Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Data-Driven Prioritization and Empirical Predictions for Bridge Scour in Nebraska

Research Objectives

Reduce the uncertainty in the scour prediction equations specific to Nebraska soils and hydraulic conditions using empirical field data collected in this project. Particular attention will be paid to the scour predictions of clayey and cohesive soils, which are currently presumed to be overly conservative in the existing FHWA HEC-18 approach.

Evaluate and provide guidance on reasonable scour estimates for Nebraska soil and hydraulic conditions. This objective is done to address engineering judgment on whether the numerical scour predictions are "unconservative" or "over-conservative". Guidance will be provided using real field measurements to benchmark and clarify the ranges of acceptable scour in this area from the highly detailed, high-fidelity site assessments.

Research Benefits

- Reduced Bridge Closures: Improved estimates of scour may lead to a reduction in sudden bridge closures, which will enhance public opinion and aid in the economic vitality of agricultural regions.
- Structural Savings for New Bridge Design: Reduced uncertainty in scour predictions can result in more efficient and economical foundation designs for new bridge structures.
- Validation and/or Limitations of Existing Scour Predictions: The data-driven predictions will be compared to existing theoretical prediction methods, to improve engineering judgment on what is a "reasonable estimate."
- Enhanced Knowledge of Scour. Correlations of the scour rate with hydraulic and soil characteristics can enhance understanding of scour mechanisms, which will have a significant impact in the broader civil engineering community. Moreover, hydraulic parameters that represent Nebraska soils will be provided.
- Model for Other States/Agencies: The developed methodology for empirical scour validation may serve as a model for other states and agencies.

Background

Bridge scour is a leading cause of bridge closures and failures in the country and Nebraska. Over the last few years, high-profile bridge closures in Nebraska have been widely publicized in the media citing scour as the primary issue. The indirect economic impacts of bridge closures can be substantial on the Nebraska economy, particularly in the agricultural and rural sectors. According to a recent TRIP report, trucks carry 91% of the ton-miles for the movement of perishable agricultural items highlighting the need for critical rural routes to remain open.

Bridge inspections are performed to assure safe and continued operations. Due to the unpredictable stream behavior, scour may occur globally over the entire channel area or locally at an individual pier or abutment. The underwater inspection of foundations is included due to the continual changes in the stream/river and its floodplain and to determine the underwater member's condition with certainty. The goal of any inspection is to ensure that the changes in the channel conditions are within an acceptable tolerance or if a trend is evidenced that may compromise that stability of the bridge and therefore require action. Scour critical bridges are typically inspected at more frequent intervals than the typical biennial schedule, including during and immediately following flooding events. In these cases, personnel and resources are required to perform these inspections, and sometimes bridge structures are closed for unsafe or unknown conditions.

Conclusion

The effect of scour at the bridge substructure results in an increase in the vulnerability of the overall bridge stability. Previous studies have found that current guidelines are often overly-conservative with respect to scour. This project aims to provide guidance on hydraulic modeling parameters and reasonable scour estimates specific to Nebraska conditions. This will enable engineers to assess bridge sites for scour more precisely for efficient and effective design and countermeasures. Four sites were surveyed for scour changes between the period of December 9, 2020, to April 20, 2021. At these four sites, overland and bathymetry survey data were collected. The data collected were fused to create a high spatial resolution point cloud data of each bridge site. The point cloud datasets were used to analyze and quantify scour changes in the field using a change detection method. Erosion tests were also conducted at each site to classify the soil properties and determine the equivalent grain size parameters. The fused point cloud data and soil parameters were subsequently inputted in hydraulic modeling software, HEC-RAS, to predict bridge scour and to compare changes over time at each of the field sites. The scour analysis data was directly compared with the quantified changes from the point cloud analysis. The project shows that high-resolution geometry and equivalent grain size parameters yield more reasonable scour estimates compared to current guidelines.

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Final report is available at:
NDOT Research Website

NDOT Recommendations Based Off Research Project

Based on this project there will be a need for future work for this project, due to the conclusions identified the limitations of the change detection. The recommendations for future work can be divided in two phases.

Phase I - Additional periods of monitoring should be considered, particularly during intervals that experience large peak discharge events for the same sites investigated in this project. This project was only able to investigate events below the Q2 threshold.

Phase II – Additional study of soil profiles for detailed site characterization and classification would yield a more accurate D50 value. With the presence of class soil with different erosion rates at varying layers, the mean of the particle size for each layer is of value to determine a more accurate scour depth. Since the varying flood events affect the different scour depths, the findings of the class soil properties along with the varying flood events would yield a much less conservative scour depth value.

- *As provided by Fouad Jaber, Lead TAC Member*

Research Readiness Level (RRL) Assessment

Level: Applied Research/Proof of Concept/Laboratory Level

RRL 2

Technology Transfer

Principal Investigator did not have any technology transfer for this research project.

This brief summarizes Project SPR-P1 (20) M104
"Data-Driven Prioritization and Empirical Predictions for Bridge Scour in Nebraska"
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