Quantitative Assessment of Soil-Structure Interaction Effects on Seismic Performance of Bridges with ABC Connections

Quarterly Progress Report
For the period ending May 31, 2021

Submitted by:
PI- Elnaz Seylabi, co-PI: Mohamed Moustafa
Graduate Student- Emily Lescher

Affiliation: Department of Civil and Environmental Engineering
University of Nevada, Reno

ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

Submitted to:
ABC-UTC
Florida International University
Miami, FL

June 2021

Description of Research Project Task Progress

In this quarter, our focus was on (1) using the adequately validated scale bridge model to develop the prototype bridge model, and (2) coupling the prototype bridge model with the soil model already developed in the previous quarter. The following is a brief description of tasks carried out to date. **Based on the provided details bellow, we had so far 80% progress in the project.**

Task 1 – Baseline finite element model for the tested two-span bridge system

The main objective of this task was to develop model and prototype scale bridge models and validate different aspects of the modeling against an experimentally tested bridge at UNR.

Progress: 100% complete

The baseline finite element model is developed in OpenSees using the design details from the previously tested bridge.

To perform soil structure interaction (SSI) analysis, the simplified wire bridge model is scaled up to the prototype scale. The prototype model has two equal spans of 100 ft (1200 in.) and is 31 ft (372 in.) wide. The bridge bent consists of two 4 ft (48 in.) diameter columns spaced 9 ft (108 in.) apart on-center and a 6 ft (72 in.) wide by 7.5 ft (90 in.) deep cap beam that spans the entire width of the bridge. The columns have a clear height of 20 ft (240 in) and are integral with the superstructure. The superstructure consists of four girders with a 9 in. deck overlay. The dimensions for the girders and deck were scaled up to support the prototype model.

Task 2 – Model calibration

The main objective of this task was to determine and improve the predictive capability of the simplified finite element model in capturing the experimental results of the recently completed shake table test.

Progress: 100% complete

The previous study by Shoushtari et al. used a complex finite element model to model the bridge system. The OpenSees code from the study was provided and used to calibrate the simplified wire model. The complex model and simplified model are analyzed using the recorded shake table accelerations. To verify the design of the simple scale model, the results for force, displacement, and mode shapes are compared to the model used by Shoushtari et al. In most cases we found acceptable agreement among the simple and complex model and test data.

Task 3- Direct modeling of SSI effects

The main objective of this task was to couple the prototype bridge model with the surrounding soil to perform direct modeling analysis.

Progress: 100% complete

For SSI modeling we use the direct modeling approach. This calls for modeling the excitation field as well as the truncation boundaries for absorbing outgoing waves. For modeling the excitation field, we use the domain reduction method (DRM) and for truncation we use the buffer zone with high damping layers. The DRM is not explicitly available in OpenSees. Therefore, we use the seismo-VLAB software (http://seismovlab.com) for generating the required nodal forces to be prescribed in the OpenSees model. The size of the modeled soil domain is 400 m x 200 m x 50 m. Then, we add the bridge model to the existing finite element mesh to perform bridge-abutment-soil interaction analysis.

So far, we have performed a series of simple analyses to build confidence on the numerical accuracy of the developed finite element model in terms of convergence and stability. Due to the large size of the domain, we use a parallel version of OpenSees, i.e., OpenSees-SP, available through the DesignSafe cyberinfrastructure at UT Austin. We also note here that based on our preliminary analysis each simulation can take between one to two days to be complete.

Task 4- Quantitative assessment of SSI effects on seismic performance of ABC connections

Currently, we work on using the developed model in Task 3 to perform a series of numerical experiments to quantitatively assess the SSI effects on two considered ABC connections for the bridge column.

To this end, we will determine the extent to which seismic demands in ABC connections and global response of the bridge are correlated with the input motion characteristics and the soil. We anticipate spending 3 months on this task.

Progress: Not Started.