Soil-Structure System Identification with Ambient Vibration Tests (A Case-Study on a Surface Pier of Kermanshah Urban Railroad)

Majid Lameie[1], Iman Ashayeri[2], Mahnoosh Biglari[3], and Mohammad Amin Kadivar[4]

1. M.Sc. Student, Civil Eng. Dept., School of Eng., Razi Univ., Kermanshah, Iran
2. Assistant Professor, Civil Eng. Dept., School of Eng., Razi Univ., Kermanshah, Iran, Corresponding Author, e-mail: i.ashayeri@razi.ac.ir
3. Assistant Professor, Civil Eng. Dept., School of Eng., Razi Univ., Kermanshah, Iran
4. Ph.D. Student, Islamic Azad Univ., Science and Research Branch, Isfahan, Iran

During an earthquake, the dynamic response of a structure located on a soil deposit could be very complex compared with the analysis of the same structure on bedrock due to the interactions between the soil and the structure. This phenomenon is technically termed as Soil-Structure Interaction (SSI) effects in literature. Most of what is currently known about soil-structure interaction (SSI) is based on theoretical and mathematical models. Therefore, it is necessary to investigate the structure treatments when they response to the ground strong motions transferred by SSI. In this regard, in an experimental field, the present study investigated the SSI effects on structure, evaluating the natural frequencies and damping of a pile-group-supported pier of Kermanshah's LRT. The frequencies and damping evaluations were performed through ambient vibration test results and system identification procedures. The purpose of system identification is to evaluate unknown properties of a system, using known inputs and outputs. There are two principal system identification procedures to build mathematical models of dynamical systems from measured data: (a) non-parametric and (b) parametric procedures. Non-parametric procedures evaluate complex-valued transmissibility functions from the input and output recordings without fitting an underlying model. Accordingly, Fourier Transform (FT), response square of transfer function, peak picking and four spectra are considered as non-parametric procedures. On the other hand, parametric procedures develop numerical models of transfer functions. More precisely, in these procedures, a mathematical model with several parameters is defined first. The considered parameters are featured with specific values determined by experimental results. Then, the system's input-output function is obtained using this described model. The studied pier was fully instrumented with two SARA and a CEM seismometers. The seismometers recorded signals of two horizontal and a vertical components that were digitally recorded at 200 Hz sampling rate. In general, measure of SSI effects was then obtained by comparing the flexible-base and fixed-base parameters to calculate the two most important effects of SSI, period lengthening and foundation damping. SAP 2000 was used to create a finite element model of the whole structure and the accuracy of the model was tested using recorded data from ambient vibration at the structure site. In summary, the current study indicates that all the utilized system identification methods are appropriate in determining the dynamic characteristics of the structure in fixed condition. In addition, it was demonstrated that peak picking and four spectral methods did not have appropriate function in investigating the interaction. However, these two procedures have appropriate function in determining the dynamic characteristics of the structure in fixed condition. As Figure (1) shows, the diagram of the period lengthening obtained from parametric method with the ratio of the structure-to-soil stiffness for the pier is approximately consistent with system identification analyses performed for the 57 sites in Stewart et al. [1]. Accordingly, inertial interaction effects were generally observed to be small for $1/\sigma < 0.1$ and for practical purposes could be neglected in such cases.

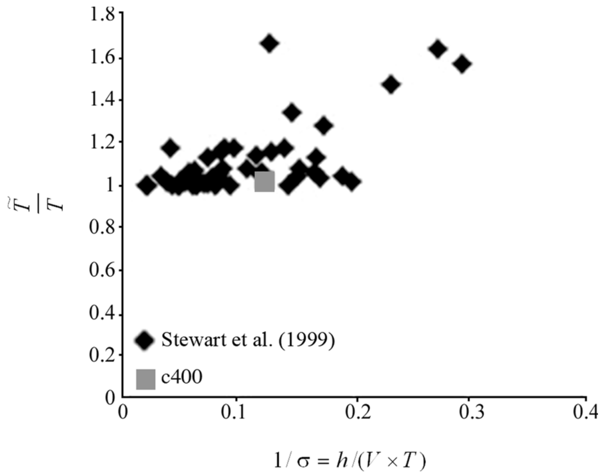

Figure 1. The period lengthening obtained from parametric method with the ratio of the structure-to-soil stiffness for the pier and the structures studied in [1]

Keywords: System Identification; Soil-Structure Interaction; Natural Frequency; Ambient Vibration; Pile Foundation

Reference

1. Stewart, J.P. and Fenves, G.L., and Seed, R.B. (1999) Seismic soil-structure interaction in buildings. I: Analytical aspects. *Journal of Geotechnical and Geoenv. Engineering,* ASCE, **125**(1), 26-37.