Seismic Site Effects for Weak Deposits in Korea

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ABSTRACT

In a nonlinear site response analysis, small strain damping is modeled as viscous damping through use of various forms of Rayleigh damping formulations. The type of Rayleigh damping formulation is known to have a pronounced influence on the response of deep soil columns. This paper performs a series of nonlinear site response analyses at weak soil profiles in Korea. Analyses highlight the strong influence of the viscous damping formulation even at shallow profiles less than 50 m in thickness, in which the simplified Rayleigh damping formulation significantly overestimates energy dissipation at high frequencies due to artificially introduced numerical damping. When using the full Rayleigh damping formulation, the artificial damping is greatly reduced. Results are further compared to equivalent linear analyses. The equivalent linear analyses overestimate the peak ground acceleration due to the stiffer response at the maximum shear strains for soft and deep soil columns.

KEY WORDS: Site response analysis, nonlinear analysis, viscous damping, equivalent linear analysis, peak ground acceleration

INTRODUCTION

One-dimensional site response analysis is widely performed to estimate local site amplification effects during an earthquake (Idriss, 1990; Kramer, 1996), in which ground motion propagation is approximated as vertically propagating horizontal shear waves through horizontal layers. Solution of wave propagation is performed in either frequency or time domain. Equivalent linear analysis, performed in frequency domain, is widely used in estimating site effects (Schnabel, Lysmer and Seed, 1972). The equivalent linear method approximates nonlinear behavior by incorporating shear strain dependent shear modulus and damping curves. However, a constant linear shear modulus and damping at a representative level of strain is used throughout the analysis. In a nonlinear analysis, the dynamic equation of motion is integrated in time domain and the nonlinear soil behavior is accurately modeled. The non-linear site response analysis formulation uses the viscous damping term to model damping at small strains. The frequency dependent nature of the formulation does not always guarantee a reliable solution. The influence of the viscous damping formulation has been known to be important for deep profiles thicker than 50 – 100 m (Hashash and Park, 2002). The influence of the formulation in shallower profiles has not yet been thoroughly studied. A series of nonlinear site response analyses are performed to investigate the influence of the viscous damping formulation at six representative soil profiles in Korea, ranging in thickness from 20 to 50 m. Results are further compared to equivalent linear analyses.