ABSTRACT
One dimensional site response analysis is widely used in estimating local seismic site effects. The soil behavior in the analysis is assumed to be independent of the rate of the seismic loading, while the laboratory results show that both the shear modulus and damping of cohesive soils are influenced by the rate of loading. The influence of the rate dependent soil behavior on ground motion propagation is not well understood. A new simplified equivalent linear analysis method is developed that approximates the rate dependence of soil behavior and is used to perform a suite of one dimensional site response analyses. The rate-dependent shear modulus has negligible influence, while rate-dependent soil damping filters out high frequency components of the motion and reduces the computed ground response.

KEY WORDS: Rate-dependent, equivalent linear, shear modulus, damping, site response analysis.

INTRODUCTION
Strong motion records from recent earthquakes have shown the importance of local site conditions on propagated ground motions. One-dimensional site response analysis is widely performed to account for local site effects during an earthquake (Idriss and Seed 1968; Roesset 1977; Idriss 1990; Kramer 1996; Hashash and Park 2001). Analysis methods include equivalent linear frequency domain approach (Assimaki and Kausel 2002; Idriss 1990; Schnabel and Idriss 1972; Sugito et al. 1994), and nonlinear time domain approach (Borja et al. 2002; Hashash and Park 2002; Matasovic 1993). Most of these approaches assume that dynamic soil properties are rate-independent. Sugito et al. (1994) and Assimaki and Kausel (2002) introduce a frequency dependent equivalent linear analysis approach to approximate nonlinear soil response but do not simulate the rate-dependent dynamic soil behavior. Laboratory tests show that cohesive soil behavior is dependent on the rate of loading (Richardson and Whitman 1963; Rix and Meng 2005; Whitman 1957), in which both the shear modulus and damping ratio changes with the rate of loading. This paper examines several models for rate-dependent dynamic soil properties which are implemented in a modified equivalent linear analysis site response analysis procedure that approximates the rate-dependent soil behavior. The developed models account for the frequencies at which the shear wave velocity profile and the dynamic soil curves (modulus reduction and damping curves) are obtained. The models are used to investigate the influence of a) rate dependence of the maximum shear modulus and modulus reduction curves, and b) rate dependence of damping.

RATE DEPENDENT SOIL BEHAVIOR
Cyclic soil behavior is commonly represented by shear modulus reduction and damping curves. Several factors are known to influence cyclic soil behavior, which include effective confining pressure (EPRI...