Earth Pressure As a Boundary Condition to Bridge Piers and Abutments

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Abstract

Bridge piers and abutments makeup the bridge substructure and transmit loads from the superstructure to the bridge foundation material (Figure 1). The bridge abutment serves three purposes: to provide vertical support to the bridge superstructure where the bridge ends, to connect the bridge with the approach roadway, and to retain roadway base materials. There are several types of abutment structures (gravity, cantilever, stub, MSE, etc.). Generally, the landside of the abutment has a lateral earth pressure applied along the face (Figure 2). Bridge piers are typically found between abutments and help transmit load to the foundation material. Bridge piers are freestanding and typically have earth pressure around the footing for a shallow foundation or around the footing and piles for a deep foundation (Figure 3 (a) and (b)). The location of a bridge may lead to a change the stabilizing design earth pressures over time. This study uses COMSOL to model the change in the bridge pier behavior due to change in earth pressure load in two dimensions (2D) and three dimensions (3D) using the Solid Mechanics Module with Eigen frequency and Static Studies. Dead and Live loads representing the bridge superstructure and a single train engine are applied where the superstructure contacts the top of the pier. The earth pressure was applied to the vertical faces of the pier footing geometry as a user defined pressure boundary condition. For this study the piers had T-footings and a vertical pressure, representing the weight of the soil-water media, was applied to the top face of the footing. A spring bottom boundary condition was applied to the bottom of the footing representing the compressibility of the foundation soil. The evaluation the bridge pier geometry under the same superstructure loading for different earth pressure loads resulted in a relationship between earth pressure, pier displacement, and Eigen frequencies. We are currently running Eigen frequency analyses that will be completed by August 2012. An example of our observed change in Eigen frequency under one earth pressure loading (3 meters of Silt) is shown in Figure 4. While this study is not complete, the initial results indicate that a site-specific relationship can be developed between earth pressure, pier displacement, and Eigen frequencies. This relationship can be used to evaluate pier performance.

Reference

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Figures used in the abstract

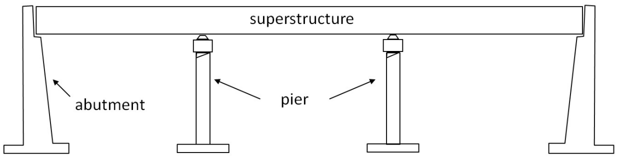

Figure 1: Simple bridge diagram with superstructure and substructure elements.

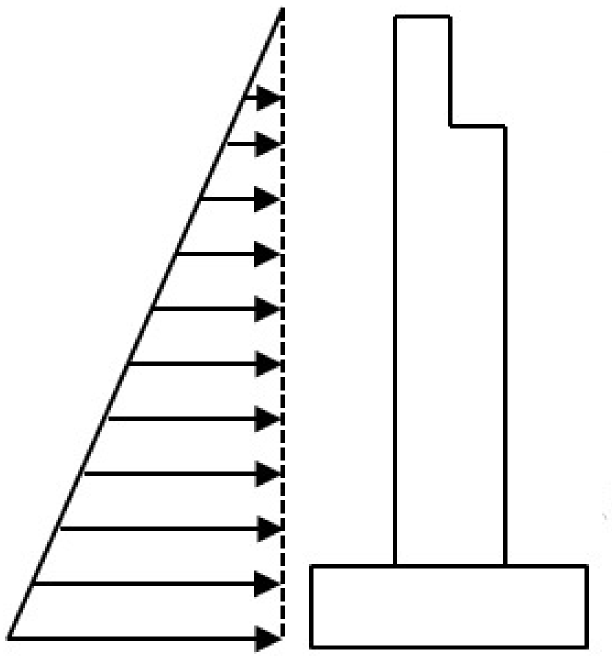

Figure 2: Lateral earth pressure on a typical abutment.

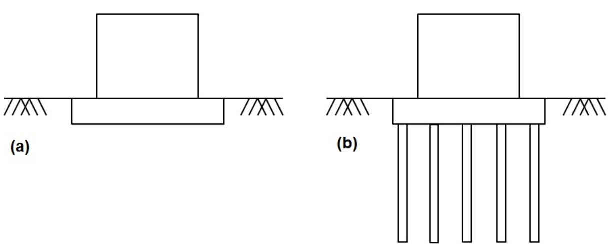

Figure 3: (a) spread footing, (b) deep foundation.

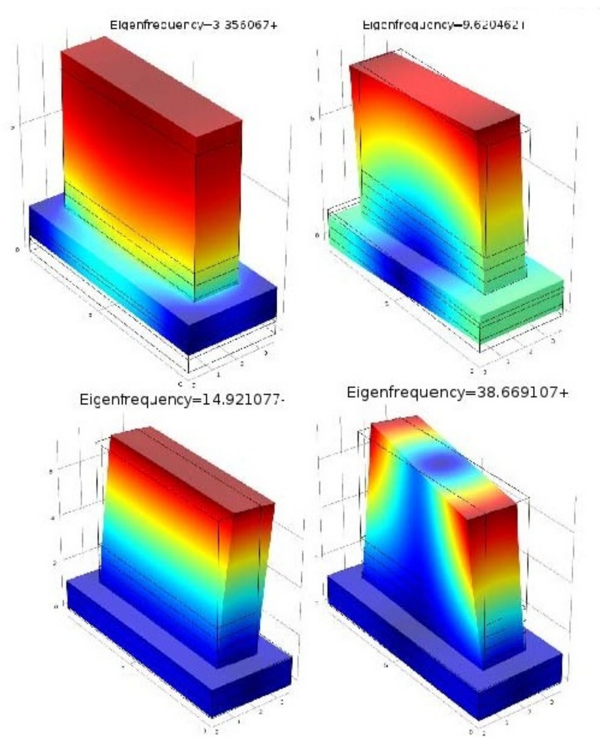

Figure 4: Eigenfrequencies observed in pier with an earth pressure equivalent to 3 meters of silt.