**TRANSPORTATION POLLED FUND PROGRAM**

**QUARTERLY PROGRESS REPORT**

Lead Agency (FHWA or State DOT): Virginia Department of Transportation

**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.*

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| **Transportation Pooled Fund Program Project #**TPF-5(229) | **Transportation Pooled Fund Program-Report Period:** √Quarterly 1 (January 1—March 31)Quarterly 2 (April 1—June 30)Quarterly 3 (July 1—September 30) Quarterly 4 (October 4—December 31) |
| **Project Title:**Characterization of Drainage Layer Properties for MEPDG |
| **Name of Project Manager(s):**Brain K. Diefenderfer | **Phone Number:**(434)293-1944 | **E-Mail:**Brain.Diefenderfer@VDOT.Virginia.gov |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):**VTRC-MOA-11-005(98289) | **Project Start Date:**September 1, 2010 |
| **Original Project End Date:**August 31,2013 | **Current Project End Date:**August 31,2014 | **Number of Extensions:**1 |

Project schedule status:

On schedule √On revised schedule Ahead of schedule Behind schedule

Overall Project Statistics:

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| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
| $270,000.00 | $261,607 | 95% |

Quarterly Project Statistics:

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| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
| $9560/6.25 | $9560 | 96% |

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| **Project Description:**The objectives of this pooled fund study are to develop methods for characterizing the elastic modulus and strength of pavement drainage layers for the Mechanistic-Empirical Pavement Design Guide (MEPDG), to perform analysis of the stability and failure of the drainage layer in the pavement structure, and to develop specifications for required minimum porosity for effective drainage. |

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| **Progress this Quarter (Includes meetings, work plan status, contract status, significant progress, etc.):**1. Perform a literature review on currently available methods to determine the resilient modulus of unbound aggregateA thorough literature review has been conducted to investigate the currently available methods to determine the resilient modulus of unbound aggregate, including both laboratory test methods and numerical simulation methods. For laboratory tests, the triaxial apparatus is usually used to apply a confining pressure and cyclic axial loading on an aggregate sample, and the stress and recovered strain during testing are recorded to calculate the resilient modulus. The AASHTO standard test method T307-99 (2003) *Determining the Resilient Modulus of Soils and Aggregate Materials* is selected as the test protocol in this study. The numerical simulation will also follow the parameters provided by this test method to facilitate comparison between laboratory data and simulation results.2. Conduct Discrete Element Method (DEM) simulation on unbound aggregate drainage layer materials for WisconsinAs stated in the previous quarterly report, the DEM software PFC3D has been used to predict the resilient modulus of unbound aggregate for Wisconsin. The previously created model in PFC3D has been modified during this quarter. The diameter and height of the specimen in the simulation have been changed to 6 inches and 12 inches respectively, to satisfy the AASHTO T307 requirement. The gradation of the specimens in simulation is selected according to the typical gradation of drainage layer material provided by Wisconsin DOT. Currently the air void content is set to be around 40% and other air void contents will be used for future study. The position of the top and confining walls are adjusted during the simulation to maintain constant confining and axial pressure in accordance with the laboratory test. The simulation is still in progress and the results will be presented in the next quarter. The stress-strain relationship throughout the loading-unloading cycles will be plotted. The stress and recovered strain during the last five loading cycles will be recorded to calculate the resilient modulus.3. Improve the FEM model to investigate the structural contribution and location effect of drainage layerPreviously, the surface layer of the pavement model was considered as elastic in the FEM simulation, for the purpose of simplicity and computational efficiency. During this quarter the FEM model has been improved in several aspects. Firstly, the properties of the surface layer has been changed from elasticity to visco-elasticity. The drainage layer is still considered as visco-elastic. Secondly, the Young’s moduli of base and subbase are changed based on the results from other studies and literatures to better present the real situation. The newly improved model has been used for calculation and the results will be reported next quarter.  |
| **Anticipated work next quarter:**The resilient modulus of typically used unbound aggregate in Wisconsin with about 40% air void content and other high air void contents will be obtained from the DEM simulation. The modified FEM analysis will be conducted to improve the conclusions on the structural contribution and location effect of the drainage layer.The resilient modulus test will be conducted on the unbound aggregates collected from Wisconsin DOT in laboratory, if the testing equipment will be available.The final report will be prepared and submitted. |

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| **Significant Results:**1. Literature review has been conducted not only on standard laboratory test methods but also on the DEM simulation to investigate resilient modulus of unbound aggregate. The AASHTO T307-99 (2003) *Determining the Resilient Modulus of Soils and Aggregate Materials* is selected as the standard protocol in this study for both laboratory test and numerical simulation.
2. The previously created DEM model in PFC3D has been improved through FISH codes. The specimen has been changed to 6 inches in diameter and 12 inches in height, as required in AASHTO T307. The confining and axial pressures are set to be the values provided in the first loading sequence in AASHTO T307. The gradation is in accordance with the typical gradation provided by Wisconsin DOT. This model is now under debugging and test running.

 1. The FEM model investigating structural contribution and location effect of drainage layer has been improved in several aspects. Most importantly, visco-elastic properties have been assigned to the surface layer of the pavement model, making the FEM model more consistent with real situations.
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| **Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect completion of the project within the time, scope and fiscal constraints set firth in the agreement, along with recommended solutions to those problems).**No problem encountered during this quarter. |

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| **Potential Implementation:** |