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

Quarterly Progress Report
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In this report, we provide a summary of our progress for the project tasks.

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

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

Progress: 75% complete

The baseline finite element model is developed in Opensees using the design details of the two-span bridge system. The columns, girders, and deck are modeled as force-based beam-column elements. The model uses the recorded shake table acceleration in the x-direction and y-direction as the input for the base excitation. We have already worked on verifying different aspects of the baseline finite element model to be used for the next tasks.

To perform soil-structure interaction analysis, we need to scale up the bridge model to the prototype scale. Currently, we are working on design aspects of the prototype bridge model.

Task 2: Data assimilation and nonlinear model calibration

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

Progress: Not started

Task 3: Direct modeling of SSI effects

The main objective of this task is to couple the bridge model with the surrounding soil. Our plan is to use the direct modeling approach to model the near-field soil.

Progress: 50% 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 plan to use either the buffer zone and high damping layers or the Lysmer dashpots. Our goal is to use the OpenSees for modeling the bridge and the DRM is not explicitly available in this software. Therefore, we use the seismo-VLAB software for generated the required nodal forces to be prescribed in the OpenSees model. Seismo-VLAB is a recently developed software to perform nonlinear wave propagation analysis in meso-scale SSI problems. This software is developed by PI Elnaz Seylabi and her collaborators Danilo Kusanovic and Domniki Asimaki at Caltech under a project supported by PG&E company. Figure 1 shows different views of the 3D mesh generated for computing the free field motion due to vertically propagating shear waves in seismo-VLAB. The size of the domain is 400 m x 200 m x 50 m. The red region shows the one-layer thickness of the DRM interface. Using seismo-VLAB we can compute the nodal forces associated with this wave field which can be used for analyzing the bridge model under DRM forces in OpenSees. Figure 2 shows a snapshot of the generated displacement field using the DRM technique. Then, one can use the generated DRM forces to run the bridge-abutment-soil model in OpenSees. To test different aspect of the modeling, we first decided to model the abutment-soil interaction in OpenSees under the DRM field. To this end, we used the parallel interpreter OpenSeesSP available on DesingSafe-CI.

Total number of elements are 56,760 and we used 4 processors to perform the simulation. Figure 3 shows the generated mesh with abutment showing the DRM interface and Figure 4 shows a snapshot of the generated displacement field under DRM forces. As a next step, we will add the bridge model to the existing finite element mesh to perform bridge-abutment-soil interaction analysis. This will allow us to move on to the next step and perform a series of simulations.

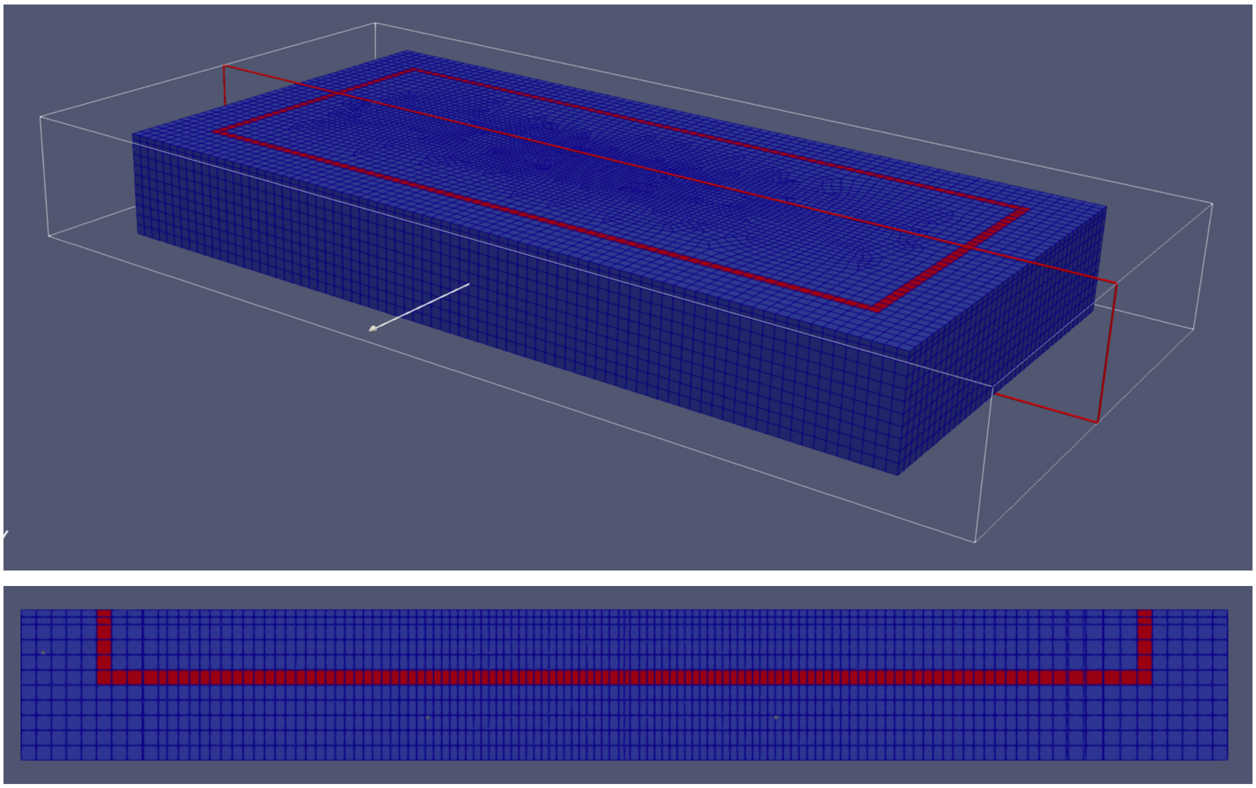

Figure 1: The 3D mesh for computing the free field motion under vertically propagating shear waves and computing the nodal forces along the one-layer thickness elements shown in red in the figure.

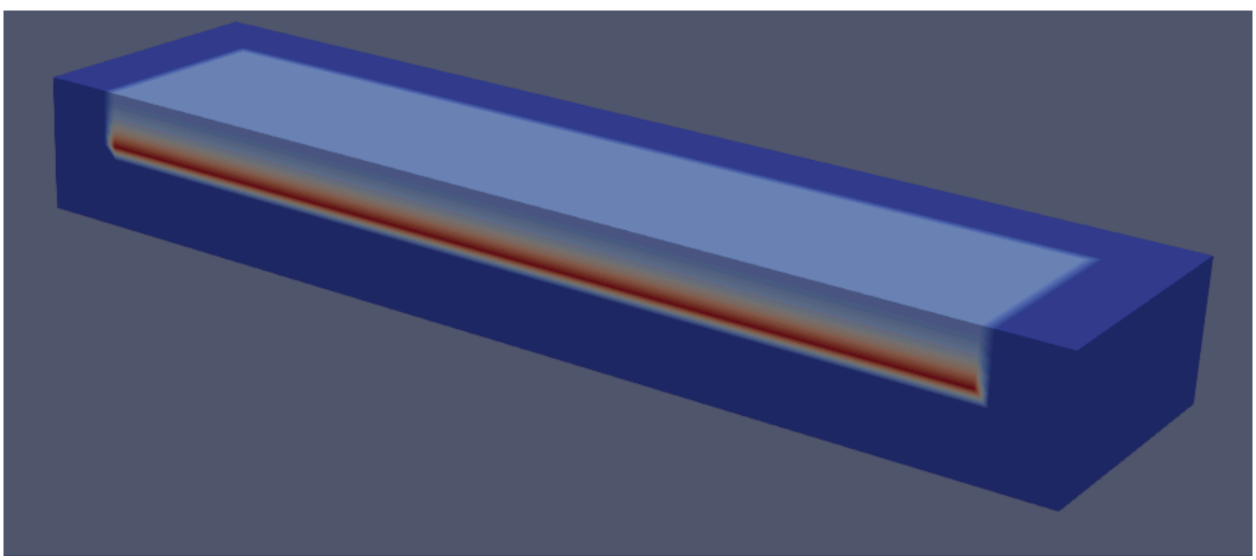

Figure 2: A snapshot of the displacement field associated with vertically propagating waves.

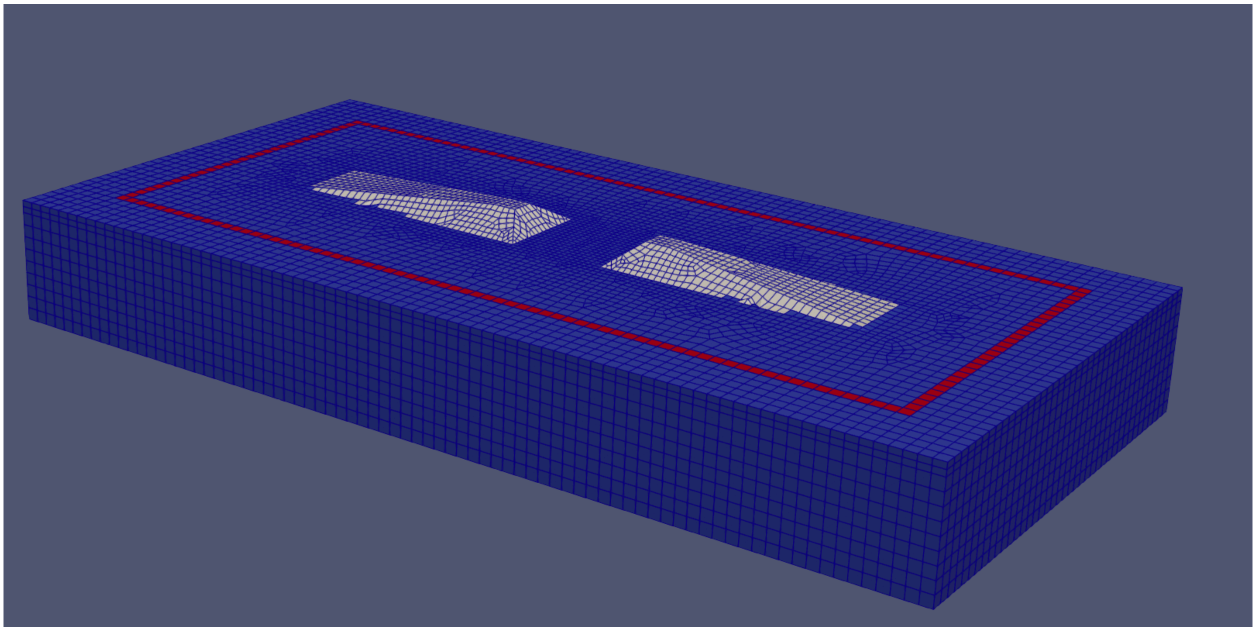

Figure 3: The 3D mesh for modeling abutment soil interaction under DRM nodal forces shown as a layer of red elements.

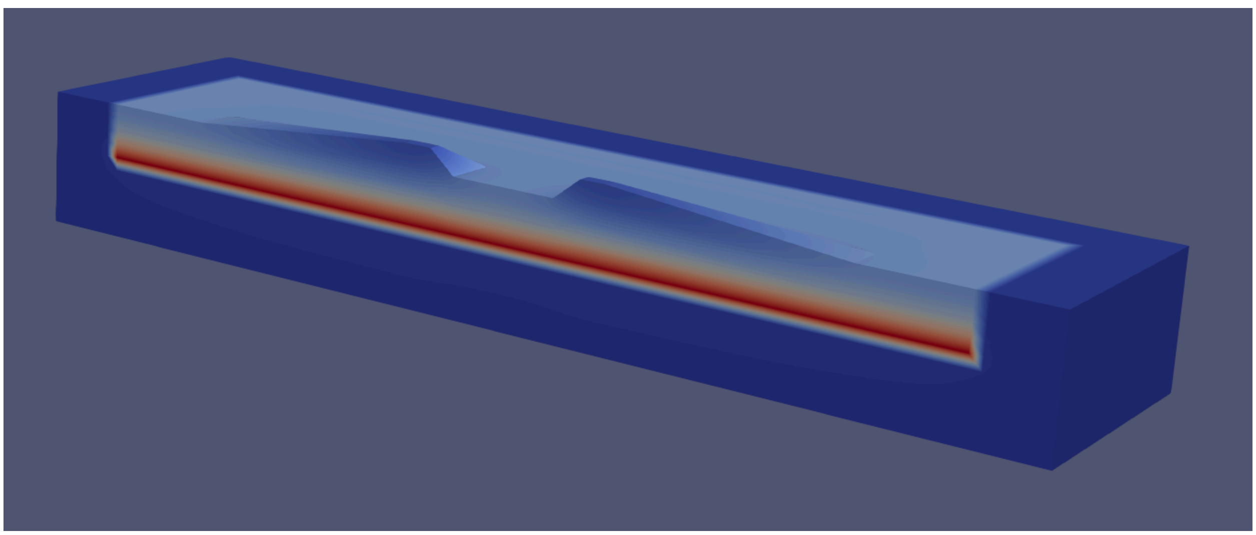

Figure 4: A snapshot of displacement field for the abutment-soil model under vertically propagating shear waves.

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

Our plan is to use 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.

To allow for the completion of all the project tasks, the study will be conducted over a period of 12 months (4 quarters) following this schedule:

Task	Status	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1	In Progress				
2	Not Started				
3	In Progress				
4	Not Started				

Percentage of work completed: 40%

Percentage of work remaining: 60%