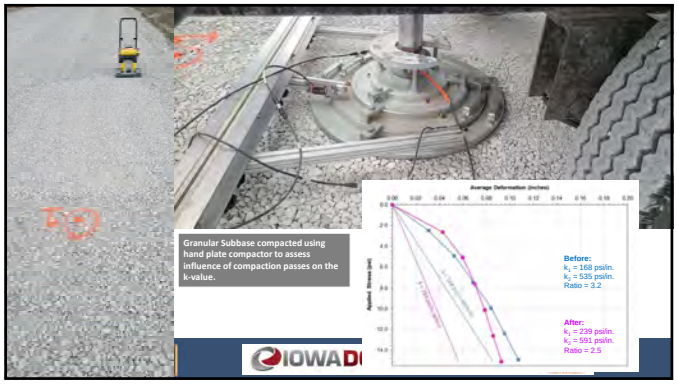

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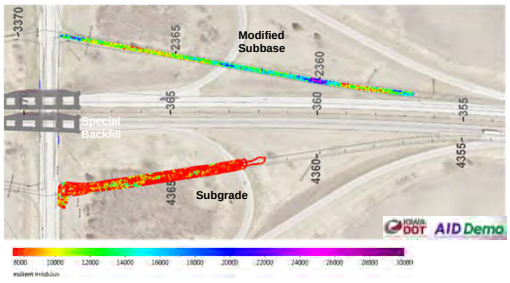
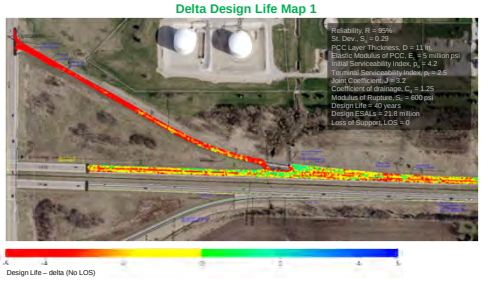
Hamilton County, I35/Hwy175 (09/03/2019)



61

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

Delta Design Life Map 1



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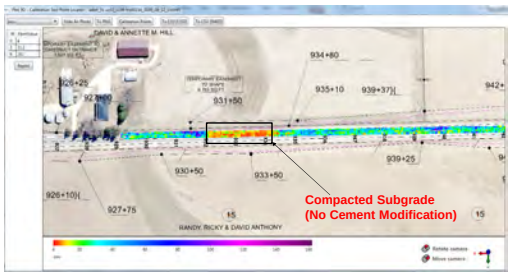
Dubuque County, US52 (08/12/2020) – Cement Modified Subgrade



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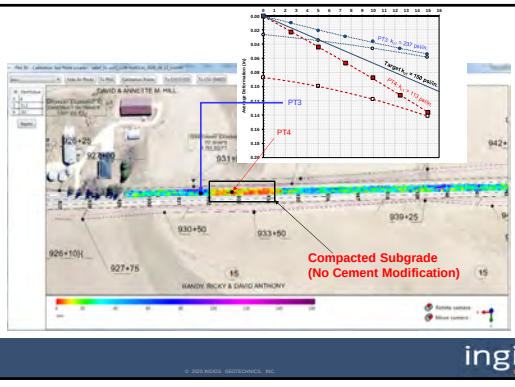

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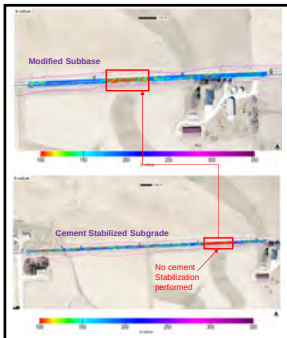


"Weak" layers in the underlying subgrade reflect on the overlying subgrade.

66

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. RT modulus mapping results provide high degree of confidence in providing k-value and M_r-value maps – R^2 values > 0.90
3. Modulus calibration records were developed for different material types across the State.
4. COMP-Score RT mapping identified "weak" areas in the underlying subgrade that are reflected on the overlying subbase layers.

STC AID Demo Accelerated Innovation Deployment

IOWA DOT | FHWA | ingios

67

68

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

Thank you!

IOWA DOT | FHWA | ingios

69

Iowa DOT Implementation Plan and Pilot Projects

Melissa Serio, Earthwork Engineer
Construction & Materials Bureau
Iowa Department of Transportation

1

Overview of Original 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.

Method Specification

Performance Specification

2

2017-18 STIC
2022 Pooled Fund
2023 Implementation (tentative)
2019-20 AID Demo
2021 & 22 Implementation

3

2021 Pilot Project Black Hawk US 20


SPECIAL PROVISIONS
FOR
MODULUS VERIFICATION USING ROLLER MAPPING OF PAVEMENT FOUNDATION LAYERS
Black Hawk County
NHSX-020-6(72)--34-07
Effective Date
February 16, 2021

- 3 miles of reconstruction of 4 lane (EB/WB) divided highway
- Mapping required on 4 layers
- Approx. 300 e-Compaction Reports.
- **Geogrid stabilization** recommendations based on real-time review of map results

4

2021 Pilot Project Boone County IA 17


SPECIAL PROVISIONS
FOR
MODULUS VERIFICATION USING ROLLER MAPPING OF PAVEMENT FOUDANTION LAYERS
Boone County
STP-017-2(23)--2C-08
Effective Date
January 26, 2021

- Grading only
- Mapping required on 6 compaction layers
- Approx. 80 e-Compaction Reports
- **Cement stabilization** recommendations based on in situ modulus mapping results

5

Lessons Learned from or during 2021 Pilot Projects

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

6

2022 Pilot Projects

- Jasper I-80
  - Marshalltown RCE
  - Grid
  - 31 total maps
- Boone IA 17
  - Jefferson RCE
  - Cement stabilization
  - 90 maps to date

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

Examples of e-Compaction reports will be shown in afternoon session

7

2022 Pilot Projects

- Dubuque IA 3
  - Manchester RCE
  - Cement stabilization (design also included grid)
  - 40 maps to date
- Benton US 30
  - Cedar Rapids RCE
  - 115 maps to date
  - Grid or cement stabilization

Continue to 2023 construction season

8

Overview of Original 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.

2023 – 2 carryover projects from 2022 and estimated 4 new projects

9

Overview of Implementation Plan – Next Steps

- Identify & evaluate specification and design changes to cost effectively deliver better performing pavement foundations
- Develop SPs for use in future years
- Quantify value proposition of longer performing foundations
- Determine best contracting arrangement to continue this work
- Continue work with TWG (includes industry)

10

Questions?

Melissa.serio@iowadot.us

11

Collaborative Session:
WHAT?, HOW?, and WHY?

Kera Gieselman – Project Manager, Ingios
John Puls, PE – Business Unit Leader, Ingios

1

TPF-5(478) Demonstration to Advance Pavement Technologies

Project Title: Support for Pavement Foundation Design Modulus Verification and Construction Quality Monitoring

Objectives:
- Provide direct support to interested states (who?) for piloting and implementing modulus-based pavement foundation construction.
- Begin to develop a state specific library of the pavement foundation material properties for use as input values in Pavement ME Design (PMED).

2

TPF-5(478) Demonstration to Advance Pavement Technologies

Project Title: Support for Pavement Foundation Design Modulus Verification and Construction Quality Monitoring

Task A: Additional Mapping Projects to Gather Data for Implementation
•Provide the DOT with modulus maps of selected projects using Ingios equipment and operator.
•Provide a report for each project. [Mapping on 5 projects = DONE]

Task B: Programmatic Support
•Develop training programs for Engineers, inspectors, and contractors and assist the DOT with integrating them into the current web-based training classes. [In-process]
•Develop model specifications to be used on future projects. [In-process]
•Develop workflow process and contractual documents for transitioning QC/QA processes from methods to performance specifications. [In-process]
•Field open house (For Iowa public agencies, contractors, and other DOT's with interest in technology partnerships) [Today]
•Develop educational and technology transfer materials. [In-process; host on e-compaction.com]
•Develop a technology brief on the value proposition of improving pavement foundation performance using data from 2022 projects and LCCA modeling completed using 2021 pilot project data [Not yet]

3

Why are we here?

☺

4

Why do we need to improve pavement foundations?

5

Why do we want pavements to last longer?

6

What do we need to do differently?

7

What are the gaps in our current pavement foundation inspection processes?

8

What happens if we verify pavement foundation design values meet the pavement design requirements.?

9

What happens if we transition to a real-time data driven QC/QA process?

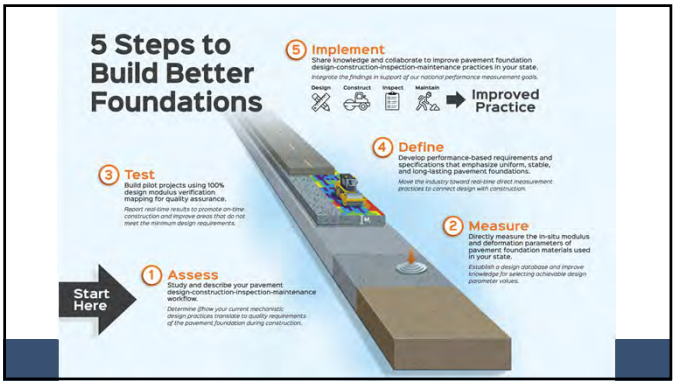
10

What does the desired outcome of this new process look like for you?

11

How do we get there?

12



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14

TPF-5(478) Demonstration to Advance Pavement Technologies

We need your help as we implement, iterate, improve the systems/processes, and participation.

- e-compaction.com
- Please respond to survey after open house mtg.

15

Learn how Advanced Technology and Automated Digital Workflow is used for Pavement Foundation Verification

October 28, 2022

PRESENTERS
Craig Swanson (Ingios)
David White, Ph.D., P.E. (Ingios)

1

Information System: Build better by bringing compaction quality data to the digital world through new technology.



Technology allows for the collection, processing, storage and distribution of information in near real-time.

Users in various roles interact within the system to perform their duties more effectively and efficiently.

Built in digital workflow enables timely decision making.

2

COMP-Score® technology enables collection, processing, storage and dissemination of information in near real-time.




Data is collected on the machine through sensors and operator input during the construction process.

Through RT, machine data is processed and displayed in real-time for operator consumption.

Data from the machine is sent to the cloud where it is stored, processed and e-Compaction reports generated.

CONNECT is a web-based software application that allows secure access for users to consume reports and provide feedback to stakeholders.

3

RT is a system implemented on the machine that enables real-time data collection and processing.





Sensors are installed on the machine and used to collect the necessary data input.

A computer system collects input data and processes into geo-referenced compaction quality results.

Operators input metadata that adds context to the data read from sensors.

Operators receive real-time feedback of compaction quality during mapping.

Data from completed maps is packaged and sent to the cloud.

4

The CONNECT web application provides secure access for users to consume and act on information.





Analyze and make timely decisions on a work area with the help of e-Compaction reports.

Supplement reports by uploading images or additional information that is appended to the report.

Communicate with stakeholders in any location by reviewing report results from directly within the application.

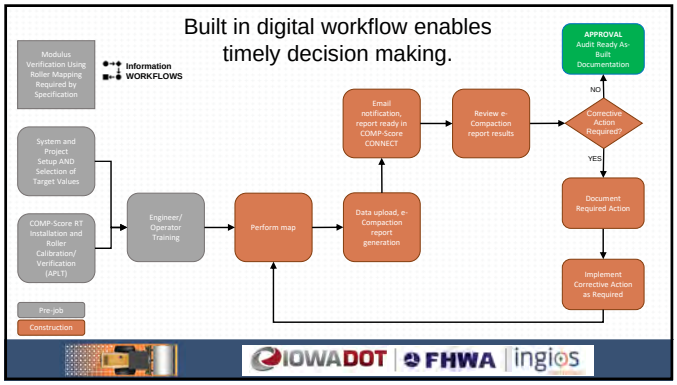
Live stream operations in real-time from directly within the application.

Centrally managed user access ensures that information is secure.

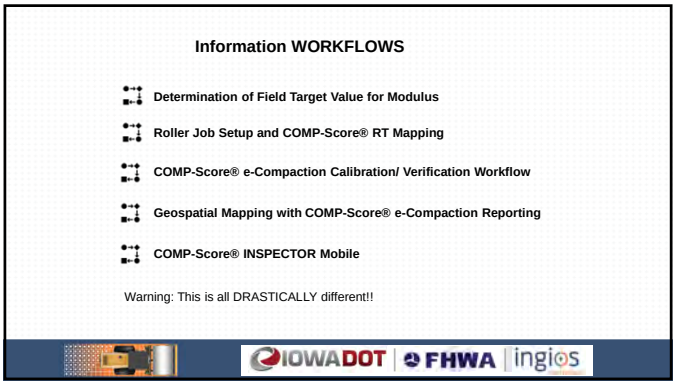
5

People interact within the system to perform their duties more effectively and efficiently.

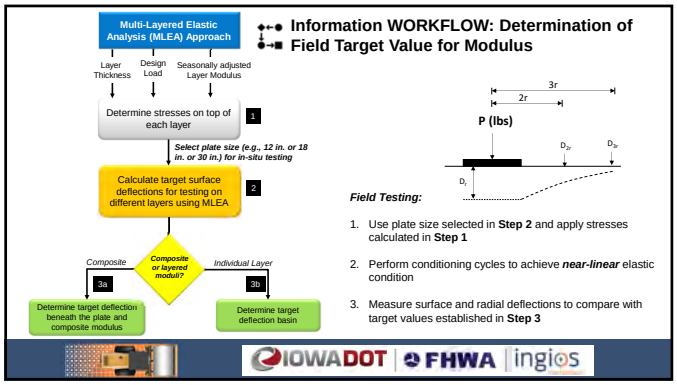
6


Built in digital workflow enables timely decision making.
Modulus Verification Using Roller Mapping Required by Specification
Information WORKFLOWS
System and Project Setup AND Selection of Target Values
COMP-Score RT Installation and Roller Calibration/ Verification (APLT)
Engineer/ Operator Training
Perform map
Data upload, e-Compaction report generation
Email notification, report ready in COMP-Score CONNECT
Review e-Compaction report results
Corrective Action required?
NO
YES
APPROVAL Audit Ready As-Built Documentation
Document Required Action
Implement Corrective Action as Required
Pre-job
Construction
IOWADOT
FHWA
ingios

7


Information WORKFLOWS
Determination of Field Target Value for Modulus
Roller Job Setup and COMP-Score® RT Mapping
COMP-Score® e-Compaction Calibration/ Verification Workflow
Geospatial Mapping with COMP-Score® e-Compaction Reporting
COMP-Score® INSPECTOR Mobile
Warning: This is all DRASTICALLY different!!
IOWADOT
FHWA
ingios

8


Information WORKFLOW: Determination of Field Target Value for Modulus
Multi-Layered Elastic Analysis (MLEA) Approach
Layer Thickness
Design Load
Seasonally adjusted Layer Modulus
Determine stresses on top of each layer
1
Select plate size (e.g., 12 in. or 18 in. or 30 in.) for in-situ testing
Calculate target surface deflections for testing on different layers using MLEA
2
Composite
Composite or layered moduli?
Individual Layer
3a
3b
Determine target deflection beneath the plate and composite modulus
Determine target deflection basin
3r
2r
P (lbs)
Field Testing:
1. Use plate size selected in Step 2 and apply stresses calculated in Step 1
2. Perform conditioning cycles to achieve near-linear elastic condition
3. Measure surface and radial deflections to compare with target values established in Step 3
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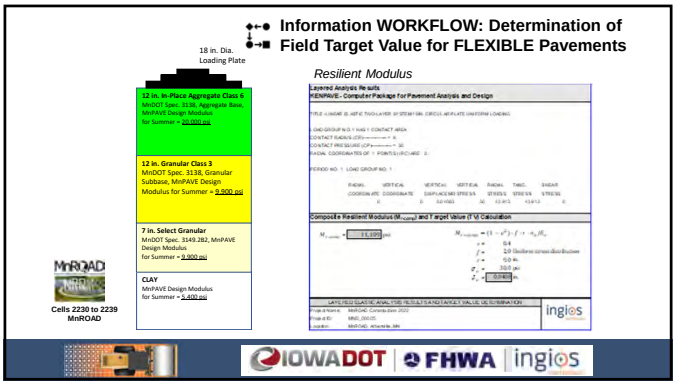
9


Information WORKFLOW: Determination of Field Target Value for FLEXIBLE Pavements
18 in. Dia. Loading Plate
Resilient Modulus
12 in. In-Place Aggregate Class 6
MnDOT Spec. 3138, Aggregate Base, MnPAVE Design Modulus for Summer = 20,000 psi
12 in. Granular Class 3
MnDOT Spec. 3138, Granular Subbase, MnPAVE Design Modulus for Summer = 9,900 psi
7 in. Select Granular
MnDOT Spec. 3149.2B2, MnPAVE Design Modulus for Summer = 9,900 psi
CLAY
MnPAVE Design Modulus for Summer = 5,400 psi
MnROAD
Cells 2230 to 2239 MnROAD
Layered Analysis Results
FENPAVE - Computer Package for Pavement Analysis and Design
Composite Resilient Modulus (M_r comp) and T arget Value (T V) Calculation
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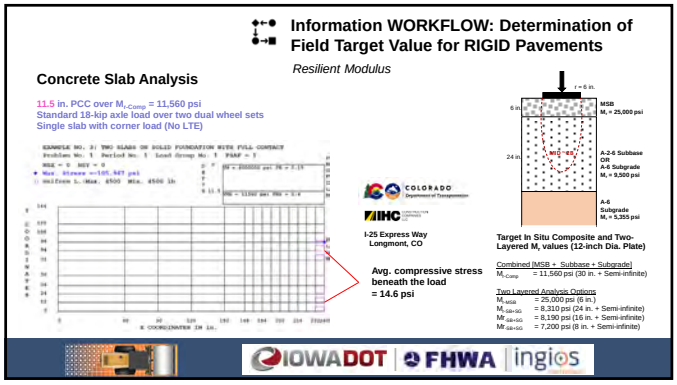
10


Information WORKFLOW: Determination of Field Target Value for RIGID Pavements
Concrete Slab Analysis
Resilient Modulus
11.5 in. PCC over M_r,Comp = 11,560 psi
Standard 18-kip axle load over two dual wheel sets
Single slab with corner load (No LTE)
I-25 Express Way
Longmont, CO
Avg. compressive stress beneath the load = 14.6 psi
MSB M_r = 25,000 psi
A-2-6 Subbase OR A-6 Subgrade M_r = 9,500 psi
A-6 Subgrade M_r = 5,355 psi
Target In Situ Composite and Two-Layered M_r values (12-inch Dia. Plate)
Combined (MSB + Subbase + Subgrade)
M_r,Comp = 11,560 psi (30 in. + Semi-infinite)
Two Layered Analysis Options
M_r,MSB = 25,000 psi (6 in.)
M_r,SB-SG = 8,310 psi (24 in. + Semi-infinite)
M_r,SB-SG = 8,190 psi (16 in. + Semi-infinite)
M_r,SB-SG = 7,200 psi (8 in. + Semi-infinite)
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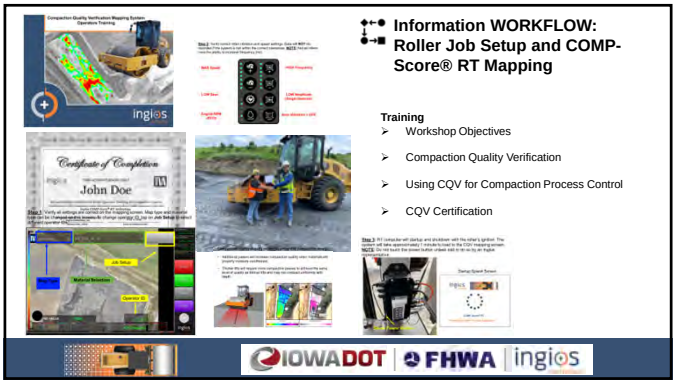
Information WORKFLOW: Roller Job Setup and COMP-Score® RT Mapping
Training
Workshop Objectives
Compaction Quality Verification
Using CQV for Compaction Process Control
CQV Certification
Certificate of Completion
John Doe
IOWADOT
FHWA
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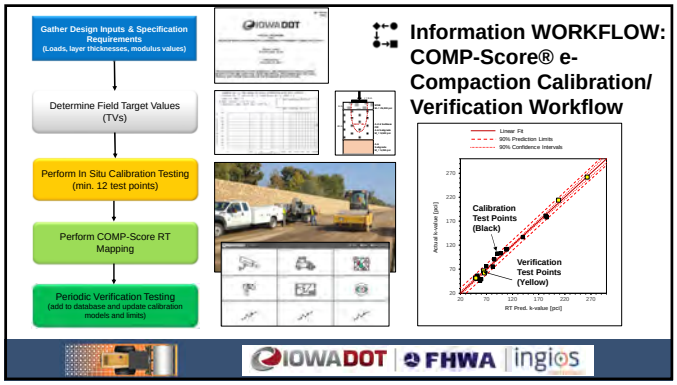
Gather Design Inputs & Specification Requirements
(Loads, layer thicknesses, modulus values)
Determine Field Target Values (TVs)
Perform In Situ Calibration Testing (min. 12 test points)
Perform COMP-Score RT Mapping
Periodic Verification Testing
(add to database and update calibration models and limits)
Information WORKFLOW: COMP-Score® e-Compaction Calibration/ Verification Workflow
Calibration Test Points (Black)
Verification Test Points (Yellow)
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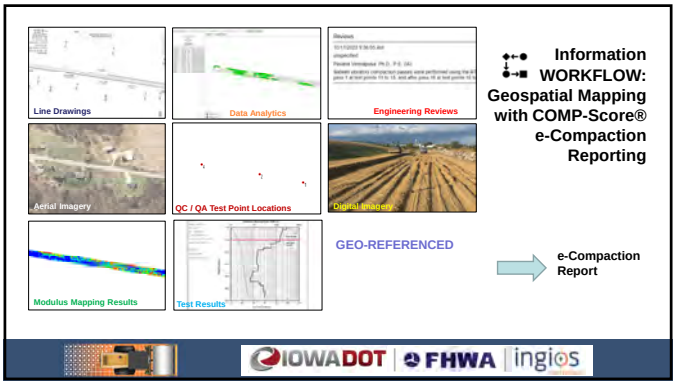
Line Drawings
Data Analytics
Engineering Reviews
Aerial Imagery
QC / QA Test Point Locations
Digital Imagery
Modulus Mapping Results
Test Results
GEO-REFERENCED
Information WORKFLOW: Geospatial Mapping with COMP-Score® e-Compaction Reporting
e-Compaction Report
IOWADOT
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14


Information WORKFLOW: COMP-Score® INSPECTOR Mobile
YOU ARE HERE
IOWADOT
FHWA
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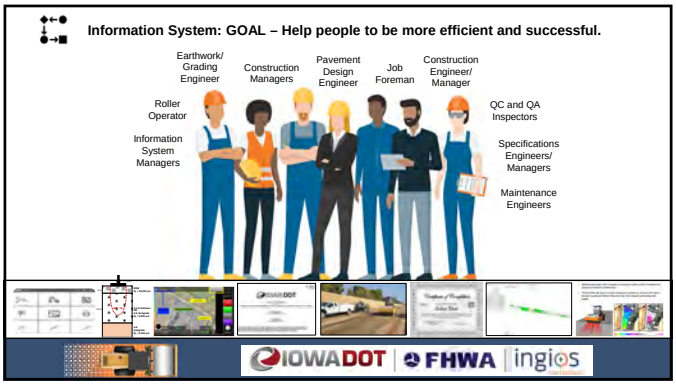
Information System: GOAL – Help people to be more efficient and successful.
Earthwork/ Grading Engineer
Construction Managers
Pavement Design Engineer
Job Foreman
Construction Engineer/ Manager
Roller Operator
QC and QA Inspectors
Information System Managers
Specifications Engineers/ Managers
Maintenance Engineers
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e-Compaction Report walkthrough
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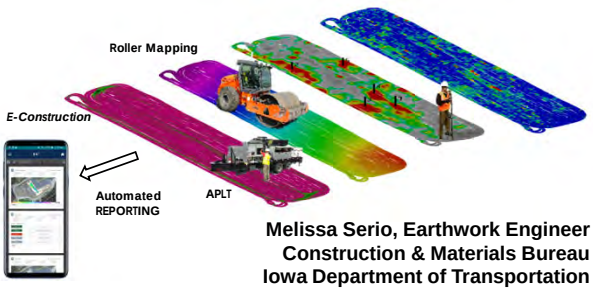
17

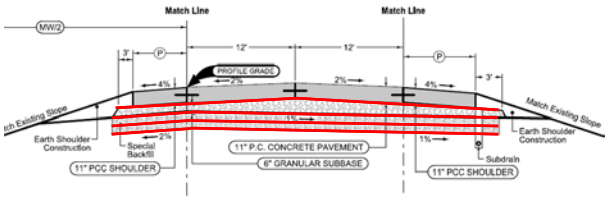
Engineering and Inspection Examples for e-Compaction Reports



Melissa Serio, Earthwork Engineer
Construction & Materials Bureau
Iowa Department of Transportation

1

Black Hawk – US 20 (2021 pilot project)

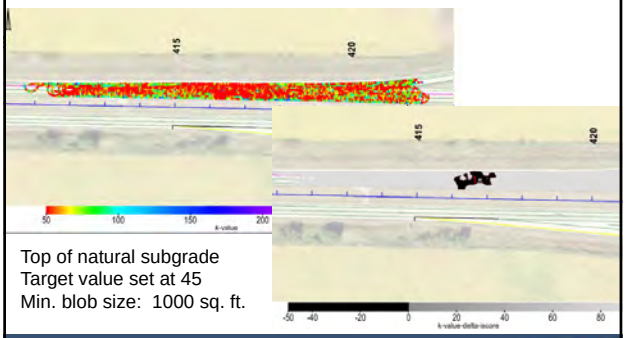


Mapped:

- Bottom of Class 13 Excavation
- Middle of Special Backfill (i.e. after first lift)
- Top of Special Backfill (i.e. after second lift)
- Top of Granular Subbase

2

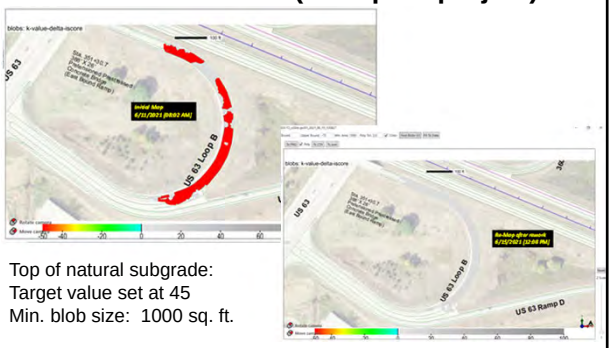
Black Hawk – US 20 (2021 pilot project)



Top of natural subgrade
Target value set at 45
Min. blob size: 1000 sq. ft.

3

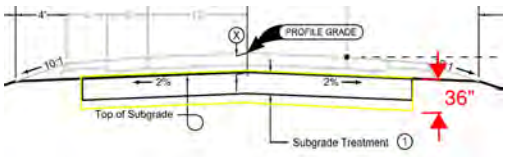
Black Hawk – US 20 (2021 pilot project)



Top of natural subgrade:
Target value set at 45
Min. blob size: 1000 sq. ft.

4

Boone IA 17 (2021 & 2022 pilot projects)



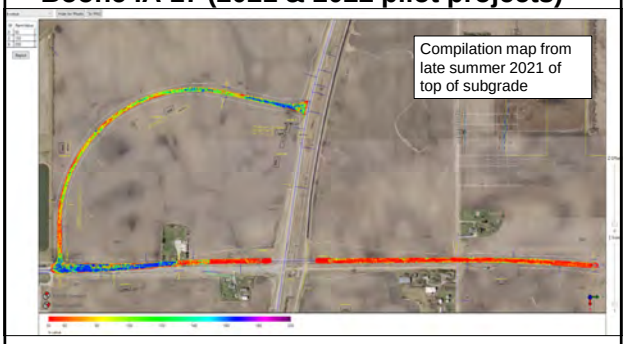
2021 Pilot Project – ML IA 17 Detail

Mapped:

- For 2021 pilot project, all compacted lifts within 36" below top of subgrade on mainline IA 17. Subgrade treatment 30" of select soil. Also top of subgrade for Robin Rd. (county road)
- For 2022 pilot project, all lifts within 24" on mainline IA 17, all cement treated areas (pre & post), granular subbase, and top of subgrade 200th St.

5

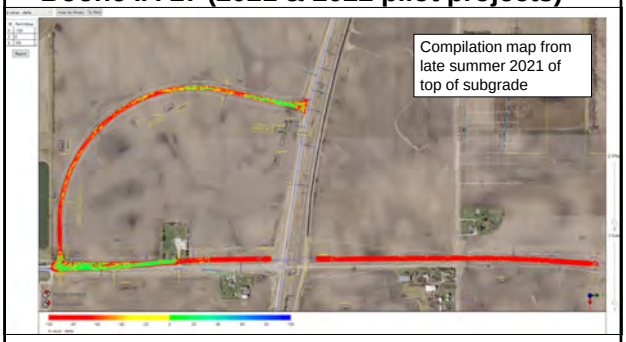
Boone IA 17 (2021 & 2022 pilot projects)



6

8. Engineering and Inspection Examples

Boone IA 17 (2021 & 2022 pilot projects)

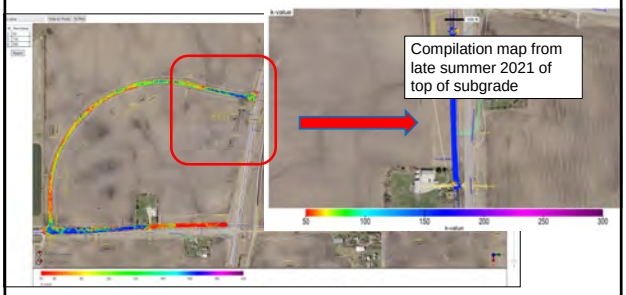


7

Boone IA 17 (2021 & 2022 pilot projects)

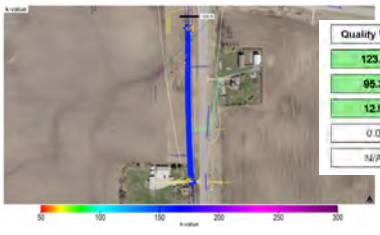
Mapped:

- Left: Top of 6" granular subbase with 12" cement treatment Fall 2021
- Right: Top of 6" granular subbase with 12" cement treatment Spring 2022



8

Boone IA 17 (2021 & 2022 pilot projects)

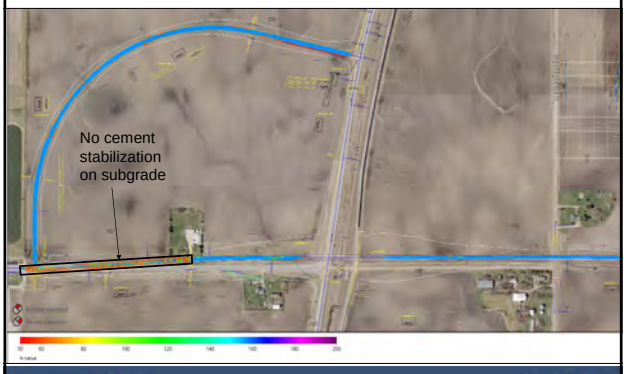


Quality Value	Criteria
123.9	CQI > = 95
95.3	80% of k-Value MVs >= 150
12.9	COV <= 30
0.0	% i-Score Blob Area >= 1000 ft^2
N/A	Lift Thickness Median Value (in.)

Parameter	Measured	% Passing	CQI	CI	Calc. TV	min.	avg.	max.	std. dev.	cov(%)	min.-delta	avg.-delta	max.-delta
XMV	No												
Resilient Modulus	No												
k-value	Yes	95.3	123.9	1.7	150.0	62.0	152.7	157.0	19.7	12.9	-88.0	2.7	7.0
Moisture Content	No												

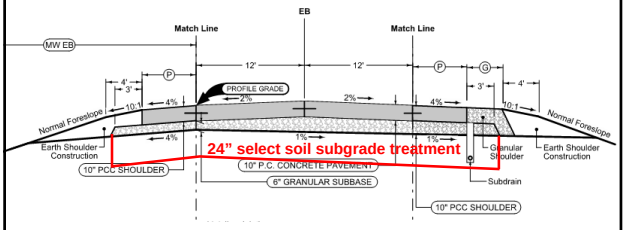
9

Boone IA 17 (2021 & 2022 pilot projects)



10

Benton US 30 (2022 pilot project)



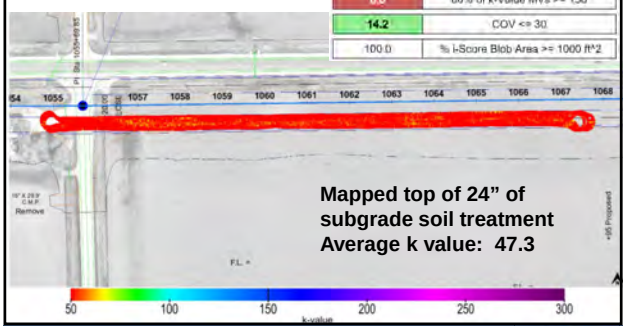
Mapped

- Top 3 lifts of subgrade

11

Benton US 30 (2022 pilot project)

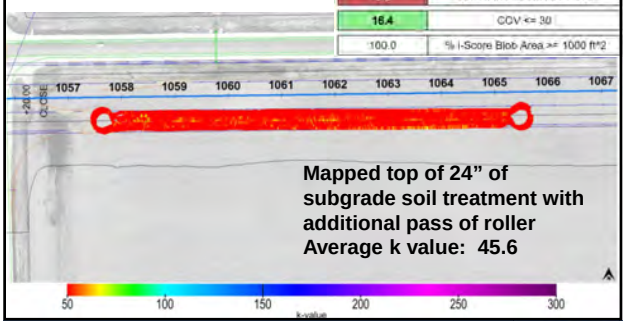
Quality Value	Criteria
27.9	CQI > = 95
0.0	80% of k-Value MVs >= 150
14.2	COV <= 30
100.0	% i-Score Blob Area >= 1000 ft^2



12

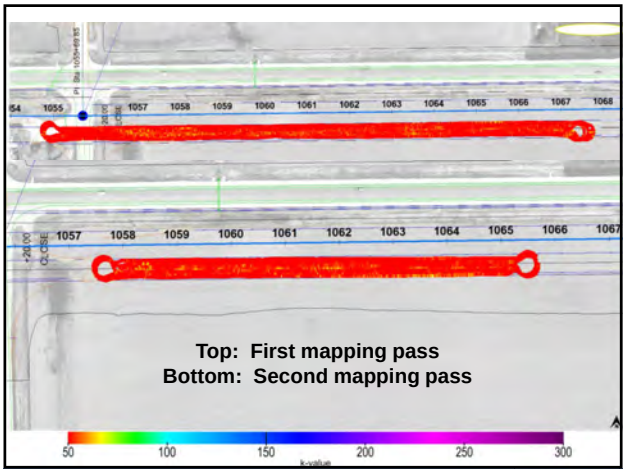
Benton US 30 (2022 pilot project)

Quality Value	Criteria
26.8	CQI > = 95
0.0	80% of k-Value MVs >= 150
16.4	COV <= 30
100.0	% i-Score Blob Area >= 1000 ft^2



Mapped top of 24” of subgrade soil treatment with additional pass of roller
Average k value: 45.6

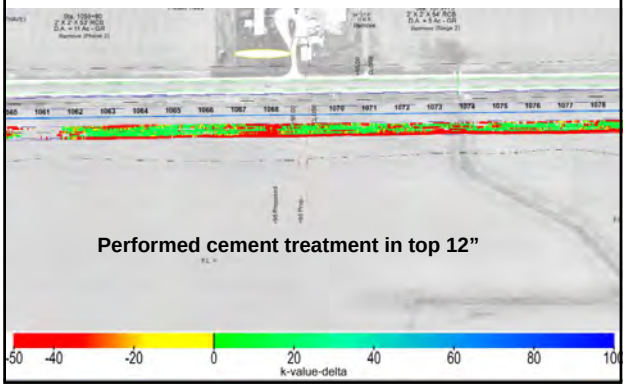
13



Top: First mapping pass
Bottom: Second mapping pass

14

Benton US 30 (2022 pilot project)



Performed cement treatment in top 12”

15

Benton US 30 (2022 pilot project)

Quality Value	Criteria
27.8	CQI > = 95
0.0	80% of k-Value MVs >= 150
14.2	COV <= 30
100.0	% i-Score Blob Area >= 1000 ft^2

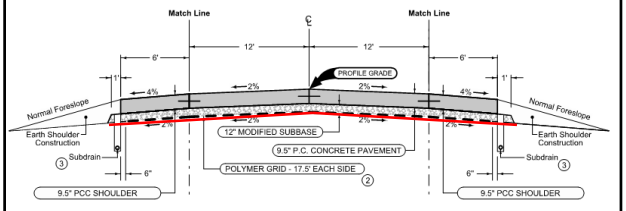
Before cement treatment
Average k value: 47.3

Quality Value	Criteria
61.9	CQI > = 95
43.0	80% of k-Value MVs >= 150
32.2	COV <= 30
75.6	% i-Score Blob Area >= 1000 ft^2

After cement treatment
Average k value: 125.0

16

Dubuque IA 3 (2022 pilot project)

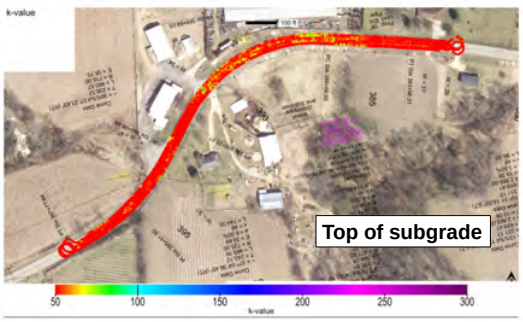


Mapped:

- Top of subgrade
- Top of subgrade – after cement treatment (if performed)
- 6” of modified subbase
- 12” of modified subbase

17

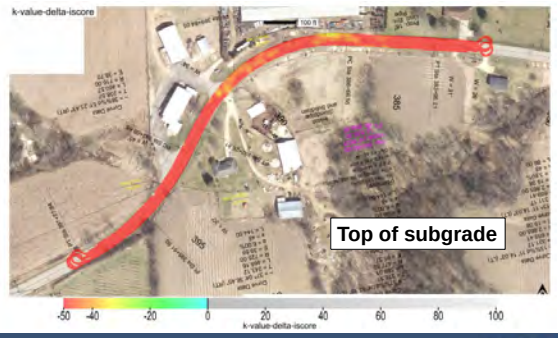
Dubuque IA 3 (2022 pilot project)



Top of subgrade

18

Dubuque IA 3 (2022 pilot project)

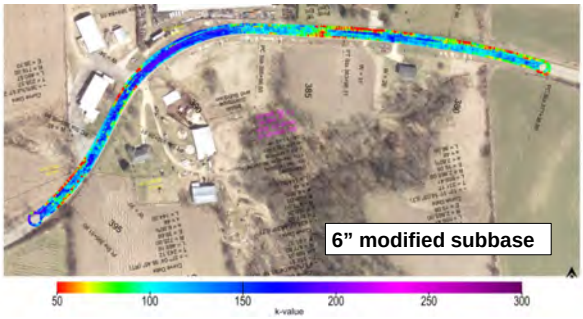


19

Dubuque IA 3 (2022 pilot project)

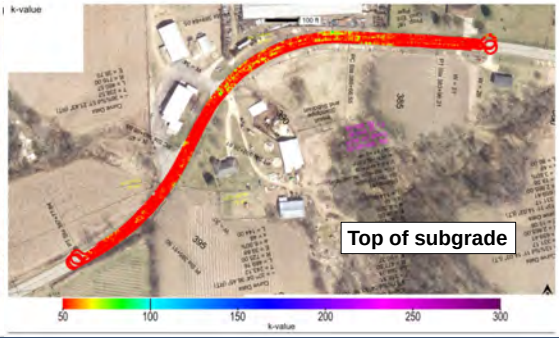
20

Dubuque IA 3 (2022 pilot project)



21

Dubuque IA 3 (2022 pilot project)



22

Dubuque IA 3 (2022 pilot project)

Quality Value	Criteria
23.4	CQI > = 95
0.0	80% of k-Value MVs >= 100
23.1	COV <= 30
100.0	% I-Score Blob Area >= 1000 ft^2

Subgrade – before cement
Ave. k value: 45.1

Quality Value	Criteria
59.6	CQI > = 95
44.7	80% of k-Value MVs >= 100
40.6	COV <= 30
45.9	% I-Score Blob Area >= 1000 ft^2

Subgrade – after cement
Ave. k value: 100.8

Quality Value	Criteria
36.2	CQI > = 95
16.3	80% of k-Value MVs >= 150
34.2	COV <= 30
86.3	% I-Score Blob Area >= 1000 ft^2

6” of modified subbase
Ave. k value: 113.7

Quality Value	Criteria
98.7	CQI > = 95
70.8	80% of k-Value MVs >= 150
18.2	COV <= 30
5.8	% I-Score Blob Area >= 1000 ft^2

12” of modified subbase
Ave. k value: 162.5

23

Show video

24

Additional Questions/Comments?

Melissa.serio@iowadot.us

9. Value of Pavement Foundation Verification

Value of Pavement Foundation Verification: Leverage Power of Data and Moving forward in a Measured Way!

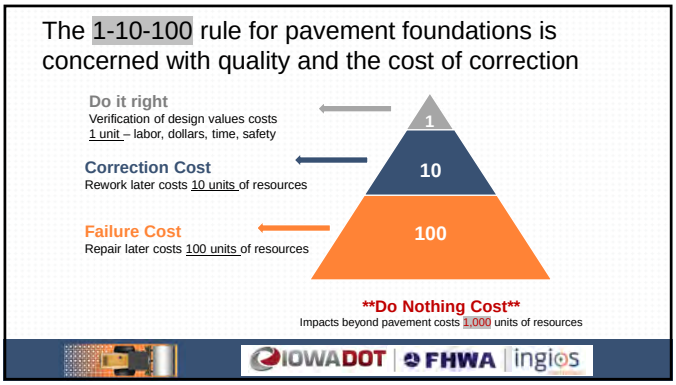
David J. White, Ph.D., P.E. – Ingios Geotechnics, Inc

1

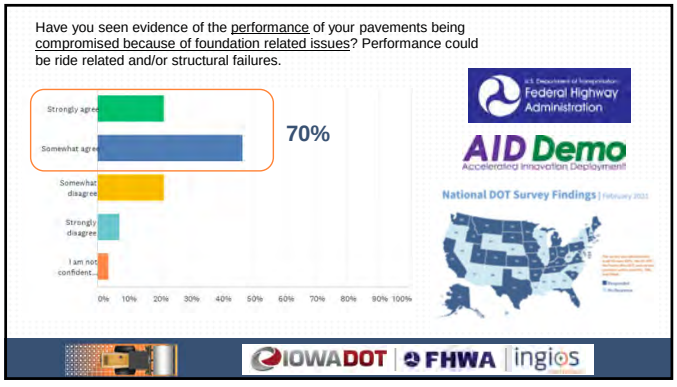
Benefit of pavement foundations is difficult to quantify.

2

3



4



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6

9. Value of Pavement Foundation Verification

70-80% of construction costs is the pavement layer

20-30% of costs are the pavement foundation layers
(granular subbase, subgrade, and embankment)

Current Industry Practice	Ingios Solutions Approach
• **Quality Control/Quality Assurance testing <0.1%** of the pavement foundation layers.	• **Quality Control/Quality Assurance testing >95%** of the pavement foundation layers.
• **Specification:** Method/end-results using **indirect Quality Control/ Quality Assurance testing** (weight/volume measurements) that do not verify in situ pavement design values.	• **Specification:** Modulus performance verification using **direct measurement** for verification of pavement design requirements.
• Quality Control/Quality Assurance testing takes **hours/days** to collect information and report results.	• **Real-time** e-construction solution because seconds count during construction. No data to manage.
• **> 90% risk** of not detecting pavement foundation support condition defects that will contribute to reduced pavement life.	• **<5% risk** using Quality Assurance approach for pavement.
• Current methods **limit ability** to improve and verify pavement foundations to support need to extend future pavement life and deliver sustainable pavement systems.	• Requires investments of 1-2% to deliver sustainable extended pavement life. **Benefits are 2 to 5x's initial investment** in terms of life cycle cost analysis.
• **Not a precise solution.** Adding greater thickness to the pavement does not prevent poor pavement foundation supporting conditions from being covered up.	• Delivers a **precision construction solution** to improve non-uniformity known as a leading cause of pavement problems.

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~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.

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8

Framework to Quantify Cost of Poor Pavement Foundations (09/24/2022) DRAFT

Condition	Impact to the Public	Impact to the DOT	Quantify Impact (Quantitatively and Qualitatively)	
Early Pavement Deterioration – near term impacts (cracking, heaving, settlement, rough pavements)	• Poor ride quality • Increased vehicle operating costs • Reduced driver safety • Impact on travel time	• Unnecessary increased maintenance activity • Increased safety exposure for maintenance forces (agency & contractors)	Product Needed • Analysis of maintenance costs • Safety analysis • Vehicle user cost associated with ride quality	Data Required • Data on pavement patching, crack sealing, non-structural overlays • Accident data • Vehicle operating costs
Shortened Pavement Life	• Requires additional public investment due to pavements not performing to design potential • Creates poor image of the DOT • Travel & safety impacts	• Rehabilitation/reconstruction required early due to deteriorated pavement condition • Unreliable pavement design life predictions • Diverts funds from other system needs • The pavement foundation has reduced value for future use	• Analysis of US 20 project example • Analysis of actual and predicted pavement design life calculating DOT ownership cost (LCCA & annually).	• Actual data from as-built conditions • Pavement management data (FWD results, maintenance & rehabilitation activities)
Reduced Ability to Reliability Manage the Roadway Network	• Diminishes reliability in programming future transportation needs as funding is diverted to address underperforming projects	• Generates more reactive rather than predicted approach to programming projects • Lost opportunity cost as expected funding is not available • Creates lack of confidence in DOT from the public	• Analysis of the program level impacts of diversion of funds to compensate for reduced pavement performance and reduced end of life salvage value.	• Pavement management data analyzing current pavement performance as compared to pavements achieving the planned performance life and maintenance /rehabilitation activities.

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Benefit	Value
Audit ready system (real-time documentation and history)	$
Optimized compaction (efficient roller patterns/improvements)	$
Reduced risk (of building poor quality) (future asset management tool/input)	$$
Improved QC/QA inspection (intelligent analytics)	$
Minimized construction delays (data driven)	$$
Improved safety (people off grade, less rework)	$$
Data as asset (less risk on bid items in future)	$$$
Cost/value: LCCA (NPV analysis showing value, needs to drive sustainable pavement solutions with extended life, 100+ yrs) (Note: Cost/project scales down quickly with increased jobs)	$$$

AID Demo
STC
IOWA DOT

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Case history #1: Summary of net present value (NPV) for alternative pavement foundation solutions.

The analytical LCCA method determines the net present value (NPV) of alternatives where the cost computed is the discounted monetary value of the benefits minus the costs.

$$NPV = Intial\ Cost + \sum_{k=1}^{N} Rehabilitation\ cost_k \left[\frac{1}{(1+i)^{n_k}}\right] - Salvage\ Value$$

where i = discount rate, n = year of expenditure

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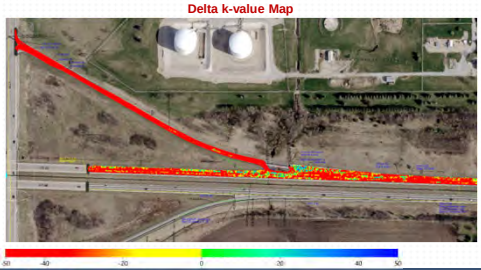
11

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

Delta k-value Map



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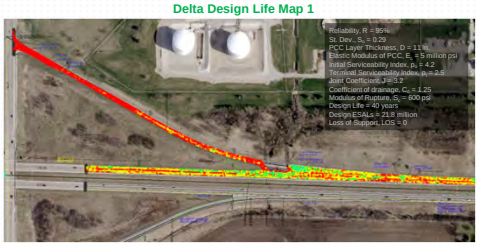
12

9. Value of Pavement Foundation Verification

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

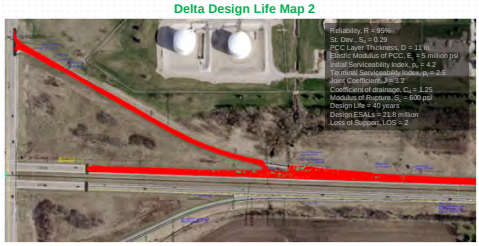
Delta Design Life Map 1



13

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

Delta Design Life Map 2



14

Summary of net present value (NPV) for alternative pavement foundation solutions.

Benefits derived from vehicle operating costs, user delay costs, and crash costs are excluded.
Benefits from salvage value matrix included.
3% discount rate.

Pavement Foundation Case	Average Design Life	NPV Cost	Benefit	Multiplier
Alt1A: As-constructed k-value (LOS =2), moderate permanent deformation	31.2	$22,611,553	$(649,823)	0
Alt1B: COMP-Score® CONNECT solution per Iowa DOT design requirement k-value (+$200k)	40 (per standard design)	$21,961,731	$-	3.2
Alt2+: COMP-Score® CONNECT solution enhanced k-value design requirement (+$350k)	50	$21,376,678	$585,052	3.5
Alt3++: COMP-Score® CONNECT solution enhanced k-value design requirements (+700k)	100	$19,805,858	$2,155,873	4.0

Benefit is 3 to 4x's the initial investment.

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Initial Estimating for Value/Benefit?

Factor	Multiplier
LCCA – Pavement Foundation Life (excluding operations/institutionalized costs of maintenance/report)	2 to 5
Real-time QC/QA (minimize construction delays)	1.5 to 10
Fix bad areas during construction versus future repair (e.g., full-depth patching)	10 to 100
Measurement with design performance verification improves knowledge and the next project	1 to 5
Safety Improvements (less rework)	2 to 10
Inspire next generation to work construction and pavements	?
Total	10 to 100

16

A BIAS FOR ACTION

- The industry must learn what's at risk and what are the rewards are for doing the right thing, right now.
- Embrace more reliable and secure construction methods to build better and lengthening the lifespan of your project.
- Minimal investments now save millions in repairs over the life of the highway without jeapardizing speed and quality.

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Framework to Quantify Cost of Poor Pavement Foundations (09/24/2022) DRAFT

Condition	Impact to the Public	Impact to the DOT	Quantify Impact (Quantitatively and Qualitatively)	
			Product Needed	Data Required
Early Pavement Deterioration – near term impacts (cracking, heaving, settlement, rough pavements)	• Poor ride quality • Increased vehicle operating costs • Reduced driver safety • Impact on travel time	• Unnecessary increased maintenance activity • Increased safety exposure for maintenance forces (agency & contractors)	• Analysis of maintenance costs • Safety analysis • Vehicle user cost associated with ride quality	• Data on pavement patching, crack sealing, non-structural overlays • Accident data • Vehicle operating costs
Shortened Pavement Life	• Requires additional public investment due to pavements not performing to design potential • Creates poor image of the DOT • Travel & safety impacts	• Rehabilitation/reconstruction required early due to deteriorated pavement condition • Unreliable pavement design life predictions • Diverts funds from other system needs • The pavement foundation has reduced value for future use	• Analysis of US 20 project example • Analysis of actual and predicted pavement design life calculating DOT ownership cost (LCCA & annually).	• Actual data from as-built conditions • Pavement management data (FWD results, maintenance & rehabilitation activities)
Reduced Ability to Reliability Manage the Roadway Network	• Diminishes reliability in programming future transportation needs as funding is diverted to address underperforming projects	• Generates more reactive rather than predicted approach to programming projects • Lost opportunity cost as expected funding is not available • Creates lack of confidence in DOT from the public	• Analysis of the program level impacts of diversion of funds to compensate for reduced pavement performance and reduced end of life salvage value.	• Pavement management data analyzing current pavement performance as compared to pavements achieving the planned performance life and maintenance /rehabilitation activities.

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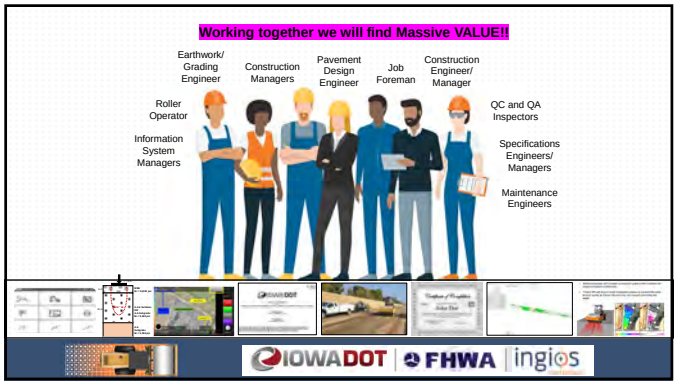
9. Value of Pavement Foundation Verification



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10. Pavement Foundations Moving Forward

Pavement Foundations Moving Forward: Collaborate for project news, workflows, specification development, and training

John Puls, PE – Business Unit Leader, Ingios

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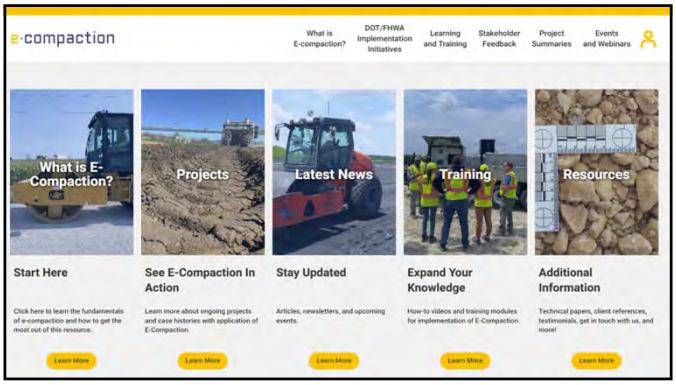

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TPF-5(478) Demonstration to Advance Pavement Technologies

Project Title: Support for Pavement Foundation Design Modulus Verification and Construction Quality Monitoring

Task B: Programmatic Support

- Develop training programs for Engineers, inspectors, and contractors and assist the DOT with integrating them into the current web-based training classes. [In-process]
- Develop model specifications to be used on future projects. [In-process]
- Develop workflow process and contractual documents for transitioning QC/QA processes from methods to performance specifications. [In-process]
- Develop educational and technology transfer materials. [In-process; host on e-compaction.com]
- Develop a technology brief on the value proposition of improving pavement foundation performance using data from 2022 projects and LCCA modeling completed using 2021 pilot project data [Not yet]

Initial Content → www.e-compaction.com ← User Community

You!

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11. Closing

Closing

- Thank you for your participation!
- Feedback survey
  - Hardcopies for in-person attendees
  - Survey will launch after webinar ends for virtual participants
- PDH certificate will be emailed following webinar/open house
- If you have any additional questions:
  - Email webinars@ingios.com and questions will be routed to appropriate individual
  - Or include on the feedback survey

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Thank you and have a great day!

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