FY 2016 Research Problem Statement

ODOT Research Section
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I. TITLE

17-009 Resolving Problems with Non-Cohesive Base Material Density Testing and Compaction

II. PROBLEM

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. This has been particularly common with mechanically stabilized earth (MSE) wall construction. As a result, the ODOT Retaining Wall Subcommittee has asked if there are other methods of density testing that may give results which will yield more constructible densities where aggregate base material is used. 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.

Based on our understanding of ODOTs challenges, two primary 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 on engineering behavior when an aggregate material is not compacted to specifications determined standard test procedures? The first of these is a soil behavior question while the second considers the use of a performance-based standard rather than a material state-based standard.

III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

The proposed research will pursue complimentary paths to answer the two research questions identified above. Specifically, the research will require laboratory characterization of aggregate materials, a survey of methods currently in use by other government agencies, and numerical modeling to assess the performance implications on MSE walls of using backfill materials that have not been compacted to a density specification developed from testing in accordance with AASHTO T99. Specifically, work will include the following tasks:

1. Perform a review of existing literature and standards for the use of various test methods for free draining materials including the Humphres method, AASHTO T99A, and AASHTO T180. Relate the procedures used in other states to those used by ODOT.
2. 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). These materials should be selected in conjunction with the Technical Advisory Committee (TAC) for the project. Material characterization will include testing for gradation, plasticity, and specific gravity.
3. Using a select cross-section of approaches and correction factors identified in (1) above, determine appropriate measures for assessment of the maximum density for the eighteen test gradations.
4. Compare the MSE design and construction specifications used by other agencies to those used by ODOT to assess the importance of meeting a specified level of compaction for aggregate backfill materials.

5. Compare the performance of nuclear densiometers to those methods identified in (1) for determining the maximum dry density and water content of each material and gradation to understand potential biases in certain test methods.
6. Measure the shear strength of each of the nine material gradations using large (6-in.) diameter triaxial tests. These tests should be performed at both 90% and 95% relative density to assess the effects of lower-than-specified density on material strength.
7. Use the outcomes from the triaxial tests to identify target gradations for pullout box testing. Using two types of reinforcement (e.g., steel strip, geogrid; selected in conjunction with the TAC), the effects of density and gradation on reinforcement pullout resistance will be measured in the OSU small pullout apparatus.
8. Using results from material and pullout testing, perform a series of numerical simulations to extrapolate the measured element-scale behavior up to the scale of ODOTs typical MSE walls.
9. Synthesize the results of the above work and document the steps necessary to implement alternative approaches to material testing, development of specifications, and determination of acceptability requirements during construction. Develop a recommendation for selection of test methods for characterizing the compaction characteristics of granular soils.

IV. POTENTIAL BENEFITS

This work has the potential to significantly reduce contractor change orders and the delays to ODOT project schedules associated therewith. The development of a comprehensive benchmark will provide confidence to ODOT engineers in charge of reviewing bid submittals, performance specifications, and contractor change orders. Additionally, ODOT will have improved confidence in the performance of their constructed facilities, ranging from roads, embankments, approach fills, retaining walls, and other constructed works using granular materials. Finally, the work will help provide a basis for a National discussion for altering or supplementing accepted AASHTO codes in which ODOT will be able to assume a leadership role.

V. IMPLEMENTATION

The product of this research will be implemented in ODOT standards used by the Construction Quality Assurance (CQA) group. Following review and approval by the ODOT Research and CQA groups, this work will be used by the Geo-Environmental Unit, Bridge Section, and Traffic Roadway Units, and its engineering consultants. The research will be presented to members of the ODOT Project Managers for Construction, to provide perspectives on how the results would be used and potential impacts to construction practices. Gregory Stellmach, ODOT Construction Quality Assurance group, will support the implementation of these guidelines within ODOT.

VI. LIST OF REFERENCES *(optional)*

Drnevich, V., A.C. Evans, and A. Prochaska. (2007). "A Study of Effective Compaction Control of Granular Soils." Final Report, FHWA/IN/JTRP-2007/12, Joint Transportation Research Program.

Humphres, H.W. (1957). "A Method for Controlling Compaction of Granular Materials." *Highway Research Board Bulletin 159*, National Academy of Sciences, Washington DC, pp. 41-57.

Johnson, A.W. and J.R. Sallberg. (1962). "Factors Influencing Compaction Test Results." *Highway Research Board Bulletin 319*, National Academy of Sciences, Washington DC.

Washington State Department of Transportation. (2013). "Method of Test for Compaction Control of Granular Materials." WSDOT Test Method T 606.

Western Federal Lands Highway Division. (2014). "Untreated Aggregate Courses." Standard Specification Section 301.

VII. CONTACT INFORMATION

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