SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

27-55 Early Warning for Oregon's Aging Post Tensioned Bridges: Proactive Detection, Longer Life, Lower Risk

PROBLEM SUMMARY

This research tackles the urgent need to safely manage Oregon's aging post-tensioned (PT) concrete bridges, which rely on high-strength steel tendons but are prone to hidden corrosion from grout voids, water ingress, and outdated grouting methods. Rising risks of tendon failure, cracking, prestress loss, or collapse drive the development of a risk-based, scalable protocol. It includes a vulnerability screening score, a centralized PT bridge database with corrosion-relevant attributes, structural modeling linking observable changes (camber, strains, natural frequencies) to internal damage, proven NDE methods (ultrasound, GPR), and practical inspection/monitoring guidelines demonstrated on a case study bridge. Integration into the ODOT Bridge Inspection Program Manual supports proactive network-level screening, prioritized inspections, service life extension, and risk reduction—enhancing safety and reliability of Oregon transportation infrastructure.

ODOT OBJECTIVES

The project equips ODOT with practical, risk-based tools to proactively manage PT bridge safety and serviceability. Main objectives are to: (1) create a vulnerability screening score that prioritizes bridges by corrosion risk factors (grout quality, duct material, exposure conditions); (2) build a centralized statewide PT bridge database for efficient network assessment; (3) develop a scalable protocol integrating visual inspections, NDE techniques (ultrasound, GPR), and damage-tolerance analysis to detect defects, predict remaining service life, and direct interventions; and (4) field-test the approach on a case study bridge and embed the resulting guidance in the ODOT Bridge Inspection Program Manual. These steps will extend bridge life, reduce hidden corrosion risks, optimize inspection efforts, lower unexpected failure potential, and enable cost-effective statewide maintenance.

BENEFITS

This research equips ODOT with risk-based tools for safer, more efficient PT bridge management. Key benefits include early detection of tendon corrosion, extended service life through targeted inspections, improved efficiency via network screening and prioritization, major cost savings by avoiding emergencies and premature replacements, consistent statewide protocols in ODOT manuals, and reduced risks to workers and the public. Overall, it supports safer, more resilient, and cost-effective stewardship of Oregon's transportation infrastructure.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 36 months
Estimated Project Budget: $400,000

ODOT Support:

- Tanarat Potisuk, Concrete Bridge Standards Engineer; Tanarat.POTISUK@odot.oregon.gov
- Ray Bottenberg; State Bridge Engineer; Raymond.D.BOTTENBERG@odot.oregon.gov

For additional details, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at: https://www.oregon.gov/odot/Programs/ResearchDocuments/27-55.pdf

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2027

PROBLEM NUMBER AND TITLE

Early Warning for Oregon's Aging Post Tensioned Bridges: Proactive Detection, Longer Life, Lower Risk

RESEARCH PROBLEM STATEMENT

Post-tensioned (PT) concrete bridges rely on high-strength steel tendons to provide prestress and maintain structural integrity. However, these tendons are vulnerable to corrosion due to environmental and mechanical stressors, such as chloride ingress from leaking expansion joints, outdated grouting practices, and void presence in ducts. The consequences of tendon corrosion are severe, ranging from loss of prestress and concrete cracking to tendon rupture and even bridge failure. Monitoring these structures presents unique challenges: (a) tendons are inside ducts that are themselves typically embedded in the concrete, making direct visual inspection of tendons impractical, and (b) the sheer number of tendons in a single bridge makes monitoring every strand infeasible. Hence, research is needed to develop a risk-based, scalable protocol for inspecting and monitoring ODOT's PT bridge inventory.

RESEARCH OBJECTIVES

In order to address the aforementioned challenges related to PT structures, the current research aims to accomplish the following.

- **Vulnerability screening:** Develop a general vulnerability score to screen PT bridges for corrosion risk;
- **Centralized database:** Create a centralized database for PT bridges with data attributes specifically related to corrosion likelihood and performance degradation;
- **Inspection and monitoring protocol:** Establish a risk-based protocol that can leverage visual inspection and non-destructive evaluation (NDE) to reveal internal defects and structural robustness analysis with damage tolerance principles to guide inspection and monitoring planning;
- **Practical implementation and field demonstration:** Incorporate research into the ODOT Bridge Inspection Program Manual and illustrate the proposed protocols on a case study bridge.

WORK TASKS, COST ESTIMATE AND DURATION

Task 1: Forming Technical Advisory Committee (TAC) and Literature Review

The research team will form a TAC consisting of ODOT bridge engineers and ODOT bridge inspectors experienced in the inspection of PT bridges. In tandem, the research team will perform a comprehensive literature review on the corrosion inspection and monitoring and service life prediction of PT bridges. The focus will be placed on common PT bridge types prevalent in Oregon, proven NDE methods, and field observations of corroded or ruptured strands. The findings from the literature review will be presented to the TAC to further refine study scope.

Time Frame: 4 months; Responsible Party: PI and Co-PI, ODOT Research Coordinator, and TAC; Deliverable: TAC meeting minutes and draft literature review; TAC Action: Attend TAC meeting #1, review research plan, and advise on scope; ODOT Action: Review TAC advice and literature review.

Task 2: Developing a Preliminary Vulnerability Score

Based on the literature review, the research team will develop a categorical vulnerability score related to corrosion damage in PT tendons. The score will be based on critical factors shown to be influential to strand corrosion, such as grouting type, duct material, and exposure conditions (e.g., proximity to leaking joints). To facilitate network-level screening, these factors will be associated with attributes available in the National Bridge Inventory (NBI), FHWA InfoBridge, and ODOT bridge database. This preliminary score will be further refined based on structure-level parametric analyses to be conducted in Task 3A.

Time Frame: 6 months; Responsible Party: PI and Co-PI; Deliverable: Technical memo on vulnerability scoring criteria; TAC and ODOT Action: Review scoring method.

Task 3: Screening ODOT Assets and Identify Case Studies

Current national databases (NBI or InfoBridge) do not distinguish PT bridges or their duct details. This task will assemble a state-level database for PT bridges with attributes relevant to tendon corrosion. Using the score from Task 2, the team will screen ODOT-owned bridges to prioritize inspection and monitoring needs and identify a set of bridges for potential case studies and field evaluation.

Time Frame: Concurrent with the start of Task 2 and 9 months; Responsible Party: PI and Co-PI; Deliverable: Oregon PT bridge database and case study candidates; TAC Action: None; ODOT Action: Provide necessary bridge data and review.

Task 3A: Structural Response Sensitivity

Using structural and service life models, the sensitives of structural response (e.g., deflection or natural vibration frequencies) and surface distress (e.g., tension cracks) to strand/tendon corrosion or rupture will be investigated, in order to set up markers for targeted inspection.

Time Frame: Following Task 3 and 4 months; Responsible Party: PI and Co-PI; Deliverable: Working, validated structural sensitivity model for case study candidate(s), report correlating observable levels of damage with degree of strand or tendon loss; TAC Action: None; ODOT Action: Provide necessary bridge data and review.

Task 4: Establishing Inspection and Monitoring Protocols

To address the hidden vulnerability and damage at or in PT tendons, the research team will synthesize proven visual inspection and NDE methods for PT bridges and categorize the methods based on their applications, including anomaly detection, early warning, service life prediction, and strand rupture detection. To handle the large numbers of tendons within a PT bridge, a risk-based approach will be established to locate critical tendons by combining service life models (likelihood of rupture until next inspection) with structural robustness analysis (structural impacts of rupture). The approach will be applied to a wide range of representative, parameterized PT bridge superstructures to finetune and supplement the preliminary vulnerability score developed in Task 2.

Time Frame: 12 months; Responsible Party: PI and Co-PI; Deliverable: NDE application matrix guiding best use cases of NDE methods, the risk-based protocol, and the finalized vulnerability scoring system; TAC and ODOT Action: Review.

Task 5: Conducting Experimental and Field Studies

To determine an optimal inspection protocol, imaging methods using ultrasound and GPR will be first evaluated and calibrated on laboratory mock-up specimens (with manually introduced defects common in Oregon bridges) before deployment to a case study bridge. The proposed protocols will be tested on a case study bridge selected from the candidates identified in Task 3. The region of interest will be scanned based on the laboratory evaluation and the risk-based approach. The team will generate and analyze field data to update the vulnerability profile and predict remaining service life. The same robustness analysis developed in Task 4 will be used to set contingency triggers based on NDT and inspection results to mitigate failure risks.

Time Frame: Concurrent with Task 4 (after the development of NDE application matrix—5 months of Task 4) and 12 months; Responsible Party: PI and Co-PI; Deliverable: Field monitoring data and preliminary report; TAC and ODOT Action: Review.

Task 6: Completing final analysis, recommendations, and reporting

This final task will consolidate all research findings, analyses, and recommendations into a comprehensive report. The report will be prepared for review and acceptance by the project's TAC, with a summary "Research Note" submitted to ODOT Research for publication. Analysis tools and datasets developed as part of the project will be provided to ODOT in a digital format. The research team will draft recommendations based on deliverables from Task 2 and Task 4 and to be considered for inclusion in the ODOT Bridge Inspection Program Manual. The research team will also prepare documentation for the inspection and monitoring protocols in preparation for future transfer of the system to ODOT.

Time Frame: 6 months; Responsible Party: PI, Co-PI, ODOT Research Coordinator, and TAC; Deliverable: Project final report, research note, draft recommendations, monitoring system documentation, and TAC meeting minutes; TAC Action: Attend TAC meeting #2 and review final deliverables; ODOT Action: Review and approval.

Key Deliverables:

- A vulnerability score of PT bridges for network-level screening
- Oregon PT bridge database with data attributes relevant to corrosion damage and performance degradation
- Final report with detailed description of the proposed risk-based protocol for inspection and monitoring of PT bridges; draft language for updating ODOT Bridge Inspection Program Manual
- An NDE methodology based on imaging and contingency plans based on inspection results and structural response for a key ODOT bridge to achieve damage tolerant operation and risk-based inspection

Estimated Project Length: 36 months
Estimated Project Budget: $400,000

EXPECTED ODOT IMPLEMENTATION ACTIONS

- The research, in particular Task 2 and Task 4, will provide draft language to update the ODOT Bridge Inspection Program Manual, specifically Section 6.2 for accessible box girders and Chapter 8 for non-accessible box girders in complex bridges.
- A NDE case study on a real-world ODOT bridge will further prove the effectiveness and benefit of the research and increase confidence among stakeholders.
- The final report and other documentation of the research will facilitate future applications and continued development by ODOT and consultants.

POTENTIAL BENEFITS

- **Operational efficiency**: streamline inspection and monitoring of PT bridges
- **Service life extension**: enable risk-based inspection plans and contingency programs
- **Risk mitigation**: mitigate corrosion-induced severability and structural safety risks, and ultimately safeguard Oregon's transportation systems

PEOPLE

ODOT champion(s):

- Tanarat Potisuk, Ph.D., P.E., S.E.; Concrete Bridge Standards Engineer; Tanarat.POTISUK@odot.oregon.gov
- Ray Bottenberg; State Bridge Engineer; Raymond.D.BOTTENBERG@odot.oregon.gov

Stage II Problem Statement Contributors:

- Thomas Schumacher, Ph.D. P.E. (DE); Professor, Portland State University; thomas.schumacher@pdx.edu
- David Yang, Ph.D.; Assistant Professor, Portland State University; david.yang@pdx.edu

STAFF REVIEW PAGE

LITERATURE CHECK

TRID&RIP

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

ODOT DECISION LENSES

Climate: This research supports climate resilience by extending the life of existing post-tensioned bridges through early corrosion detection and targeted maintenance, avoiding high-emission replacements or reconstructions. It reduces construction impacts and potential detour-related emissions while preserving durable infrastructure against climate-exacerbated degradation.

Equity: This research promotes equity by preventing load-posting or closures of post-tensioned bridges that often serve rural, tribal, and underserved communities. Risk-based monitoring and consistent statewide protocols help maintain reliable access to jobs, healthcare, and services, reducing disparities in transportation reliability across Oregon.

Safety: This research directly improves safety by enabling early detection of hidden tendon corrosion in post-tensioned bridges, reducing risks of cracking, prestress loss, or collapse. Vulnerability scoring, structural modeling, risk-based protocols, and NDE methods protect workers, the public, and emergency responders while ensuring reliable performance of these aging structures.

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 IMPACTS

- List ODOT partners or impacted units: Bridge Section

- Identify any issues of concern raised by an ODOT partners. Note expected mitigation that addresses these concerns.