

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Outdoor Laboratory and Testbed for Bridge Health

Research Objectives

The proposed research project has one overarching objective to transform two bridge sites (a total of three bridges) into a national research and educational facility for bridge health and testing. This will permit access for nondestructive evaluation and destructive test verifications. Furthermore, this facility can be leveraged for future research projects and identify strategic directions for this first-of-its-kind facility on realistic aging infrastructure.

Research Benefits

The project aims to establish a research and educational facility for studies related to bridge health and the training of students/future engineers, bridge engineers, and bridge inspectors. Due to the closed-traffic conditions of these bridges, this laboratory facility will enable testing of new methods for analytical modeling (with calibration), remote sensing, and diagnostic and health monitoring procedures. This project will provide a detailed characterization of realistically aged bridges (two steel bridges at Yutan and one concrete bridge at Omaha). In the long term, this project aims to study key questions on bridge health to address statewide and national needs. This facility will also increase national visibility of NDOT and UNL Engineering.

Principal Investigator

Richard L. Wood (P.I.)

Christine E. Wittich (Co P.I.)

Joshua S. Steelman (Co P.I.)

Jinying Zhu (Co P.I.)

Daniel G. Linzell (Co P.I.)

Jay A. Puckett (Co P.I.)

University of Nebraska

NDOT Lead TAC Member

Fouad Jaber

NDOT Bridge Engineer

Background

A 2017 study conducted by the American Society of Civil Engineers (ASCE), assigned nationwide bridges a disappointing grade of C+. This includes an estimated 9% of bridges considered structurally deficient, and nearly four out of ten bridges at or older than 50 years. This highly publicized study details the need for bridges to have significant maintenance, rehabilitation, retrofit, or replacement. In the absence of intervention and the fallout of our failing infrastructure, ASCE estimates \$3.6 trillion to repair and replace this infrastructure. However, most bridge agencies, including NDOT, have limited resources to maintain and operate their inventory. Therefore, it is critical to understand how to effectively employ these resources and extend bridge service lives.

Bridge health assessment invokes inspection, nondestructive evaluation, and destructive testing. Inspection and nondestructive evaluation are commonly implemented in practice; however, these techniques may involve subjective decision making, human interactions, and lack of verified or calibrated approaches. Furthermore, destructive tests such as deck coring and overstressing structural elements beyond their elastic limit are not commonly performed in practice due to their detrimental impacts to in-service structures. Therefore, realistic out-of-service bridge site(s) are critically needed to fully understand how bridges behave throughout their service life.

Conclusion

Due to the aging problem of bridges and the limited financial resources in the United States, it is necessary to form a deeper understanding of existing, aging bridges in an effort to extend their in-service life. To address this problem, researchers from the University of Nebraska-Lincoln (UNL) and engineers from the Nebraska Department of Transportation (NDOT) identified three, out-of-service bridges (two steel and one concrete) to establish the Nebraska Outdoor Bridge Lab (NOBL). As the first step in NOBL's development, geometric surveys of the current condition of each bridge were produced using lidar and Structure-from-Motion (SfM). This data contributed to the generation of finite element analysis models for each bridge, which were used to anticipate bridge response under various loading patterns and were validated using measured ambient vibration tests. Live load demonstrations were further performed for each bridge under various traffic loads. Geometric data, finite element models, and the results of the live load demonstrations are detailed in this report and are available for use by researchers and practitioners utilizing the NOBL facility moving forward. Additional potential uses of the NOBL facility are included along with areas for further research as concluding remarks in this report.

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Interested in finding out more?
Final report is available at:
[NDOT Research Website](#)

NDOT Recommendations Based Off Research Project

This project aims to establish a research and educational facility for studies related to bridge health and the training of students/future engineers, bridge engineers, and bridge inspectors. The Department launched this project with UNL, which has provided marketing and establishing a baseline set of data for use by others. To this end, the NOBL project has a dedicated website at <http://nobl.unl.edu>. This webpage exists at the University of Nebraska-Lincoln College of Engineering level for an extended lifespan. The generated datasets from this project are available for use by others by request. The available data includes for all bridge sites:

- Plan drawings.
- High-fidelity and high-detailed geospatial datasets in terms of three-dimensional point clouds and 2D orthomosaic images.
- Constructed finite element analysis (FEA) models in CSiBridge.
- Constructed FEA models in other platforms for the NOBL North bridge site only. This includes
- SAP2000, CSiBridg, AASHTOWare BrR, and COMSOL.
- Ground penetrating radar survey data and (likely) delamination maps, etc

Since the establishment of this site, the site has been used by non-UNL personnel including NDOT, NSP, Omaha Police Department, and the Nebraska Wing of Civil Air Patrol (Fremont Cadet Squadron). As well as, teaching facility for the following courses:

- CIVE 102 – Introduction to Geomatics for Civil Engineers
- CIVE 441 – Steel Design I
- CIVE 443/843 – Advanced Structural Analysis
- CIVE 839 – Bridge Design
- CIVE 891 – Non-Destructive Testing Methods

However, part of the agreement with the University was to use those bridges till the time comes to remove them, which is scheduled XXXXX

- 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

Webinars/Presentations

Wood RL* (2021). Nebraska Outdoor Bridge Lab (NOBL) Facility Introduction and Use. University of Missouri-Columbia Structural Engineering Seminar, Invited Speaker, Columbia, MO (and online), September 25, 2021.

Website

- <https://nobl.unl.edu/>

**This brief summarizes Project SPR-P1 (20) M107
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