Oregon Department of Transportation

Stage 1 Research Problem Statement

Number*: 25-34*

Proposed Title: Best Practices for Soil Sampling: Process and Equipment Improvements

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

Numerous bridge substructures, bridge approaches, and embankments are underlain by the silt soils of the Willamette and Columbia River Valleys, which represents Oregon's largest population centers. These soils can exhibit several critical aspects of behavior, including susceptibility to liquefaction ("sand-like") or cyclic softening ("clay-like") depending on their local characteristics, the seismic loading applied by an earthquake, and the corresponding consequences (e.g., post-shaking strength and stability, settlement) on critical transportation lifelines. Accordingly, researchers and ODOT personnel have recently spent considerable resources characterizing the behavior of our silt soils and have unanimously concluded that sampling and testing of these materials represents the best approach to develop seismic design parameters for economical construction of highway infrastructure. Unfortunately, these fragile soils are susceptible to sample disturbance during the exploration phase of projects, and routinely implemented practices for sampling these soils may result in such great degrees of disturbance as to obscure their true stiffness, strength, and seismic resistance. The impact of sample disturbance to design can lead to potential over-conservatism, resulting in higher costs of construction of substructure foundations and ground improvements specified to meet ODOTs seismic resilience goals. This issue is of such concern that the Washington State DOT (WSDOT) is seeking to purchase a gel-push sampler recently developed in Japan for use by Oregon State University to help WSDOT improve their sampling processes. Despite this potential advancement in equipment, such a sampler remains untested in the USA and it is not clear how varying levels of sophistication in the sampling of our fragile silt soils will impact their engineering properties. This project seeks to leverage WSDOTs investment to propose a joint ODOT-WSDOT effort to establish the best practices for soil sampling based on a study of commonly available and recently developed, untested solutions and to train ODOTs engineers and scientists to use the equipment.

2. Document how this **transportation issue** is important to Oregon and will meet the Oregon Research Advisory Committee Priorities

The 2023 Oregon Transportation Plan (OTP) sets clear goals for achieving resilience in the face of climate change and natural hazards, while balancing other important goals. Specifically, this research addresses OTP Objectives SP.2, SP.3, SP.4, SP.6, and directly addresses seismic vulnerabilities identified in the Seismic Lifelines Study prepared for ODOT and implemented by the OTP. Moreover, this transportation issue addresses four of the focus areas identified by the RAC, including: (1) process and equipment improvements, (2) cost reductions or savings to construction, (3) workforce development, and (4) innovative technologies. Identifying the best practices (process and equipment, innovative technology) for sampling fragile silts will serve to advance the requirements set forth in the GDM and used by ODOTs engineers and consultants. Use of engineering properties which are the least impacted by sample disturbance will lead to cost reductions and savings for new and retrofitted infrastructure and reduced uncertainty surrounding engineering decisions. Training field staff to use the developed best practices will ensure that the results of this research are directly transferred to the people who can make a difference during their day-to-day ODOT responsibilities.

3. What **final product or information** needs to be produced to enable this research to be implemented?

There are two envisioned products that should be produced to enable implementation of this research. The first is a comprehensive technical memorandum with training video that prescribes the use of one or more specific samplers, drilling techniques, sampling tubes, and handling and storage protocols for intact samples of silt soils. This relatively brief product will be heavily illustrated using photographs, videos, and other media developed during the research, focusing on equipment and procedures. The second product will take the form of additions of requirements to the ODOT GDM that will prescribe adherence to the technical memorandum. In both products, references will be made to the final report to ODOT synthesizing the results of this research where the interested reader can obtain a comprehensive understanding of the basis for the proposed best practices.

4. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

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5. Other comments:

The envisioned scope of work necessary to support the development of and training to achieve best practices for sampling silt soils under this joint ODOT-WSDOT collaboration includes:

Task 1 – Literature Review: Perform a detailed survey of the literature on sample disturbance, its quantification using consolidation and small-strain (shear wave velocity, V_s) testing, and its effects on the mechanical response of soils with a particular focus on silty soils.

Task 2 – Field Study and Training: In coordination with ODOT staff, one or more sites underlain by non-plastic and low-plasticity silts where pre-existing CPT and V_s data will be identified for drilling and sampling. Side-by-side boreholes will be advanced to obtain nominally identical samples (e.g., at identical depths) using mud-rotary drilling and: (1) standard Shelby tubes with standard hydraulic-push sampling, (2) standard Shelby tubes with piston sampling, (3) sharpened stainless steel thin-walled tubes with piston sampling, and (4) gel-push sampling with proprietary sampler and gel lubricant. ODOT staff identified with the assistance of the project champion will attend, observe, and be trained on aspects of drilling and sampling during this activity, with a particular focus on the use of the sharpened stainless-steel tubes and the gel-push sampler. Photographers and videographers will record the field activity which will form the basis for the media component to accompany the technical memorandum in Task 5.

Task 3 – Laboratory Assessment of Sample Quality: Specimens prepared from nominally-identical samples will be prepared and tested using paired incremental load and constant rate-of-strain consolidation tests to demonstrate how differences in consolidation test procedures may lead to differing conclusions of sample quality. Measurements of V_s will be performed on separate specimens subjected to their in-situ vertical effective stresses as a measure of soil fabric integrity and compared to the results of the available downhole V_s data collected within the soil deposit to provide an independent and complementary measure of sample disturbance.

Task 4 – Laboratory Assessment of Impacts of Sample Quality on Soil Strength: Specimens prepared from nominally-identical samples will be prepared and tested for monotonic and cyclic strength and post-cyclic behavior to quantify the linkage between measured sample disturbance and soil fabric damage and reductions in strength and post-seismic responses.

Task 5 – Synthesis, Reporting, and Technical Memorandum: The work conducted in Tasks 1 – 4 will be synthesized and documented in a Final Report and presented during an interactive, statewide seminar to ODOT staff and their consultants. The report will be accompanied by a separate technical memorandum with electronic media supplement that prescribes the use of one or more specific samplers, drilling techniques, sampling tubes, and handling and storage protocols for intact samples of silt soils and training videos. The prescribed protocols will be incorporated into the ODOT GDM with the coordination and assistance of ODOT personnel.

6. Corresponding Submitter's Contact Information:

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