Quarterly Progress Report – December 2009
For the period October 1, 2009 to December 31, 2009
TPF-5(183)

Project Dates: August 17, 2009 – August 16, 2011

Project Title: Improving the Foundation Layers for Concrete Pavement

Principal Investigator: David White, 515-294-5798, email: dwhite@iastate.edu

Progress Report:

Project is on schedule	Yes
Project is within budget	Yes
Significant changes in project description	No

Problems (current or anticipated):

Products and tangible results this quarter (reports/articles written, oral reports/interviews given):

Interaction with Technical Monitor and/or Project Advisory Committee:
A technical advisory committee (TAC) meeting was held on October 6, 2009, in St. Louis, MO as part of the National Concrete Consortium meeting. A list of the TAC state representatives and other guests attended the meeting is provided below. An overview of the results from the field project sites was presented at the meeting. Topics of discussion at the TAC meeting included: ideas for testing and evaluation at future project sites, topics to include as part of the final *Manual of Practice*, how to address uniformity in foundation construction and its economic feasibility, alternative foundation and foundation layer stabilization materials used by different states, test sections with stabilized foundation layers available in different states to obtain long term performance information, and life-cycle cost analysis.

<u>Attendees: TAC Committee members & guests:</u> Mehdi Parvini (California DOT), Mark Grazioli (Michigan DOT), John Staton (Michigan DOT), Heath Schopf (Wisconsin Paving Association); Jim Parry, (Wisconsin DOT), Tyson Rupnow (Louisiana DOT),Tony Zander (Indiana DOT), Clayton Schumacher (North Dakota DOT). Dave Meggers (Kansas DOT), Brett Trautman (Missouri DOT), Kenny Seward (Oklahoma DOT), Hua Chen (Texas DOT), Nancy Whiting (Purdue), Mark Niemuth (Lafarge), Robert Kennedy (Koss Construction), Jim Vaughn (Lafarage), Gary Crawford (FHWA), Jim Grove (FHWA), Steve Siekowski (Turner Fairbank), Leif Wathne (ACPA), David White (Earthworks Engineering Research Center), Tom Cackler (CP Tech Center), Bob Steffes (CP Tech Center).

Brief summary of this quarter's research and activities pertaining to the project:
Main research activities during this quarter involved conducting:

- a TAC meeting on October 6, 2009;
- a half-day research team meeting on December 17, 2009, in addition to the bi-weekly one-hour research team meetings;
- field testing on SR422 pavement stabilization project in Indiana, PA;
- and analysis of data obtained from three project sites visited during the last two quarters: (1) I-94 North of Detroit, MI; (2) I-29 in Monona County, IA; and (3) SR 22 in Blairsville and Clyde, PA.

<u>Review of research team meeting:</u> A half day research team meeting was conducted on December 17, 2009 to review this quarter's work, research results, and develop a work plan and research tasks for the next quarter. The meeting was attended by David White, Barry Christopher, Heath Gieselman, Pavana Vennapusa, Bob Steffes, and Alexander Wolfe. The meeting contributed to discussion regarding various research topics. Some key research topics discussed during the meeting – pavement drainage analysis, design and development of a new laboratory lateral flow permeability testing method, freeze-thaw testing (laboratory testing) and analysis methods, field instrumentation to capture seasonal variations in the

pavement foundation layers, geotextiles in pavement foundation layers, analysis techniques to better capture and characterize uniformity, geophysical methods for in-situ testing (electromagnetic surveys), and in-ground instrumentation for pore-pressure measurements in the foundation layers.

<u>Brief overview of in-situ testing and data analysis:</u> The main objectives of field testing were to: (a) characterize the strength, stiffness, and permeability characteristics (using various in-situ QC/QA testing methods) of the existing foundation layers and compare with the newly constructed foundation layers, and (b) document the current construction QC/QA procedures. Field testing was conducted using a variety of in-situ test measurements: falling weight deflectometer (FWD) tests, light weight deflectometer (LWD) tests, and static plate load test (PLT) to measure stiffness/modulus, dynamic cone penetrometer (DCP) tests to measure strength/California bearing ratio (CBR), nuclear gauge (NG)tests to measure moisture and dry density, and in-situ gas permeameter tests (GPT) to measure permeability, and shelby tube samples (of subgrade) to obtain laboratory resilient modulus and shear strength properties. Brief summary information, field testing and data analysis performed for each project site are as follows:

I-94 North of Detroit, MI: This project involved reconstruction of about 6.2 mile interstate highway section located north of Detroit. The reconstruction process included removal of the old PCC surface layer and the foundation layers, and construction of a new base layer and a PCC surface layer. The old pavement was about 9 inches thick and was originally constructed in 1969, and the underlying foundation layers included 6 inches thick gravelly sand base underlain by 12 inches thick fine sand subbase and compacted silty clay subgrade. The old base and subbase layers were replaced with a 16 inches thick permeable open-graded steel slag base material placed and compacted on top of a geotextile separation layer underlain by the existing silty clay subgrade. The new PCC pavement is about 11 inches in thickness.

In-situ testing on the project involved obtaining FWD, LWD, PLT, NG, DCP, and GPT measurements. In addition, roller-integrated intelligent compaction (IC) measurements were also obtained using Caterpillar vibratory smooth drum roller (equipped with CMV and MDP measurement systems) to correlate with various above described in-situ point measurements. Scanning electron microscopy (SEM) tests were conducted on the steel slab base material to characterize the material morphology. A poster was generated with preliminary data analysis and results and was presented at the TAC meeting. In-situ test measurements conducted in a dense grid pattern on several test beds allowed for characterization of the "uniformity" of the foundation layer strength/stiffness/permeability properties and spatial visualization of the results. In-situ tests conducted on the old and new pavement foundation layers allowed for comparison in the pavement thickness design parameters. The research team is currently working on finishing up a project report documenting the field test results, photos, and the construction procedures.

I-29 Monona County, IA: This project involved reconstruction of the existing interstate highway section in Monona County, IA. The reconstruction process included removal of the old PCC surface layer and the foundation layers, and the construction of new subbase and base layers, and a PCC surface layer. The old pavement was about 9 inches thick and was originally constructed in 1967, and the underlying foundation layers included 3 inches thick sand subbase underlain by wet and soft silty clay subgrade. During reconstruction, the subbase layer was removed and the subgrade layer was undercut down to about 2 feet. Then the excavation was replaced with 12 inches thick reclaimed asphalt special backfill material and 6 inches thick open-graded permeable base material (recycled and virgin). The new PCC pavement is about 12 inches in thickness.

In-situ testing on the project involved obtaining FWD, LWD, PLT, NG, DCP, and GPT measurements. In addition, roller-integrated intelligent compaction (IC) measurements were also obtained using a Volvo smooth drum vibratory roller (equipped with CMV measurements system) to correlate with various above described in-situ point measurements. Roller-integrated IC measurements are calibrated to a variety of in-situ point measurements (e.g., LWD, CBR, and density) on subgrade, subbase, and base layers by constructing one-dimensional test strips on the project site. The calibrated IC measurements with 100% coverage allow for characterizing "uniformity" of the foundation layer properties. In-situ tests conducted on the old and new pavement foundation layers allowed for comparison in the pavement thickness design parameters. Some preliminary data analysis results were presented at the TAC meeting. The research team is currently working on finishing up a project report documenting the field test results, photos, and the construction procedures.

SR-22 Clyde and Blairsville, PA: The SR-22 projects involved reconstruction and expansion of the existing highway (from two-lane to four-lane). The new pavement foundation layers consisted of variable subgrade material with clay and rock fill, 18 inches thick rock cap, 2 inches thick leveling subbase, and 3 inches thick cement-treated or asphalt-treated permeable base layers. The new PCC pavement is about 10 inches in thickness.

In-situ testing on the project involved obtaining FWD, LWD, PLT, NG, and DCP measurements on subgrade, rock cap, and subbase/base layers, and GPT measurements on the permeable treated base layers. In addition, roller-integrated intelligent compaction (IC) measurements were also obtained using Caterpillar vibratory smooth drum roller (equipped with CMV and MDP measurement systems) on the subgrade and rock cap layers to correlate with various above described in-situ point measurements. Some preliminary data analysis results from the project were presented at the TAC meeting. The research team is currently working on finishing up a project report documenting the field test results, photos, and the construction procedures.

SR-422 Indiana, PA: The SR-422 project provided a unique opportunity to evaluate the performance of injected light-weight foam stabilized pavement base. The project involved stabilizing about 6 mile long four-lane highway section which showed mid-panel cracking on the 11 inches thick PCC pavement (panel dimensions: 12 feet wide by 20 feet long). Field observations indicated that the width of the cracks at the mid-panel ranged from about 0.1 to 3 inches with faulting from about 0.1 to 0.75 in. The foundation layers under the pavement consisted of 4 inches thick open-graded base (OGS) underlain by 2 inches thick leveling stone and rocky subgrade. It was presumed that the settlement of the OGS layer due to traffic loading and aggregate particle breakdown is the main reason for mid-panel cracking.

The stabilization process involved drilling 3/8 inch diameter holes in a triangular pattern at 8 to 9 locations on each panel and injecting light weight foam fill (density of about 5 pcf) into the pavement base layer to fill the voids in the base material. Our field testing involved evaluating the foam-stabilized base layer sections by removing the pavement for uniformity of strength/stiffness/density/permeability properties, evaluating the load transfer efficiencies of the PCC pavement before and after stabilization, monitoring the elevation difference profiles (using robotic total station) before and after stabilization, and instrumenting the pavement section at three different locations (one section with foam, on control section without foam, and one section with future stabilization with cement grout) to monitor seasonal temperature changes with depth in the foundation layers. For comparison purposes, a 500 feet long section is also planned for cement grout stabilization of the base layer during spring/summer 2010. Some preliminary test results and analysis are communicated to Pa DOT. Some key findings from our preliminary data analysis are as follows: (a) load transfer efficiency for the joints is about 79% before and after stabilization (based on 4 measurement locations); (b) load transfer efficiency for the mid-panel cracks is about 43% before stabilization and 88% after stabilization (based on 4 measurement locations); (c) corner slab deflections post-stabilization are less than 0.5 mm (based on 4 measurements). The research team is currently working on finishing up a project report documenting the field test results, photos, and the construction procedures. Our plan is to conduct periodic FWD testing over the next two to three years on the project (to monitor changes in stiffness of the foundation layers and load-transfer efficiencies) and obtain robotic total station elevation measurements (to monitor pavement settlements relative to immediately post stabilization).

Main emphasis for next quarter:

The main emphasis for the next quarter is to complete data analysis for the four field projects, develop project reports for TAC review and comments, and develop experimental plans for field testing in California and Wisconsin. A pre-cast PCC project near San Francisco, California is a potential project site for testing which is going out to bid soon.

No.	Task Description	Completion Date Expected	% completed
1.1	Form a Technical Advisory Committee	8/31/09	100
1.2	A comprehensive review of the literature	3/30/10	20
1.3	Document the applications and benefits of various techniques used to improve the engineering properties of pavement foundations	3/30/10	10
1.4	The Phase I draft report	5/30/10	10
2.1	Review previous and on-going M-EPDG sensitivity studies	1/31/10	
2.2	A TAC meeting to review the results of the sensitivity analysis; workshop report will be developed	7/30/10	
2.3	Based on Phase III field data studies, a performance evaluation using the M-EPDG, finite element methods, and ICM will be conducted	5/30/11	
3.1	Twelve field forensic studies will be conducted	1/31/11	
3.2	Develop failure/performance mechanisms for each project site. The field monitoring results will be summarized	4/30/11	
3.3	A TAC meeting will be conducted to review the results of the sensitivity analysis; workshop report will be developed	5/50/11	
3.4	Submit a draft report to TAC summarizing the results and conclusions from the forensic studies.	6/30/11	
4.1	A research team and TAC meeting will be conducted to review the results of the in-situ forensic investigations.	6/30/11	
4.2	A final report	7/30/11	

DATA FOR THE QUARTER ENDING DECEMBER 31, 2009

BUDGET CATEGORY DESCRIPTION	AMOUNT BUDGETED	EXPENDITURES THIS PERIOD	CUMULATIVE EXPENDITURES
SALARIES/WAGES	$315,669.00	$9,600.00	$50,101.03
BENEFITS	$73,377.00	$1,195.38	$5,430.18
TRAVEL	$56,500.00	$668.20	$7,999.54
SUPPLIES/MATERIALS	$4,100.00	$0.00	$4,473.01
OTHER DIRECT COSTS	$105,910.00	$509.75	$44,619.28
TOTAL DIRECT COSTS	$555,556.00	$11,973.33	$112,623.04
INDIRECT COSTS (University Overhead)	$144,444.00	$3,113.07	$29,281.99
CATEGORY TOTALS	$700,000.00	$15,086.40	$141,905.03

NOTES:

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