Research Project Highlight

Influence of Kinematic SSI on Foundation Input Motions for Bridges on Deep Foundations

Project # 1119-NCTRBR

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Start-End Dates:
7/1/2014-6/30/2016

Abstract
The seismic analysis of bridge structures is often performed using the substructure method, in which the foundation is replaced by an equivalent set of "springs" representing foundation impedance. Ground motions from seismic hazard analysis correspond to a free-field condition, and must be modified to account for kinematic soil-structure interaction to obtain the appropriate foundation input motion. The modification arises from the pile movement being different from the free-field soil movement, and is most prominent when the wavelength of the free-field wave is short relative to the pile length. At typical earthquake frequencies, this condition corresponds to large-diameter stiff pile foundations embedded in soft soils. Although a number of studies have been performed to quantify the effects of kinematic soil-structure interaction, they are often limited to idealized boundary conditions (e.g., uniform elastic soil, linear soil-structure interaction, and linear pile response), and do not provide spectral modification factors for use in structural design of bridges for earthquake loads. This project performed a suite of dynamic analyses of deep foundations embedded in realistic soil profiles and subjected to realistic earthquake ground motions. The results are presented as transfer functions intended to be applied to a free-field ground motion time series for the purpose of obtaining a foundation input motion time series for a dynamic response analysis, and also as response spectrum modification factors intended to be applied to a design free-field response spectrum to obtain a design foundation-input spectrum for spectral analysis.

Deliverables
This project will produce a PEER report detailing all project activities, several conference and journal papers describing the analysis methodology and key results, and part of Ben Turner's PhD dissertation.

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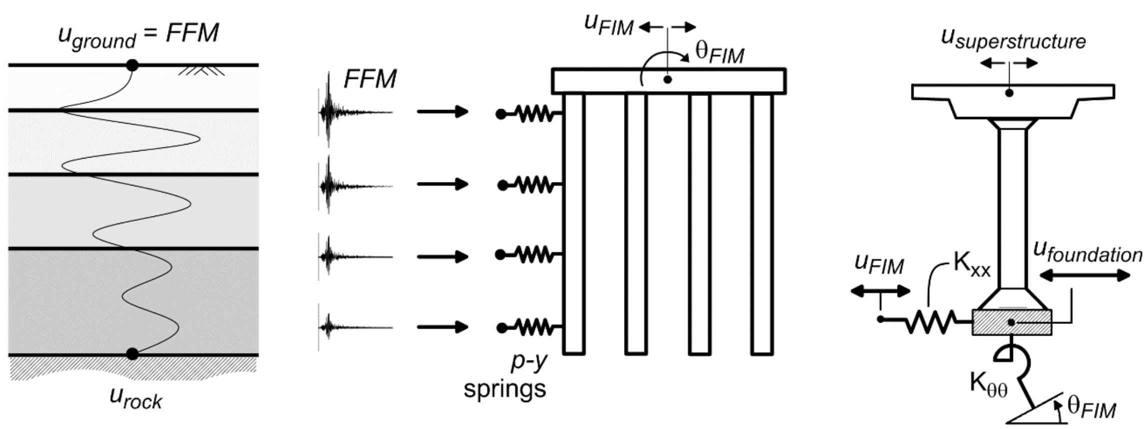
Research Impact
The impact of this research will be improved assessment of the seismic response of bridges founded on deep foundations, particularly for large-diameter stiff foundations in soft soils. Piles that are restrained rotationally by a pile cap result in the foundation input motion being lower than the free-field motion, particularly at high frequencies. Free-head piles exhibit kinematic amplification over certain frequency ranges, and reductions at high frequency. Hence, the foundation input motion may be either higher or lower than the free-field motion. We anticipate that the transfer functions and spectral modification factors will be most important for bridge structures involving large-diameter foundations and poor soil conditions. These important bridges are typically expensive, and the added complexity of considering kinematic soil-structure interaction is worthwhile.

Project Image



(a) Ground response analysis

(b) BDNWF pile-soil interaction analysis

(c) Superstructure analysis

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