Project TPF 5(341): Permeability of Base Aggregate and Sand

INTERIM REPORT: TASK 1 - INITIAL MEMORANDUM ON EXPECTED RESEARCH BENEFITS AND POTENTIAL IMPLEMENTATION STEPS

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Introduction

Lack of proper pore water drainage is one of the main causes of the failure of geosystems. Many geosystems such as roadway base course and retaining wall backfills are designed to quickly drain porewater to minimize elevated pore pressure, minimize freeze-thaw damage, and prevent failure of the geosystem. The requirements for drainability vary depending on the specific requirements of the structure. A simple and reliable tool capable of estimating drainability values for common aggregate types will aid in material selection and design. Additionally, when a failing material is used on a project, knowing the material's permeability will aid the engineer in deciding whether the material should stay in place with a monetary price adjustment assessed, or be removed.

Most existing formulations assess permeability of coarse aggregates from D_{10} (sieve opening size that passes 10% by weight of the material) and fines content (percent passing sieve #200). However, coarse materials of different gradations but of the same D_{10} and fines content may have very different permeabilities. There is a need to assess the permeability from more information about the particles such as grain size distribution, crushing percentage, fines content, angularity, and material type.

The objective of this project is to quantitatively assess permeability of a wide range of coarse materials from base course (2" minus) to sand size (less than 20% finer than sieve #200) for design. Laboratory permeability tests will be conducted on aggregates of different types, gradations, angularity, fine contents, and crushing percentages. The test results will be analyzed using statistical methods to develop a simple predictive tool that may be used to assess permeability from gradation, crushing percentage, fines content, aggregate angularity, and material type. Drainage characteristics will consider both the saturated and unsaturated condition.

Research Benefits

Reduced Life Cycle Costs
Improved Safety
Material Cost Savings
Construction Savings
Reduced Environmental Impacts

Permeability of the base course and sub base is one of the main parameters in designing pavement systems and in post-construction performance and safety of the pavement structure. Low permeability of a roadway base course material and associated elevation of pore water pressure in the material will reduce the stiffness and strength of the base course, which can lead to surface rutting and cracking after a short time post precipitation. This will significantly reduce the pavement life cycle, increase maintenance costs, and lead to poor roadway performance and safety. Developing more robust methods to estimate permeability from surrogate material properties during the design phase to identify suitably drainable materials will thus reduce pavement life cycle costs and improve safety. An improved empirical approach to estimate material permeability will also potentially realize material cost savings, construction savings, and reduce environmental impacts (e.g., material sourcing and transport) by allowing a wider range of

locally available materials to be considered for construction during the design and construction phase. Implementation of the results of this research will lead to improvement of safety and reduction of maintenance and engineering costs associated with repairing roadways. This will reduce overall road user costs.

Methodology and Implementation Steps

This research will be conducted in three tasks (not including the initial memorandum on research benefits and implementation steps): literature review, laboratory tests and data analysis, and preparation of final reports.

Literature Review: A literature review will be conducted to gather available information on permeability of coarse aggregates and sands used in geosystems and existing methods for estimating permeability from other properties (e.g., gradation, unit weight, porosity, etc.). The available research results on permeability of aggregates as a function of affecting factors such as gradation, void ratio, level of compaction effort, fines content, angularity, material type, and other factors will be collected and tabulated. Available case studies on performance evaluation of geosystems such as pavement base course, sub base, and retaining wall backfills at various drainage capacity will be collected and synthesized.

Laboratory Testing and Analysis: Coarse aggregate and sand samples will be procured from different sources and subjected to laboratory permeability tests. Input (and materials) from stakeholders (DOT representatives) will be obtained to produce a suite of materials currently used in or being considered for use in pavement construction and representing a range of coarse-grained soils of different types, gradation, crushing percentage, angularity and fine contents. Statistical and multi-regression analyses will be conducted on the test results to establish relationships between aggregate permeability and affecting factors such as fines content, gradation, crushing percentage, angularity and aggregate type. Performance of existing empirical models identified during the literature review will be assessed by comparison with the experimental data, including a critical summary of pros and cons, applicability, and limitations for each relationship. Saturated and unsaturated seepage analysis will be conducted to inform the model performance and implications to material acceptance guidelines. Final recommendations will be made for design and material acceptance based on the performance of the newly developed and existing empirical models identified in the literature review.