SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2017

ODOT Research Unit
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I. PROBLEM NUMBER AND TITLE

17-009_CPM Improved Laboratory Density Testing for Roadway Base and Retaining Wall Backfill Materials

II. RESEARCH PROBLEM STATEMENT

The Oregon Department of Transportation (ODOT) uses the AASHTO T99 procedure as the basis for determining density specifications for the compaction of soils and aggregates. This procedure is well-known and is associated with a long history, but it may not be appropriate for the testing of aggregate materials with little or no fines. As such, ODOT currently requires that TM 223 be used to modify results obtained using AASHTO T99 for testing of base aggregate material in order to provide a higher degree of confidence that the maximum dry density best reflects as-built field performance.

Since ODOT began requiring T99 Method A for base aggregate density testing there have been concerns raised that the maximum density measured by these methods are sometimes unobtainable by contractors during construction. Consequently, change orders have been used to modify compaction requirements on projects using base aggregate where there has been difficulty achieving 95% of the maximum T99 density. The Washington State Department of Transportation (WSDOT) and the Western Federal Lands Highway Division (WFLHD) use the Humphres method (e.g., WSDOT Test Method T606) as an alternative for testing granular materials. However, there is some resistance to moving away from the more common engineering standard (i.e., AASHTO T99) and thus, this method has not seen widespread adoption.

III. RESEARCH OBJECTIVES

The objective of the proposed research is to develop ODOT Test Methods for compaction specification of unbound and cement-treated aggregate materials. Based on ODOT's current challenges, two complimentary research questions should be answered: (1) what is the appropriate procedure for laboratory characterization of the moisture-density relationship for granular materials; and (2) what are the effects of changing moisture content and gradation on the compaction and performance of in-place cement treated base (iCTB)? The objectives will be achieved through a systematic laboratory study coordinated with the ODOT Technical Advisory Committee.

IV. WORK TASKS, COST ESTIMATE AND DURATION

The proposed work will consist of two parallel tracks designed to assess compaction of both granular materials and iCTB materials. Specifically, work will include the tasks outlined below.

Track A: Maximum Dry Density

A1. Perform a literature review of common and proposed test methods for compaction of free-draining materials including the development of the Humphres method, AASHTO T99A, and AASHTO T180. Relate the procedures used in other states to those used by ODOT.

A2. Characterize three different materials (e.g., angular, sub-angular, and sub-rounded) of two sizes (3/4" and 1 1/2"), each with three gradations (to account for allowable variability within the aggregate specification) commonly used by ODOT. These materials will be selected after consultation with the Technical Advisory Committee (TAC). Material characterization will include testing for gradation, plasticity, specific gravity, and minimum index density (ASTM D 4254).

A3. Perform moisture density testing on each of the materials identified in A2 using the test methods identified in A1. The maximum dry density measured and predicted with each approach will be compared and differences across methods will be identified and discussed with a view towards implementation. ODOT will provide access to a Humphres device.

A4. Compare design and construction specifications used by other agencies to those used by ODOT to evaluate the appropriate specified level of compaction for aggregate backfill materials.

A5. Synthesize the results of this study and the steps necessary to implement alternative approaches to material testing, develop specifications, and determine acceptability requirements during construction. Develop a new ODOT Test Method.

Track B: in-place Cement Treated Base Mix Design Process

B1. Perform a review of the archival literature and the testing procedures used by other agencies for the characterization of cement treated base (CTB) and in-place cement treated base (iCTB) materials. Include a review and discussion of the Australia/New Zealand method.

B2. A total of nine mix designs will be considered: three different moisture contents (wet, dry, and at optimum, as identified in Task A3 above) and three gradations (selected from those considered in Track A). For each of the nine mix designs, prepare iCTB specimens for strength testing using both the ODOT Humphres device and AASHTO T99A (i.e., 18 combinations in total). All specimens will be prepared at 5% cement content.

B3. Perform unconfined compression tests and split tensile tests on each of the mix design-compaction procedure combinations (i.e., 36 tests in total). Analyze results and compare strength as a function of mix design variables, compaction procedure, and test type.

B4. Update the ODOT mix design Test Method. Include equipment operation as part of the same test method or a separate test method.

In addition to the tasks outlined in Tracks A and B above, a final report documenting all findings will be prepared. The total project duration is expected to be 24 months with a budget of approximately $195,000.

V. IMPLEMENTATION

Justin Moderie will oversee technical transfer and implementation within ODOT, including incorporation into the pavement design, materials laboratory, construction specifications, and construction inspection manuals. Implementation within ODOT will be facilitated through the development, by OSU, of new or modified Test Methods for treated and untreated sub-base aggregate materials. Additionally, the results of this study will be transferred through presentations given in meetings and workshops with ODOT personnel to provide perspective on how the results would be used and potential impacts to construction practices. Findings will be summarized in a technical report, and in conference proceedings and journal papers.

VI. POTENTIAL BENEFITS

ODOT is responsible for approximately 7,400 miles of highway, including Interstate and State Highways. Each year, hundreds of miles of new highway is constructed or rehabilitated, with an average cost of about $1.25M to $1.75M per lane per mile. Advances in the uniform and reliable testing, specification, and field confirmation of pavement materials, such as the untreated and treated base that forms the focus of this study, will lead to significant cost savings by reducing re-work, contractor change orders, and construction delays associated with change orders. This work will provide specific and actionable guidance for clear implementation on one of ODOT's largest line items. Helping to deliver quality roadways will help to avoid the projected loss of 100,000 jobs and $94B in lost GDP in Oregon over the next 20 years (ODOT 2014; *Rough Roads Ahead*). The development of an improved test method will provide confidence to ODOT engineers and field technicians in the performance of their constructed facilities. Proposals and results from this research could be shared on a national level to promote the new test method.

VII. SUBMITTED BY

Stage 1 Submitter	***Stage 2 Submitter***	***ODOT champions***
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