Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-69 – "Development of a Standardized Laboratory Cyclic Testing Procedure to Reliaby Assess the Liquefaction Resistance of Silt Soils"

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

Soil liquefaction during earthquakes can cause significant damage to highway bridges. While most past research has focused on sand liquefaction, few studies have explored the liquefaction susceptibility of silts. Many ODOT assets, including highway bridges, are in areas abundant with silt-rich soil deposits, such as the fine-grained Missoula Flood deposits in the Willamette Valley and the silt deposits of the Columbia River and Willamette River. Consequently, assessing the liquefaction potential of these soils is often part of the seismic evaluation for these projects.

The recommended liquefaction evaluation approach for silt soils involves sampling and testing the soils in the laboratory using either Cyclic Direct Simple Shear (CDSS) or Cyclic Triaxial (CTX) testing. The recent availability of cyclic testing services at research institutes (PSU and OSU) for industry projects as well as several local geotechnical consulting firms in Oregon has led to more frequent testing and thorough understanding of geotechnical seismic hazards. However, one crucial unknown regarding cyclic testing is how to consolidate soil samples in the laboratory to replicate field stress conditions. Two approaches for laboratory testing on silt soils are acceptable by industry standards, SHANSEP and Recompression approaches, however, in practice the resulting design parameters from each approach can be significantly different. This research will investigate these two approaches to understand which more closely captures in situ test conditions.

This problem of which approach to use for cyclic soil testing was separately and independently identified by consulting engineers in Washington State who work with Washington DOT, showing that this is a problem that impacts geotechnical engineering practice in the region.

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

The primary outcome of this research involves a recommended laboratory cyclic testing procedure to assess the liquefaction resistance of silt soils. These recommendations may be used to guide upcoming testing programs for ODOT projects. The results will be detailed in a practice-ready recommended amendment to the ODOT Geotechnical Design Manual (GDM) to facilitate the adoption and implementation of the proposed methods in ODOT projects.

The recommended procedure will be developed with test results on silt soils using Recompression and SHANSEP approaches. The testing will aim to: (i) quantify the impact of sample disturbance on cyclic behavior when using the Recompression approach, (ii) quantify the influence of stress history (i.e., OCR) uncertainty on cyclic behavior when using the SHANSEP approach, and (iii) examine how measured cyclic strength and post-cyclic performance parameters (i.e., settlement and shear strength loss) vary between Recompression and SHANSEP approaches, and if differences between Recompression and SHANSEP approaches relate to soil properties (i.e., plasticity index) and stress history.

3. (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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4. Decision making lenses

Please complete the following three sections. Your answers to these questions will be applied on a programmatic basis to support agency decisions. Answering yes to the questions below is not required. Resolving a narrowly focused technical research problem may meet agency needs without answering yes to any of the following questions. The ODOT Research Section will seek a balanced portfolio some projects will answer yes to one of the three categories below (e.g. climate, equity, and/ or safety) and other projects in a different category.

We are looking for an overall program balance and no one project is expected to balance all categories. Generally, a research problem statement is expected to be able to answer yes with clear and verifiable information in only one of the three categories below, some projects may be able to answer yes in two or even three categories. Some projects (i.e., needs focused on specific elements of infrastructure design), may have no yes answers but may still be high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. Every mile driven in Oregon is powered by a clean source of fuel. We seek research that supports construction and maintenance operations are carbon neutral and investments in mobility that support travel by low and no emission modes. While every research project may not result in a reduction in emissions, transportation investments overall support emission reductions to achieve state goals. Oregon envisions a transportation system that is resilient in the face of seismic and climate events and impacts to the degradation of the natural environment are reduced. Our vision includes a transportation infrastructure is built in a way that avoids impacts on key habitat and results in better environmental conditions for wildlife and native vegetation. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4f. Will addressing the **transportation issue** identified as a need in Question 1 develop, or validate methods for the estimation, measurement, or monitoring of transportation generated greenhouse gasses (GHG)?

☐Yes ☒No ☐Unsure

4g. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☐Yes ☒No ☐Unsure

4h. Will addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☐Yes ☒No ☐Unsure

4i. Will the solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐Yes ☒No ☐Unsure

4j. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☐Yes ☒No ☐Unsure

4k. Will the solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation ?

☐Yes ☒No ☐Unsure

4l. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

Equity

Equity can have many dimensions and impacts relating to communities, and transportation. It is important that problem statement proposals clearly explain in what capacities are equity dimensions or impacts being examined within problem statements. It is a goal of the OTP to "Improve access to safe and affordable transportation for all, recognizing the unmet mobility needs of people who have been systemically excluded and underserved. Create an equitable and transparent engagement and communications decision-making structure that builds public trust". Proposed research may have the intent of studying elements of this goal or apply analysis to specific transportation topics to ensure the resulting research recommendations is consistent with our equity goals. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4a Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes ☒No ☐Unsure

4b If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☐Yes ☒No ☐Unsure

4c Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐Yes ☒No ☐Unsure

4d Is the intended final product or information expected to support ODOT's equity efforts (Including but not limited to supporting one of the equity related objectives of the ODOT's Strategic Action Plan or Oregon Transportation Plan)?

☐Yes ☒No ☐Unsure

4e If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

Safety

Research outcomes may include interventions and countermeasures to prevent or reduce the frequency of crashes or other causes of transportation-related injury or death; or may include measures to reduce severity of injury (including prevention of death) after a crash or other injurious event. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan, Oregon Transportation Safety Action Plan and Oregon Transportation Plan.

4m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes ☒No ☐Unsure

4n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐Yes ☒No ☐Unsure

4o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☐Yes ☒No ☐Unsure

4p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐Yes ☒No ☐Unsure

4q. Will solving the **transportation issue** support improving safety through **investing strategically**?

☐Yes ☒No ☐Unsure

4r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

5. Other comments:

The objectives in this research can be achieved using a large database of cyclic shear tests on silt-rich soils. This database includes over 200 cyclic tests from 38 sites in Oregon, Washington, British Columbia, and Alaska, compiled by PSU researchers and their collaborators. Additionally, a small number of CDSS tests may be conducted to fill gaps in the database, and test specific relationships and hypotheses that develop from the database.

6. Corresponding Submitter's Contact Information:

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This form is not a grant application or contract document.