Quarterly Progress Report
For the period January 1, 2011 to March 31, 2011
TPF-5(183)

Project Dates: March 16, 2009 – March 15, 2014

Project Title: Improving the Foundation Layers for Concrete Pavement (addendum 352)

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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):
Draft reports on Pennsylvania US422 foam stabilization project and Michigan I-94 pavement foundation layer reconstruction project have been completed.

Interaction with Technical Monitor and/or Project Advisory Committee:
Periodic contact has been made with states to discuss and schedule field projects and request project information.

Brief summary of this quarter's research and activities pertaining to the project:
Significant progress was made this quarter in terms of laboratory testing, analysis of laboratory and field testing results, and project reports. Field testing was conducted in Iowa seasonal test sites.

The main research activities during this quarter involved the following [related research task number is in the parenthesis]:

- Conducting laboratory testing on samples obtained from the field projects [Sub Task 1.5],
- Fabrication of laboratory large scale lateral flow permeameter and frost-heave/thaw-weakening test setup[Sub Task 1.5],
- Conducting in-situ test data analysis from four 2009/2010 field projects (Michigan I-94, Michigan I-96, Pennsylvania SR-22, and California I-15) and preparing field project reports [Sub Tasks 3.1, 3.2, 1.5, and 1.7],
- Conducting periodic performance testing in Iowa at 5 project sites [Sub Task 3.1],
- Design parameter selection and sensitivity analysis [Sub Task 2.1]

Laboratory testing: Laboratory testing this quarter involved conducting particle-size analysis tests on samples collected from I-35 granular base construction project in Iowa and laboratory permeability testing on samples obtained from various field project sites from 2009/2010 testing.

Particle Size Analysis: As documented in the last QPR, laboratory particle size analysis tests were conducted on about 100 samples obtained from the I-35 project. These samples were obtained from test sections that were compacted in field for various roller passes (varying from 1 to 10) under vibration and static conditions. The particle size analysis results were analyzed this quarter for fines content changes between the different test sections. Bag samples were also obtained from field from the top two inches to investigate changes in fines content in each test section and its relationship with field permeability results. These samples have been tested and the results were analyzed.
Laboratory Permeability Testing: Laboratory permeability testing was conducted using large scale aggregate compaction mold permeameter on Michigan I-96 aggregate base and sand sub base materials, and I-35

recycled concrete base materials. Falling head permeability tests were conducted on cement treated base materials samples obtained from Pennsylvania SR22 project.

Laboratory large scale lateral flow permeameter: An overview of the new laboratory large scale lateral flow permeameter was provided in the previous QPRs. Fabrication of the main body frame of the device, fabrication of tanks, lid seal, and steel legs has been completed during the last quarter. The plumbing design has been modified from the original design to allow for a wide range of material permeability values. Spent time on planning on manifold plumbing items, valves, connectors, etc to allow for the modified plumbing design. It is anticipated that all the parts will be acquired and the fabrication process will be completed in the next quarter along with initiating testing material collected from various project sites.

Laboratory frost-heave and thaw-weakening test setup: Progress has been made in finishing the fabrication of the laboratory testing equipment for evaluation of frost heave and thaw weakening according to ASTM D5918. It is anticipated that testing on materials collected from the project sites will begin soon.

Pavement performance testing: As described in the previous QPRs, FWD and DCP testing is being conducted at five sites in Iowa at frequent intervals to capture the seasonal variations in the pavement foundation layers. Four of the five sites were tested in February when the foundation layers were in frozen condition. All five test sites were tested frequently in March (two to three times within a two week period) to capture the thawing period. At each site, 10 to 16 FWD tests were performed to determine the load transfer efficiency at joints and center panel deflections under dynamic loading. A DCP test was also performed at each site to obtain a soil profile and an additional source of strength values to verify the FWD data. Weather station data available at the Moville, Denison, and Plainfield sites were used to verify ground temperature conditions. These temperature sensor data will be used to correlate data between laboratory and field testing.

Comparison between laboratory and in-situ moduli: Significant progress has been made this quarter on preparing a draft report that primarily focuses on comparison between laboratory measurement moduli values, in-situ measured moduli values, and design assumed moduli values from various field project sites. In situ moduli were obtained from lightweight deflectometers (LWD), falling weight deflectometers (FWD), and static plate load tests (PLT), and empirical correlations (documented in the literature and AASHTO/MEPDG pavement design guide) from DCP tests. DCP test measurements were converted to resilient modulus values using several empirical correlations. Laboratory moduli were obtained from resilient modulus tests. The tests encompassed pavement foundation materials obtained from the following field project sites: Michigan I-94, Michigan I-96, Iowa I-29, Pennsylvania US-22, and Wisconsin US-10. As described in the last QPR, laboratory resilient moduli samples were tested as single and composite samples to compare with the composite layers. Single material samples were studied to compare the effects of different conditions found in situ (e.g., moisture and dry unit weight variances) as well as a way to compare with composite samples. Composite samples were investigated to simulate the layering effects found in-situ. Statistical analyses were performed to determine the effects of generally weak subgrade layers on composite sample moduli.

Field project reports and data analysis overview: A brief overview of the various field projects is provided in the previous QPRs. Recently, the research team has communicated with the state DOT project contacts to fill out a table with the design assumptions and values. The table composed of design assumptions/values used for traffic loads, design period, pavement surface layer properties, and foundation layer properties (i.e., base layer thickness, base layer modulus, subgrade resilient modulus, coefficient of drainage, etc.). A separate table has been prepared for AASHTO 1993 and 1972 methods, and PCA methods. The purpose of this table is to compare the actual measured modulus and drainage parameters in the field with the design assumed values. Data analysis with a detailed comparison of design assumed values versus the measured values from the Michigan I-94 project has been recently completed. Field moduli were measured using LWD, FWD, and PLT measurements and also have been empirically estimated using DCP measurements based on various correlations published in the literature and the AASHTO 1993 design. A detailed draft report on the I-94 project has been completed with these analysis results and is currently in the final review process within the research team. Similarly, analysis on the Michigan I-96 project is nearly complete and the research team is

currently working on finalizing a draft report for that project. The main focus in the next quarter will be to complete similar analysis on the Wisconsin US10, Pennsylvania SR22, Iowa I29, and California I-15 projects and finish project reports. A draft final report for the Pennsylvania US422 has been completed and revised based on review within the research team. An unanticipated delay occurred in obtaining X-Ray CT scanning results on foam treated samples from the US422 project. The research team is waiting on including those results in the project report before sending it for TAC review.

Design parameter selection and sensitivity analysis: During the past quarter, the MEPDG was run again for a variety of soil types and stiffness to complement the previous runs from last year that just look at slab cracking as the failure criterion. In these runs, the criteria for failure was joint faulting, slab cracking, and IRI. The results of the runs showed that the cracking of the slabs still controlled for the stiffer slabs but for the low strength soils, such A-7-6, the IRI of the concrete pavement controlled the design. This behavior was seen in all the cases analyzed that involved the A-7-6. In some of the cases, increasing the slab thickness did not allow the design to meet the failure criterion for IRI and therefore this empirical model must be overly sensitive to fine-grained soil and IRI and possibly may need re-adjustment. Another task that was worked on this quarter was to develop a theoretical 2-D semi-variogram model that can translate soil spatial variation into quantitative procedure to analyze its effect in the finite element program ISLAB2000.

Main emphasis for next quarter:
Following will be the main emphasis for the next quarter:

- Complete data analysis for the field projects and develop project reports for TAC review and comments.
- Finish a report summarizing M-EPDG sensitivity analysis results.
- Finish phase I report.
- Conduct periodic performance monitoring testing in Iowa.
- Plan field testing on additional project sites in summer 2011.
- Plan follow-up performance testing in US422, MI I-94 & I-96, and WI US-10 projects.
- Finish fabrication of the large scale permeameter.
- Finish frost-heave susceptibility testing equipment.
- Field data will be used to analyze the slab stresses due to the spatial variation of soil modulus measure from the field projects. Concurrently semi-variogram examples will be constructed and run in ISLAB2000 to look at more idealized cases of how systematic changes in non-uniformity change the stress state in the slab.

DATA FOR THE QUARTER ENDING MARCH 31, 2011

BUDGET CATEGORY DESCRIPTION	AMOUNT BUDGETED	EXPENDITURES THIS PERIOD	CUMULATIVE EXPENDITURES
SALARIES/WAGES	$315,669.00	$22,993.55	$111,433.78
BENEFITS	$73,377.00	$5,560.98	$15,995.09
TRAVEL	$56,500.00	$0.00	$8,026.19
SUPPLIES/MATERIALS	$4,100.00	$0.00	$5,124.37
OTHER DIRECT COSTS	$105,910.00	$5.17	$44,958.33
TOTAL DIRECT COSTS	$555,556.00	$28,559.70	$185,537.76
INDIRECT COSTS (University Overhead)	$144,444.00	$6,643.44	$46,303.98
CATEGORY TOTALS	$700,000.00	$35,203.14	$231,841.74