# FY 2017 Research Problem Statement

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## I. TITLE

**17-049 Development of a Design Procedure for Open-Graded Wearing Courses**

## II. PROBLEM

Open-graded wearing courses (OGWC) have been used in the United States since 1950 (Kandhal and Mallick, 1998). The major advantages of OGWCs are faster drainage, less splash from vehicles, improved driver visibility, reduced traffic noise, cleaner runoff, and increased surface friction (safety) (Kandhal and Mallick, 1999; Coleri et al., 2013). Although most of the states have reported good performance, some states stopped using OGWC layers due to poor performance (Smith, 1992). Although there are many proposed mix design procedures available for OGWC mixes, a particular mix design procedure with unique test methods is not available to date (Alvarez et al., 2010). In addition, there are no structural design methods specifically developed for OGWC thickness design. The impact of using smaller aggregates in open-graded mixes (using E-mixes rather than F-mixes) and replacing F-mixes with conventional dense graded mixes (DGAC) on performance, noise, friction, and user costs (vehicle operating costs) should be investigated to determine the best strategies for Oregon.

## III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

This research would have three major objectives: i) develop laboratory test procedures to characterize rutting, cracking, raveling, and moisture susceptibility performance of OGWC mixes; ii) develop structural and mix design methods for OGWC mixes; iii) evaluate the impact of mix properties (comparison of E, F, and dense-graded mixes) on performance, noise, friction, and user costs. The research tasks are:

1. **Laboratory Investigation:** By conducting laboratory experiments, the effects of aggregate size, gradation, volumetrics, binder content, air void content, polymer modification, compaction, and binder grade on OGWC performance will be determined. Rutting resistance of OGWC mixes will be determined by flow number and asphalt pavement analyzer (APA) testing. Raveling resistance will be quantified by Cantabro tests. Hamburg wheel tracking tests will be conducted to evaluate moisture susceptibility. Cracking resistance will be measured by beam fatigue and indirect tensile strength (IDT) tests. Volumetric properties of asphalt mixes will also be measured for performance evaluation.

2. **Development of Design Procedures:**
   a. *Mix design:* Using the results from task 1, the effectiveness of each test method and procedure in identifying the rutting, cracking, raveling, moisture resistance of OGWC mixes will be determined. A method for identifying optimum mix designs for OGWC will be developed by using the test results. The possibility of modifying conventional DGAC mix design methods (Bailey and Superpave mix design methods) to use for designing OGWC mixes will also be investigated.

   b. *Structural design - Finite element and mechanistic-empirical modeling:* According to the literature, practitioners have been using current structural design methods for designing OGWC layer thicknesses by assigning a structural value ranging from equating OGWC to DGAC to giving OGWC no structural value (Coleri et al., 2013). In this research study, viscoelastic finite element (FE) models with simulated dynamic truck loads (Coleri et al., 2015) will be used to develop factors that can be used to convert OGWC layer thickness to DGAC equivalents by quantifying the structural value of OGWC layers. Using the developed conversion factors, conventional and/or mechanistic-empirical design methods (such as MEPDG) can be used to predict the in-situ performance of pavement structures with OGWC layers.

3. **Field Testing:** Data from ODOT's pavement management system (PMS) and previous research studies will be used to determine the field performance of E, F, and DGAC mixes. Using the PMS data, the effectiveness of developed mix and structural design methods (tasks 2a and 2b) will be determined.

   The difference in noise *(using a noise car)*, surface friction *(using dynamic friction tester)*, texture *(using sand patch or laser texture scanner)*, and surface profile *(using inertial road profiler)* for E, F, and DGAC mixes will be quantified by conducting field experiments. Using the collected data, the impact of mix properties (E, F, and dense-graded mixes comparison) on noise, friction (safety), and user costs will be quantified.

## IV. POTENTIAL BENEFITS

Using the implemented OGWC structural and mix design methods, performance of these pavements in Oregon can be improved. Improved performance will lead to reduced life cycle costs and encourage the widespread use of these mixes in Oregon. E-mixes (with small-sized aggregates when compared to F-mixes) are expected to reduce pavement texture depth and noise levels. Reduced texture is expected to improve user comfort and reduce vehicle operating costs. The safety benefits of using OGWC mixes when compared to conventional DGAC mixes will also be determined using field friction measurements. Results of this study will help ODOT develop more effective pavement management strategies for the Oregon road network.

## V. IMPLEMENTATION

In this research study, comprehensive procedures and tools (software) will be developed to design OGWCs in Oregon. Information and guidelines will also be produced to implement developed OGWC mix and structural design methods. In addition, developed design tools will quantify noise, friction, and vehicle operating cost benefits of different OGWC mixes.

## VI. LIST OF REFERENCES *(optional)*


Alvarez A.E., A. Epps Martin, and C. Estakhri. (2010). A Review of Mix Design and Evaluation Research for Permeable Friction Course Mixtures. Construction and Building Materials, 25(3), p.1159-66.

Coleri, E., J.T. Harvey, K. Yang, and J.M. Boone. (2013). Micromechanical Investigation of Open-graded Asphalt Friction Courses' Rutting Mechanisms. Construction and Building Materials, 44, p.25-34.

Coleri, E., J.T. Harvey, I. Zaabar, A. Louhghalam, and K. Chatti. (2015). Model Development, Field Section Characterization and Model Comparison for Excess Vehicle Fuel Use Due to Pavement Structural Response. Accepted for Presentation at the 95th Annual Meeting of the Transportation Research Board, Washington D.C.

Kandhal P.S. and R.B. Mallick. (1998). Open-Graded Friction Course: State of the Practice. Transportation Research Circular No: E-C005, Transportation Research Board.

Kandhal P.S. and R.B. Mallick. (1999). Design of New-Generation Open-Graded Friction Courses. The National Center for Asphalt Technology (NCAT) Report No. 99-3.

Smith H.A. (1992). Performance Characteristics of Open-Graded Friction Courses. National Cooperative Highway Research Program Transportation Research Board, Washington (DC): National Research Council, Washington, D.C.


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