Reconsideration of Multiple Nonlinear Effects

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Evaluation of the effects of soil nonlinearity is an important issue for the prediction of strong ground motions (e.g. Aki, 1993; Beresnev and Wen, 1996). Conventional approach for evaluating the effects of soil nonlinearity is based on the assumption that the seismic wave is affected by soil nonlinearity only after its incidence to the local soft soil layers. In this approach, synthetic ground motions at the free surface is obtained, at first, assuming the linear behavior of the whole media using the empirical Green's function (EGF) method, etc. Next, the incident wave at the bottom of the soft soil layers is evaluated with a linear deconvolution analysis. Finally, by using the incident wave as an input motion, nonlinear ground response analysis is carried out to obtain true free surface motions.

If we consider a seismic ray connecting the source and the site, however, it usually crosses the soft soil layers several times. Therefore, it is more reasonable to assume that the seismic wave is affected by soil nonlinearity several times during the transmission from the source to the receiver. In this case the incident wave at the bottom of the local soft soil layers is already affected by soil nonlinearity. This phenomenon is referred to as the multiple nonlinear effects.

In this article, empirical Green's function method is applied to the downhole array records at Port Island during the 1995 Hyogo-ken Nanbu earthquake to confirm the existence of the multiple nonlinear effects and to identify the nonlinear parameters(Nozu and Morikawa, 2003) which represent the multiple nonlinear effects.