TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): ____IOWA DOT_______________________________________

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *TPF-5(183)*	**Transportation Pooled Fund Program - Report Period:** X Quarter 1 (January 1 – March 31, 2019) Quarter 2 (April 1 – June 30, 2019) Quarter 3 (July 1 – September 30, 2019) Quarter 4 (October 1 – December 31, 2019)	
Project Title: Improving the Foundation Layers for Concrete Pavement		
Project Manager: Brian Worrel	**Phone:** 239-1471	**E-mail:** brian.worrel@dot.iowa.gov
Project Investigator: Peter Taylor (David White)	**Phone:** 294-3781	**E-mail:** ptaylor@iastate.edu
Lead Agency Project ID: RT 0314	**Other Project ID (i.e., contract #):** Addendum 352	**Project Start Date:** 3/16/09
Original Project End Date: 3/15/14	**Current Project End Date:** 12/31/2018	**Number of Extensions:** On-going pooled fund project

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule X Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Total Percentage of Work Completed
$875,000	$875,000	98

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter

Project Description:

The objective of this research is to improve the construction methods, economic analysis and selection of materials, in-situ testing and evaluation, and development of performance-related specifications for the pavement foundation layers. The outcome of this study will be conclusive findings that make pavement foundations more durable, uniform, constructible, and economical. Although the focus of this research will be PCC concrete pavement foundations, the results will likely have applicability to ACC pavement foundations and, potentially, unpaved roads. All aspects of the foundation layers will be investigated including thickness, material properties, permeability, modulus/stiffness, strength, volumetric stability and durability. Forensic and in-situ testing plans will be conceived to incorporate measurements using existing and emerging technologies (e.g. intelligent compaction) to evaluate performance related parameters as opposed to just index or indirectly related parameter values. Field investigations will be conducted in each participating state. The results of the study will be compatible with each state's pavement design methodology and capable for use with the Mechanistic-Empirical Pavement Design Guide (MEPDG). Evaluating pavement foundation design input parameters at each site will provide a link between what is actually constructed and what is assumed during design. There are many inputs to the pavement design related to foundation layers and this project will provide improved guidelines for each of these. The study will benefit greatly from maximizing the wide range of field conditions possible within the framework of a pooled fund study.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

- State Practices Summary Table was completed (attached) and these results will be integrated into Ch. 4.
- All of the state reports are available: https://cptechcenter.org/research/in-progress/improving-the-foundation-layers-for-concrete-pavements/
- Final report continues to be completed.
- A list of available deliverables is attached. They are available in a CyBox.

Anticipated work next quarter:

- Despite the contract ending, we will honor our commitments to complete the project.
- A final report will be submitted.
- A web-based TAC meeting will be held
- A webinar will be held.

Significant Results:

Circumstance affecting project or budget (Describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope, and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

TAC committee:

Brian Worrel Iowa DOT
Todd Hanson Iowa DOT
Kevin Meryman Iowa DOT
Mark Grazioli Michigan DOT
Mehdi Parvini California DOT
Brian Williams Missouri DOT
Georgene Geary Georgia DOT
Jim Brennan Kansas DOT
Wan Chen Texas DOT
David White, Researcher
Peter Taylor, CP Tech Center
Tom Cackler, Woodland Consulting

Table x. Comparison of responses from questions summarizing state-of-the-practice PCC pavement design, pavement foundation testing, and stabilization practices.

State Agency	What design method is being followed for PCC pavement currently (e.g., AASHTO (2008), PCA, other?)?	Does or has your state measured the in situ pavement foundation parameters as part of design calibration/verification? Y/N, if yes what parameters (e.g., resilient modulus	What QC/QA testing is required for embankment, subgrade, and aggregate base (e.g., percent relative compaction)?	What test frequency is required for embankment, subgrade, and aggregate base (e.g., 1 test per 1000 ft)?	Is QC/QA testing selection based on random sampling (i.e., random number generator to determine locations) or systematic sampling (i.e. every 500 ft, or at location of poor quality), or some other approach?	Are there any requirements for requiring "uniformity" of support in the pavement foundation layers? Y/N, if yes how is uniformity measured?	Are any of the following stabilization methods incorporated into pavement foundation design? (a) Subgrade stabilization using lime or fly ash? Y/N (b) Subgrade stabilization using cement? Y/N (c) Aggregate base stabilization using cement? Y/N (d) Aggregate base layer stabilization using geogrid? Y/N (e) Use of geosynthetics for separation or drainage? Y/N (f) Other stabilization practices in use???
Iowa	Currently PCA, but intent is to use AASHTOWare Pavement ME in the future	We currently have a research project underway to measure some in situ foundation parameters. Limited lab testing of material was done previously.	New embankment or subgrade soil: moisture (typical) or moisture and density (infrequent). Aggregate: typically, no testing	New embankment or subgrade soil: 1 test per 1500 ft. (max. volume of 1300 cubic yards)	Random for moisture and/or density. Representative for proctors.	Require natural subgrade to be "uniformly firm". Proof roll required.	(a) Generally, no, not in design; however, "Yes" as a construction expedient. (b) Generally, no. (c) No. (d) Yes, on interstate projects. Occasionally on urban projects or when desired by District. (e) Typically, not in design; however, "Yes" in rare circumstances as a construction expedient. (f) None.
Michigan	AASHTO 93. Much effort has been put into switching to MEPDG for many years through statewide calibration research but were not there yet.	Yes. There was statewide research to assign Mr threshold based on soil classification. FWD is collected on most large project for comparison, at this point.	Nuclear Density verification for all three, including moisture content no higher than optimum. Gradation and physical properties testing for aggregate base. Soils Engineers verify subgrade stability and frost susceptibility for needed correction.	*Subgrade, Subbase, and Aggregate Base Course:* 1 test per 500 feet per width of 24 feet or less. *Embankment:* 1 test per 1000 cubic yards of material with a minimum of one test per layer.	Density testing based on systematic approach with a preference to verify visually questionable areas. Aggregate testing is systematic. Subgrade verification is systematic with a preference to verify questionable areas.	Not through measurement.	(a) No. Used on some projects but not incorporated in design method. (b) No. Used on some projects but not incorporated in design method. (c) Yes. (d) No. Used on some projects but not incorporated in design method. (e) No. Used on most projects but not incorporated in design method. (f) No.

California	Caltrans has prepared its own Design Catalog (set of design tables) for PCC which is based on both past empirical rigid Pavement design and early version of Mechanistic-Empirical pavement design software (MEPDG, Ver. 1). The Design Catalog considers traffic (in terms of TI), climate region, soil type, and lateral support. The Design Catalog is available in Caltrans Highway Design Manual (HDM), Chapter 620, available at: http://www.dot.ca.gov/design/manuals/hdm.html	No. Caltrans originally used the subgrade R-value for preparing its Design Catalog. Later on a correlation was made between R-value and Unified Soil Classification System (USCS), which is now available in design tables.	Subgrade and embankment, it is relative compaction. For Soil Stabilization, it is relative compaction, and stabilization agent application rate. For Aggregate sub-base, it is gradation, R-value, sand equivalent, and percent relative compaction.	For Lime Stabilization, every 500 cu yd, the relative compaction and moisture content is checked. For bases, it is 500 cu yd or 1 day production.	The QC/QA testing selection is based on systematic sampling.	No, there is no special requirement for uniformity of support.	(a) Yes. (b) Yes. (c) Yes. (d) Yes. (e) Yes. (f) N/A
Wisconsin	AASHTO 72	Sometimes FWD (resilient modulus)	Embankments – Sometimes (special compaction, NDG); Subgrade – same as embankments; Aggregate Base – sometimes (NDG) only Asphalt Surfaces	Embankments – Sometimes (special compaction, NDG); Subgrade – same as embankments; Aggregate base – Sometimes (NDG) only Asphalt Surfaces	Quality Manage Program (QMP): Embankment/Subgrade one NDG test for 3,000 cubic yards random sampling. (minimum 95% of T-99); Aggregate base one NDG for 1,500-foot lane mile, random sampling (only Asphalt Surfaces)	No, meeting the minimum density requirement for special compaction or minimum deflection requirement with standard compaction.	(a) Yes, rare (fly ash) (b) Allowed, very rare (c) No (d) Yes, sometimes (e) Yes, sometimes (f) Large Aggregate Bases/Select Crushed Material
Pennsylvania	AASHTO (1993)	Yes, resilient modulus.	*Subbase:* Compact to a condition of non-movement as specified in Section 206.3(b). *Subgrade:* Compact and proof roll the	*Embankment or Fill:* 1 QC test per lift for each 1,000 square yards placed; minimum 3 tests per lift per day. 1 acceptance test per lift for each 4,000 square yards placed;	At locations directed by the Representative.	(not demined from specifications provided?)	(a) Yes (b) Yes (c) Yes (d) Yes (e) Yes (f) Asphalt-treated permeable base course

			entire subgrade surface	minimum one test per lift per day. *Subgrade:* 1 QC test per lift for each 800 square yards placed; minimum four tests per lift per day. 1 acceptance test per lift for each 3,000 square yards placed; minimum one test per lift per day.			

Other Final Technical Reports – available on CyBox

1. Li, J., White, D.J., and Vennapusa, P. (2018). "Field Assessment of Variability in Pavement Foundation Properties," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
2. White, D.J., Vennapusa, P., and Zhang, Y. (2016). "Field Assessment of Jointed Portland Cement Concrete Pavement with Premature Distresses — Iowa US 34 Field Study", DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
3. White, D.J., Vennapusa, P., and Zhang, Y. (2016). "Jointed Concrete Pavement Rehabilitation with Precast Concrete Pavement – California I-15 Field Study (Field Project Report)," DTFH 61-06-H- 00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
4. White, D.J., Vennapusa, P., Gieselman, H., Zhang, Y., Zhao, L., and Zhang, J. (2016). "Pavement Foundation Layer Reconstruction – Iowa I-35 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
5. White, D.J., Vennapusa, P., Li, J., Wolfe, A., Douglas, S. (2016). "Pavement Foundation Layer Reconstruction – Pennsylvania US 22 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
6. White, D.J., Vennapusa, P., Zhang, Y., Johnson, A. (2016). "Assessment of Seasonal Variations in Concrete Pavement Foundation layers – Multiple Test Sections in Iowa," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
7. White, D.J., Vennapusa, P., Zhang, Y., Gieselman, H., Prokudin, M. (2016). "Pavement Foundation Layer Reconstruction IA US 30 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
8. White, D.J., Vennapusa, P., Franz, R., Gieselman, H., and Wolfe, A. (2015). "Pavement Foundation Layer Construction – Wisconsin US10 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
9. White, D.J., Vennapusa, P., Gieselman, H., Wolfe, A.J., Douglas, S., and Li, J. (2015). "Pavement Foundation Layer Reconstruction Michigan I-94 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
10. White, D.J., Vennapusa, P., Gieselman, H., Wolfe, A.J., Johnson, A., Franz, R., and Zhao, L. (2015). "Pavement Foundation Layer Reconstruction with Cement Treated Base Underlain by Geotextile – Michigan I-96 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA
11. White, D.J., Vennapusa, P., Wolfe, A. (2015). "Jointed Concrete Pavement Rehabilitation with Injected High Density Polyurethane Foam and Dowel Bar Retrofitting – Pennsylvania US 422 Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
12. Vennapusa, P., Taylor, P., and White, D.J. (2015). "Field Evaluation of Premature Pavement Joint Deterioration – Iowa Urbandale Drive Field Study," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
13. White, D.J., Vennapusa, P., Gieselman, H., Wolfe, A.J., Johnson, A., and Douglas, S. (2015). "Pavement Foundation Layer Reconstruction Project – Iowa I-29 Field Study," DTFH 61-06-H- 00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
14. Brand, A.S., and Roesler, J. R. (2014). "Mechanistic-Empirical Pavement Design Guide (MEPDG) Sensitivity Analysis," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.
15. Brand, A.S., Roesler, J.R., Chavan, H.L., and Evangelista, F. (2014). "Effects of a Non-Uniform Subgrade Support on the Responses of Concrete Pavement," DTFH 61-06-H-00011 Work Plan 18, National Concrete Pavement Technology Center and Center for Earthworks Engineering Research (CEER), Iowa State University, Ames, IA.

Technical Papers

1. Zhang, Y., Horton, R. White, D.J., Vennapusa, P. (2018). "Seasonal frost penetration in pavements with multiple layers," *Journal of Cold Regions Engineering*, 32(2): 05018002. https://ascelibrary.org/doi/10.1061/%28ASCE%29CR.1943-5495.0000159

2. Zhang, Y., White, D.J., Vennapusa, P., Johnson, A., Prokudin, M. (2018). "Investigating Frost Heave Deterioration at Pavement Joint Locations," *Journal of Performance of Constructed Facilities*, ASCE, 2018, 32(2): 04018001. https://ascelibrary.org/doi/10.1061/%28ASCE%29CF.1943-5509.0001143

3. Vennapusa, P., Zhang, Y., and White, D.J. (2018). "Assessment of Support Conditions of Concrete Pavement Using FWD Deflection Basin Data," *Journal of Testing and Evaluation*, ASTM, https://doi.org/10.1520/JTE20170226. ISSN 0090-397. https://doi.org/10.1520/JTE20170226.

4. Zhang, Y., Vennapusa, P., White, D.J., and Johnson, A. (2017). "Seasonal variations and in situ assessment of concrete pavement foundation mechanistic properties," *International Journal of Pavement Research and Technology*, Vol. 11, 363-373. https://doi.org/10.1016/j.ijprt.2017.09.007 https://www.sciencedirect.com/science/article/pii/S1996681417300366

5. Vennapusa, P., Zhang, Y., and White, D.J. (2016). "Comparison of Pavement Slab Stabilization Using Cementitious Grout and Injected Polyurethane Foam," *Journal of Performance of Constructed Facilities*, ASCE, 04016056. https://ascelibrary.org/doi/10.1061/%28ASCE%29CF.1943-5509.0000916

6. Roesler, J. R., Chavan, H., King, D., and Brand, A.S. (2016). "Concrete slab analyses with field- assigned non-uniform support conditions," *International Journal of Pavement Engineering*, 17:7, 578-589. https://www.tandfonline.com/doi/abs/10.1080/10298436.2015.1007231?journalCode=gpav20

7. Zhang, Y., Johnson, A., and White, D.J. (2015). "Laboratory freeze-thaw assessment of cement, fly ash, and fiber stabilized pavement foundation materials," *Cold Regions Science and Technology*, Vol. 122, 50-57. https://www.sciencedirect.com/science/article/pii/S0165232X15002657

8. Vennapusa, P., and White, D.J. (2015). "Field assessment of a jointed concrete pavement foundation treatedwith injected polyurethane expandable foam."*International Journal of Pavement Engineering*, 16:10, 906-918. https://www.tandfonline.com/doi/abs/10.1080/10298436.2014.972917

9. Brand, A. and Roesler, J. R. (2014). "Finite element analysis of a concrete slab under various non-uniform support conditions", *International Journal of Pavement Engineering*, 15:5, 460-470. https://www.tandfonline.com/doi/abs/10.1080/10298436.2013.837463

Thesis/Dissertations

1. Zhang, Y. (2016). "Assessing Seasonal Performance, Stiffness, and Support Conditions of Pavement Foundations," Ph.D. Dissertation, Iowa State University, Ames, IA. https://lib.dr.iastate.edu/etd/15474/

2. Wolfe, A.J. (2011). "Behavior of composite pavement foundation materials subjected to cyclic loading," M.S. Thesis, Iowa State University, Ames, IA. https://lib.dr.iastate.edu/etd/12000/

3. Li. J. (2013). "Permanent deformation and resilient modulus of unbound granular materials", M.S. Thesis, Iowa State University, Ames, IA. https://lib.dr.iastate.edu/etd/13114/

4. Li. J. (2017). “A study on the variability of pavement foundation properties,” Ph.D. Dissertation, Iowa State University, Ames, IA. https://lib.dr.iastate.edu/etd/16166/

5. Zhang, Y. (2013). “Frost-heave and thaw-weakening of pavement foundation materials,” M.S. Thesis, Iowa State University, Ames, IA. https://lib.dr.iastate.edu/etd/13617/

6. Johnson, A. (2012). “Freeze-thaw performance of pavement foundation materials,” M.S. Thesis, Iowa State University, Ames, IA. https://lib.dr.iastate.edu/etd/12824/