**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:**□Quarter 1 (January 1 – March 31)□ Quarter 2 (April 1 – June 30)X Quarter 3 (July 1 – September 30)□Quarter 4 (October 4 – December 31) |
| **Project Title:****Improving the Foundation Layers for Concrete Pavement** |
| **Project Manager: Phone: E-mail:**Mark Dunn 515-239-1447 mark.dunn@dot.iowa.gov |
| **Project Investigator: Phone: E-mail:**David White 515-294-1463 djwhite@iastate.edu |
| **Lead Agency Project ID:**RT314 | **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:** | **Number of Extensions:** |

Project schedule status:

x On schedule □ On revised schedule □ Ahead of schedule □ Behind schedule

Overall Project Statistics:

|  |  |  |
| --- | --- | --- |
|  **Total Project Budget** |  **Total Cost to Date for Project** |  **Total Percentage of Work** **Completed** |
| $700,000 | $276,742 | 65 |

***Quarterly*** Project Statistics:

|  |  |  |
| --- | --- | --- |
|  **Total Project Expenses** **This Quarter** |  **Total Amount of Funds**  **Expended This Quarter** | **Percentage of Work Completed** **This Quarter** |
| $44,900 |  | 8% |

**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.):**

Two presentations were made by the PI at the National Concrete Consortium (NCC) Meeting held September 13-15, 2011 in Rapid City, South Dakota (see attached). Fabrication of the large scale lateral flow permeameter has been completed.

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

* Conducting laboratory testing (frost-heave/thaw-weakening and cyclic triaxial testing) on samples obtained from the field projects [Sub Task 1.5],
* Fabrication of laboratory large scale lateral flow permeameter test setup[Sub Task 1.5],
* Conducting in-situ test data analysis on three other field projects (Iowa I-35, Michigan I-96, and Pennsylvania SR-22) and developing field project reports [Sub Tasks 1.5, 1.7, 3.1, 3.2, 3.4,]
* Organizing field data to conduct performance evaluation using M-EPDG and finite element methods [Sub Task 2.3]
* Obtaining temperature sensor array data on Iowa Hwy 30 project and conducting in-situ testing [Sub Task 3.1],

Laboratory testing:

Laboratory Frost-Heave and Thaw-Weakening Testing: This quarter, a total of five samples were tested from the Pennsylavia US-22, Iowa I-29, and Iowa US-30 projects. The test is performed over a five day period that constitutes two freezing and thawing cycles. During the testing period, the temperature profile and heaving of the samples is continuously recorded and the data is automatically saved on a data logger. Temperature is being measured using thermocouples and heave is being monitoring using laser displacement sensors. Once the test period is completed, a CBR test is performed on each sample. The post freeze-thaw CBR is compared to the CBR of the material at its optimum moisture content to determine the magnitude of the loss in strength. The ability of the sample to resist frost heave and thaw weakening is being evaluated based on the heave rate of the sample and the post freeze-thaw CBR value.

Cyclic Triaxial and Aggregate Degradation Testing: A total of six cyclic triaxial testing with 100,000 loading cycles was conducted on samples obtained from the recycled portland cement concrete (RPCC) subbase material from Iowa Hwy 30 project. For these tests, a target of 10% moisture content was used in the sample preparation process and 15 psi confining pressure was used during testing, but the target dry unit weight and deviator stresses were varied. One of the six samples was compacted to 95% relative density (RD) and tested at 3 psi deviator stress. The other five samples were compacted to 90% RD and tested at 3 to 15 psi deviator stresses. Particle size analysis tests were conducted on the samples before and after cyclic triaxial testing to evaluate the particle degradation under repeated loading. A review of cyclic triaxial test results indicated permanent strain values for the RPCC material in the range of 0.02% to 0.12% after 100,000 cycles. Unconsolidated undrained (UU) triaxial tests were conducted on the RPCC material to characterize the undrained shear strength properties. UU tests were conducted right after 1000 cycles of repeated load tests. Cyclic triaxial and aggregate degradation testing is being conducted on materials obtained from all field project sites to derive relationships between permanent deformation/particle degradation properties and fines content, dry unit weight, and deviator stress.

Field project reports and data analysis overview:

Significant progress has been made this quarter in analyzing results from the Iowa I-35, Michigan I-96, and Pennsylvania SR-22. Draft reports for each project are being generated and being simultaneously updated with laboratory data from laboratory freeze/thaw and cyclic triaxial/degradation testing.

Laboratory large scale lateral flow permeameter:

All enhancements and modifications to the system plumbing design were finalized and fabricated. Initial testing phase for workability and accuracy of flow throughout system was conducted and satisfactory results were achieved. Vacuum testing of system and calibration will be conducted early next quarter. This will be followed immediately by the testing of six different types of relatively homogenous materials to analyze the effectiveness of the permeameter and compare with results obtained from testing conducted using a laboratory vertical permeameter system and gas permeability testing device being used for field testing on this research project.

Pavement performance testing:

During this quarter, the five seasonal variations sites were tested with the FWD and DCP. The results will be used to show the change in pavement strength throughout the year.

Field Testing and Instrumentation on US Highway 30, Iowa:

A summary of instrumentation installed on the US Hwy 30 project is provided in the last QPR. In brief, a temperature probe array was installed in the foundation layers with eight sensors placed horizontally on top of the 12” modified subbase layer at every 2 ft intervals from the center of the pavement to the end of the shoulder lane and six sensors placed vertically below the top of the 12” modified subbase layer down in to subgrade to a depth of about four feet below the bottom the pavement. The horizontal array was placed to evaluate temperature variations across the pavement width while the vertical array was placed to capture temperature variations with depth in the foundation layers. During this quarter, a CR5000 data logger has been programmed and installed on-site this quarter to continuously (every 1 hour) record the temperature in the foundation layers. Data obtained from these temperature probes will allow for comparisons to be made with laboratory testing as well as help coordinate field testing during peak freezing/thawing periods. Field testing was also conducted on the final compacted base layer on the project. Testing involved conducting LWD and DCP testing over a 500 ft long section of the base layer over. It is anticipated that periodic testing will be conducted at these locations to evaluate performance.

Field data to conduct performance evaluation using M-EPDG and finite element analysis:

Field testing on most of the field projects included capturing spatial variability of foundation layer stiffness characteristics with dense grid testing. Geo-spatial semivariogram analysis of all field data has been completed. These semivariogram data will be utilized in finite element analysis (ISLAB 2000) to study how systematic changes in non-uniformity of foundation layer stiffness changes the stress states in the slab. A mathematical model for assigning support values in 2-D space for implementation into ISLAB2000 based on semi-variograms has been developed. This allows for idealized modeling of non-uniformity based on various theoretical semi-variograms. This is especially important in understanding the systematic effects of non-uniformity on slab stress development. A 3-D finite element analysis has been under development also during this quarter. The 3-D model will give an insight into how subgrade support especially non-uniformity effects the performance of concrete slabs particularly when the concrete slabs have an initial, partial-depth crack (top or bottom-initiated).

**Anticipated work next quarter:**

* Complete data analysis for the field projects and develop project reports for TAC review and comments.
* Conduct periodic performance monitoring testing in Iowa.
* Finish field testing on US30 pavement foundation layer reconstruction project in Iowa.
* Plan field testing on two additional project sites (field testing on 9 project sites is completed, and one project site is under way).
* Plan follow-up performance testing in US422, MI I-94 & I-96, and WI US-10 projects.
* Complete fabrication and test large scale lateral flow permeameter, then conduct horizontal permeability testing on samples from numerous project sites.
* Continue frost-heave, CBR, cyclic triaxial, and aggregate degradation testing on samples collected from all field project sites.
* 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. 3-D finite element analysis on partially-cracked slabs will be run to determine the effects of support on failure of concrete pavements.
* A research team meeting is schedule at ISU for August 16-17, 2011 to update the design manual outline and organize field data for the FEA.

**Significant Results:**

See the following links for presentations from the NCC conference held in September.

<http://www.cptechcenter.org/t2/documents/D.White_PavementFoundations.pdf>

<http://www.cptechcenter.org/t2/documents/D.White_MEPDG_Rapid_City.pdf>

**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).**