Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-30 - "Phase III: Diatomaceous Soil Modeling at the Wickiup Junction Site to Directly Inform Future Design"

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

The Wikiup Junction site was designated for an overpass to connect US-97 over a railway and provide continual transportation access through the town of La Pine, Oregon. Construction of the overpass started in 2016. However, before construction was completed in Spring 2017, large and unexpected settlements of the approach embankments and bridge abutments were measured. Construction of the overpass was abandoned in response to these settlements. Since 2017, Cornforth Consultants has measured ongoing settlements at the site, and in 2019 OSU/PSU/ODOT performed subsurface geotechnical investigations as part of SPR 820. These studies showed that (i) extensive deposits of soft and compressible diatomaceous soils underlay the site, and (ii) there are ongoing settlements at the embankments of about 1.75 inches per year. Furthermore, the Cornforth Consultants feasibility study estimates that settlement mitigation for future overpass construction will cost $47M to $63M. The discrete (e.g., CPT, laboratory testing) and time series (e.g., inclinometers, piezometers) data collected to date at Wikiup presents a unique opportunity for researchers to develop a comprehensive case study of the site, including calibrated numerical models. These numerical models can provide a valuable decision-making tool for ODOT to use as remedial design options are explored. In parallel, the well-documented case study will augment the decidedly lacking archival literature on construction in diatomaceous soils, providing significant benefit to ODOT engineers on future projects and to the broader transportation geotechnics community as a whole.

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

There will be two products of this research that will be used to understand settlement and construction options at Wikiup Junction site:

1. A numerical model that is calibrated to the soils and conditions at Wikiup Junction and validated with settlement monitoring data. This model can be used by ODOT to investigate the Cornforth feasibility study options to study the likely performance, explore alternative mitigation options, and investigate cost-effective changes to the design and/or construction process. Additionally, the model can be used for future investigations and construction at other diatomaceous deposits.

   The model will be developed in a geotechnical modeling software, such as FLAC2D or FLAC3D, with a soil model that reasonably captures the unique behavior of diatomaceous soils.

2. A published case history of the Wikiup Junction site. Diatomaceous soils are unique and non-standard materials for geotechnical engineers. Therefore, few, if any, comprehensive case histories of construction and performance in diatomaceous soils are documented in engineering literature. This is problematic because geotechnical engineering practice is largely informed by case histories, particularly when engineers are designing in "non-textbook" soils that do not

exhibit the correlatory behaviors observed in the vast majority of soils. In these instances, case histories are used to validate design and assessment methods with real-world design and performance. Case histories are used extensively in geotechnical engineering to guide site investigation, testing, design, analysis, and monitoring for similar sites and projects. The comprehensive dataset from site investigation, construction, and monitoring at Wikiup Junction provides a unique opportunity to develop a high quality case history of construction and performance within diatomaceous soils.

Developing and publishing a comprehensive case history will showcase ODOT's efforts to study and understand diatomaceous soils and impact engineering practice at other diatomaceous sites. The case history will be published as a journal paper, submitted for publication in the American Society of Civil Engineering *Journal of Geotechnical and Geoenvironmental Engineering* (ASCE JGGE) or a similar journal. The ASCE JGGE publishes high-quality case history papers for an audience of practicing engineers and researchers.

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.

Name	Title	Email	Phone
Tom Grummon	State Foundation Engineer	Tom.GRUMMON@odot.oregon.gov	
Chris Carpenter		Chris.Carpenter@ccilt.com	503-452-1100
T. Matthew Evans	Professor	matt.evans@oregonstate.edu	541-737-8535
Diane Moug	Assistant Professor	dmoug@pdx.edu	503-725-4283

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:

Developing the case history will be performed with the following tasks:

Task 1: Synthesize construction data, monitoring data, subsurface investigation data, and laboratory test data from the Wikiup Junction site. The monitoring data was collected by Cornforth Consultants from June 2017 to April 2023 and includes piezometers, inclinometers, tiltmeters, and survey hubs.

Task 2: Additional site investigation through cone penetration testing (CPT) at the Wikiup Junction site. The additional explorations will target locations around and through the embankment and close to instrumentation locations. CPT profiles will characterize the subsurface stratigraphy to define model geometry.

Task 3: Simulate site performance with a numerical model. This task will require building the site model with subsurface data and construction data, as well as calibration of model properties with laboratory test results. The simulated embankment settlement will be validated against the surveyed settlements.

Task 4: Investigate diatomaceous soil performance mechanisms. After calibration and validation of the numerical model in Task 3, various aspects of long-term performance with diatomaceous soils can be investigated. In particular, the roles of primary and secondary compression will be investigated. These will be examined for the as-constructed embankment conditions and in the context of one or more of the feasibility options proposed in the Cornforth feasibility study. Development of this numerical model will also allow investigation into the unique behavioral aspects of these soils, and how their properties and behaviors affect construction, design, and performance. Additionally, this model can be used to explore the feasibility options and other construction alternatives.

Task 5: Publish the Wikiup Junction case history. The case history will present the comprehensive dataset at the Wikiup Junction site, including geotechnical data, construction data, and settlement observations. The settlement at the embankments will be estimated with various methods ranging from standard textbook evaluation methods to the advanced numerical model of the site. The case history will be an example for engineering practice and ODOT of investigation, analysis and construction performance for diatomaceous soils.

6. Corresponding Submitter's Contact Information:

Name:	Diane Moug
Title:	Assistant Professor
Affiliation:	Portland State University
Telephone:	5037254283
Email:	dmoug@pdx.edu

This form is not a grant application or contract document.