SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

24-31 Developing guidelines for improved construction, repair, and rehabilitation of large culverts.

PROBLEM SUMMARY

In Oregon, a significant number of culverts have reached the end of design and service life. Constructing new culverts and rehabilitation of existing culverts are essential to reliable performance. Developing specifications based on the local geochemical, physical factors, and environmental conditions can help develop protocols for better material lifespan. Research is needed to address culvert deterioration, which includes examining pH, resistivity, Cation Exchange Capacity (CEC), chlorides, and sulfate content of the soils and their interactions with the respective materials.

ODOT OBJECTIVES

This research aims to provide clear design guidance for selecting and evaluating in-situ soil and backfill material around culverts. Particularly, the research will focus on recommendations and construction techniques for chemically modifying the in-situ soil & backfill material. Both successful techniques and detrimental techniques will guide ODOT's policy. The recommendations will be incorporated into ODOT's Hydraulic Design Manual and Chapter 4 of the ODOT Geotechnical Design Manual. Developing and implementing these guidelines will allow for improved durability & future cost savings for the construction and maintenance of culverts in Oregon.

BENEFITS

This research aims to develop recommendations and cost-effective methods for constructing and maintaining culvers in Oregon. Additional benefits include a better understanding of in-situ soil and backfill material on the three materials primarily used for culverts. This research allows for informed decision-making and material selection with the focus of reduced deterioration and improved lifespan. The financial benefits are difficult to estimate, however, the recommendations can potentially save a significant amount of maintenance costs as Oregon expands its transportation infrastructure. If this research is not performed, the current and associated durability issues can persist, leading to substantial use of funds for the maintenance of culverts.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 36 months.
Estimated Project Budget: $330,000
ODOT Support: Robert E. Trevis, P.E., ODOT Sr Culvert Hydraulic Engineer, Curran Mohney, ODOT Sr Engineering Geologist

FOR MORE INFORMATION

For additional detail, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at:
https://www.oregon.gov/odot/Programs/ResearchDocuments/24-31.pdf

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2024

PROBLEM NUMBER AND TITLE

24-31 Developing guidelines for improved construction, repair, and rehabilitation of large culverts

RESEARCH PROBLEM STATEMENT

In Oregon, a significant number of culverts have reached the end of design and service life. Constructing new culverts and rehabilitation of existing culverts are essential to ensure reliable performance. ODOT's culvert program has actively used advanced techniques to repair and rehabilitate damaged culverts. Developing specifications based on the local geochemical and environmental conditions can help develop protocols for efficient material selection. A significant factor influencing the long-term durability of concrete, thermoplastic, and metal culverts is the physicochemical properties of the soil around the culvert and the culvert material. Typical chemical factors affecting degradation include pH, resistivity, Cation Exchange Capacity (CEC), chloride, and sulfate content of the backfill and the material. For concrete culverts, pH, sulfate, and chloride content are considered critical in the long-term performance of culverts. Similarly, for metal culverts, pH and resistivity are critical parameters as they influence the corrosion rate of metal culverts. In addition, physical factors such as gradation and compaction can influence water diffusion through the surrounding soil to the culvert and subsequently affect its durability. The presence of nearby geotechnical components, such as driven steel pipes does change the properties of soil as they can produce electrostatic induction and, thus, localized corrosion due to the oxidation-reduction reactions in the soil particles around it. Therefore, a multi-faceted evaluation considering chemical and physical factors is required to develop a robust recommendation for constructing and repairing culverts.

Oregon has a wide range of near-surface geology ranging from sandy silts to expansive clays. The soil's physical structure and mineralogical composition around the zone of the culverts significantly impact concrete and metal. For example, the presence of aggressive soils (soil with pH < 7) can cause significant deterioration of culverts. ODOT has used polyliners, a trenchless technique for the repair of culverts. Developing specifications and design guidelines incorporating the effect of regional geology and seasonal moisture changes can increase the service life and reduce repairs, culvert failures, and save maintenance costs. This further substantiates the need to develop recommendations based on local conditions.

The results from ODOT's Pipe Zone survey indicate that most DOTs do not use pH or resistivity of the soil as a criterion for selecting pipe zone material. Indiana DOT has used a culvert program incorporating soil pH's effect to calculate abrasion. The "State Wide Corrosivity Study on Corrugated Steel Culvert Pipe" report published by FHWA in cooperation with MDOT identified pH and resistivity of the soil around the culverts as the main indicator for culvert corrosion. In addition, the report recommended AASHTO T288 Minimum Soil Resistivity Test Method as the basis for resistivity determination. Building on the results from these studies and developing specifications by incorporating field and lab data collected from Oregonian soils will enable the appropriate design and selection of materials and the construction of resilient culverts.

Another frequently overlooked option for improving the durability of culverts is the chemical modification of in-situ soil. Specifically, modifying the pH and resistivity of the soil with chemical stabilizers such as lime and cement can be a cost-effective and efficient approach to improving the durability of culverts. Chemical modification and subsequent compaction of surrounding soil during the constriction or repair of culverts can increase the pH and resistivity and reduce the CEC and permeability of the soil. These changes can significantly improve the service life of the culverts. Therefore, incorporating such recommendations in ODOT's Hydraulic (Chapter 5) and Geotechnical (Chapter 4) Design manual will further improve the

resiliency of the culverts.

RESEARCH OBJECTIVES

This research aims to provide clear design guidance for selecting and evaluating in-situ soil and backfill material around culverts. In addition, this research will provide recommendations for modifying both in-situ soil and backfill materials to improve the resilience of culverts, with full consideration of local soil conditions. The proposed field and lab experiments will consider the effect of dynamic soil properties due to seasonal changes. Although this work focuses on identifying the thresholds for parameters such as pH, resistivity, CEC, and similar geochemical parameters, this research will also provide recommendations and construction techniques for chemically modifying the in-situ soil and backfill material. The recommendations will be incorporated into Chapter 5 of ODOT's Hydraulic Design Manual and Chapter 4 of the ODOT Geotechnical Design Manual. Developing and implementing these guidelines will allow for improved durability and future cost savings for the construction and maintenance of culverts in Oregon.

WORK TASKS, COST ESTIMATE AND DURATION

Task 1: Literature review: Perform a literature review on factors influencing the degradation of culverts (survey). Review research carried out by other state and federal agencies in this area.

Task 2: Site identification: The research team will interview ODOT staff and identify at least 10 locations with varying amounts of damage to culverts. The criteria for selection will include soil geology, age, damage level, and accessibility.

Task 3: **Field investigation:** Evaluate the in-situ properties such as pH and resistivity of the soil, backfill material, and water. Record the data seasonally for the project duration. Collect representative samples for laboratory evaluation.

Task 4: Laboratory investigation: Test soils before monitoring – what is the initial condition? Investigate the effect of varying moisture and compaction levels. Compare parameters from sites with minimal damage to culverts and sites with significant damaged sites. The focus of this investigation is to critically evaluate the geochemical parameters that contribute to the enhanced durability of the culverts. For example, the pH and the resistivity of the soil or backfill material may be higher in sites with minimal damage to culverts as compared to sites with damaged culverts.

Task 5: Develop Mitigation techniques: Evaluate the effect of modifying in-situ soil with chemical stabilizers such as s lime and cement. Specifically, focus on the change in pH and resistivity. In addition, the research team will investigate the effect of the compaction effort of the soil and backfill materials. The proposed outcome of this task is a set of guidelines for determining the appropriate dosage and compaction effort for enhancing the durability of culverts.

Task 6: Revise existing guidelines: Generate recommendations regarding the selection of appropriate backfill material and propose revisions to ODOT's Hydraulic design manual (C5) and ODOT Geotechnical Design Manual (C4).

Task 6: Develop new guidelines: Develop guidelines for a pipe backfill & standard compaction drawing large culverts. This will include new standards for culverts with a span greater than 72 inches.

Task 7: Report: Document findings and submit a final report.

Key Deliverables: ODOT needs guidance (via data) for local conditions (environmental and through soil forces) for improved construction, repair, and rehabilitation of large culverts for improved culvert lifespan.

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IMPLEMENTATION

This new technology will be transferred through presentations given in meetings and workshops with ODOT personnel. Findings will be summarized in technical reports, conference proceedings, and journal papers and will be distilled into improved evaluation and design guidelines. Following review and approval, this work will be used by ODOT culvert engineers and its engineering consultants. The recommendations will be incorporated into Chapter 5 of ODOT Hydraulic Design Manual and Chapter 4 of the ODOT Geotechnical Design Manual.

POTENTIAL BENEFITS

This research develops recommendations and cost-effective methods for constructing and maintaining culvers in Oregon. Additional benefits include an improved understanding of the effect of in-situ soil and backfill material on the culverts, allowing for informed decision-making and material selection. The use of the new recommendations can potentially save a significant amount of maintenance costs as Oregon expands its transportation infrastructure. If this research is not performed, the current and associated durability issues can persist, leading to substantial use of funds for the maintenance of culverts.

PEOPLE

ODOT champion(s): Robert E. Trevis, P.E.**,** ODOT Sr Culvert Hydraulic Engineer; Supported by Paul Wirfs, ODOT State Geo-Environmental Manager

Problem Statement Contributors: Pavan Akula, PhD, Oregon State University; Robert E. Trevis, P.E.**,** ODOT Sr Culvert Hydraulic Engineer; Curran Mohney, ODOT Sr Engineering Geologist; and Jon Lazarus, ODOT Research Coordinator

REFERENCES

AASHTO RAC Survey Results: Asset Management System for Culverts (Alaska DOT, 2021)
Literature Review: Factors Affecting the Service Life of Culverts (Wilt, 2020)
AASHTO RAC Survey Results: Culvert Fill and Material Survey (Oregon DOT, 2019)
AASHTO RAC Survey Results: Best Practices for Assessing Culvert Health and Determining Appropriate Rehabilitation Methods (South Carolina DOT, 2016)

Additional references can be made available on request.

STAFF REVIEW PAGE

Literature Check

TRID&RIP

☒ A review of TRID & RIP databases found no existing research that answers the research question

- The Literature Review conduced for Kira has many references and citations. It doesn't seem to be published online with the ODOT Library. Additional references will be made available as part of this file, if requested.

Technology & Data assessment

☒ No Identified T&D output

☐ At the end of this project, the implementing unit(s) within ODOT will need to coordinate the adoption of new technology or data in order to realize the full potential of this research.

Cross-agency stakeholders

- List stakeholders or impacted units
    - Initial stakeholders identified through the authors and contributors
    - Maintenance and Ops reps will need to be involved in project (TAC) if funded.
    - JML 3/1/2023

- Identify any issues of concern raised by an ODOT stakeholder. Note expected mitigation
    - None identified after review – JML 3/1/2023