Department of Civil Engineering and Engineering Mechanics
Columbia University

Profound Effects of the Rate of Loading and Deformation on the Input Soil Parameters for the Seismic Site Response Analyses

Mladen Vucetic
Professor of Civil Engineering
Civil and Environmental Engineering Department
University of California, Los Angeles

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253 Engineering Terrace

One of the methods for the reduction of seismic risk and damages in populated areas is the site response analysis of local soil deposits. Its purpose is to evaluate the behavior of soil formation at a specific location of an existing or planned structure during anticipated earthquake. The elementary component of soil behavior due to seismic load is the cyclic stress-strain loop. Consequently, the computer models for seismic site response analyses include the properties of the cyclic loops and their variation with the level of cyclic shear strain amplitude, γ_c, and the number of cycles, N. The modulus reduction curve, G_{s1}/G_{max} versus log γ_{c1}, and damping curve, λ_1 versus log γ_{c1}, are the most frequently used curves describing the variation of the slope and size of the initial loop with γ_c. Here, $G_{s1}=\tau_{c1}/\gamma_{c1}=$ secant shear modulus of the initial stress-strain loop (slope of the loop), where γ_{c1} and τ_{c1} are the cyclic shear strain and stress amplitudes in the first cycle, G_{max}=maximum shear modulus at γ_c approaching zero, and $\lambda_1=\Delta W_1/(2\pi\gamma_{c1}\tau_{c1})=$ initial equivalent viscous damping ratio, where $\Delta W_1=$ the area of the first fully closed cyclic loop. Besides γ_{c1} and N, the properties G_{s1}, G_{max} and ΔW_1 depend on many other factors such as soil type, confining stress, geologic history and the rate of loading or shear straining. Among them, it seems that the effects of the rate of shear straining have not been adequately recognized and taken into account in engineering practice, although they can profoundly affect the outcome of the seismic site response analysis.

In the lecture, the results of relatively recent studies on the effects of the rate of shear straining and cyclic loading frequency on the shape of cyclic loop and the values of G_{s1}, G_{max} and ΔW_1 are described. Some unique results covering the range of very small γ_c, which are essential for seismic site response analyses, are also presented.