EFFECT OF LOCAL SOIL CONDITIONS ON GROUND SURFACE RESPONSES

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The effects of local soil situations in modifying the nature of free field ground motion have long been probed (Safak, 2001; Wolf, 1985). These effects are paid by special attention on way of ground response analyses, which the ground surface motion is evaluated by application of the wave propagation theory. In this situation, the bedrock motion is used as an input dynamic motion at the bottom boundary of soil deposit and the analyses are conducted with considering one (1D), two (2D) or three dimensional (3D) of the medium. Depending upon the site conditions and geometry, the effects of soil on ground surface responses may be performed whether 1D, 2D or 3D analysis. The previous researches showed that 1D ground analysis provides a reasonably good estimate of the free field ground motion in many cases (wolf, 1985). Although, the 1D analysis is computationally simple, but it seems that the factors such as nonlinear behaviour, Poisson's ratio and etc. of the soil medium at the other orthogonal coordinates should alter the ground surface response which it could not be considered on the 1D analysis. In this paper, the 1D and 2D ground surface analyses are conducted by programming in Matlab which is capable of simulating linear and nonlinear dynamic behaviours of soil medium under seismic excitation at bedrock elevation. The linear analysis of soil medium is performed in time and frequency domains and the ground surface responses are compared on these both cases. In order to verify the developed code on evaluation of free field ground motion, the ground surface responses are also investigated by the EduShake version 1.12 program which is one of the well-known softwares for estimating local soil effects under the bedrock motion

In the frequency domain analysis for the linear ground response, the special algorithm is proposed with using Fourier transforms which the free field ground response can be easily obtained due to S-H wave propagating for a specific time history of bedrock motion. Previous studies showed that S-H wave is predominantly governed dynamic motion of the ground surface (Towhata, 2008). The analysis results for three different soil properties (Table 1) under the El Centro earthquake as a bedrock motion are verified the considered algorithm for soil with linear behaviour (Figure 1).

Table 1. Three different material properties for soil

Sample	Thickness (m)	Damping ratio (%)	Shear wave velocity (m/s)	Mass per unit volume (Kg/cm^3)
Soil1	50	5	80	1600
Soil2	50	5	200	1800
Soil3	50	5	600	2000

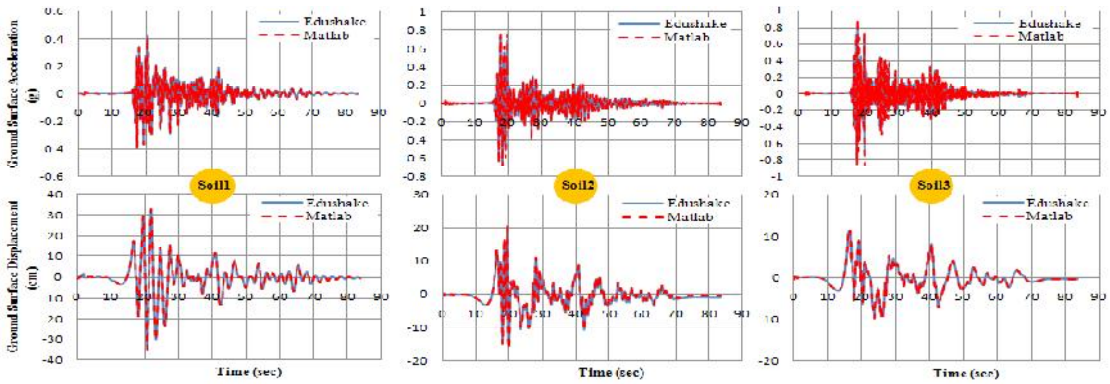

Figure 1. Ground surface acceleration and displacement with Matlab and Edushake program for linear soil

In the time domain analysis for the linear and nonlinear ground response, the soil medium is discretized as a number of shear beam elements. The soil mass is assumed to lump at the elements centre and the following equations of motion are solved numerically to find the time history of response at the considered points:

$$M\ddot{u} + C\dot{u} + R(u) = -MI\ddot{u}_g \qquad (1)$$

If the soil has linear behavior, *R(u)* is constant and equal to *(K.u)*; else *R(u)* is the nonlinear force-displacement relationship of the soil under seismic excitation. As the nonlinear behaviour of soil causes dissipation of seismic energy in addition to the material damping of soil, the variations of shear modulus and equivalent damping ratio with shear strain variation should be introduced in the considered coding. The nonlinear ground surface response (e.g acceleration) for the assumed soil properties with 1D and 2D simulations is shown in Figure 2.

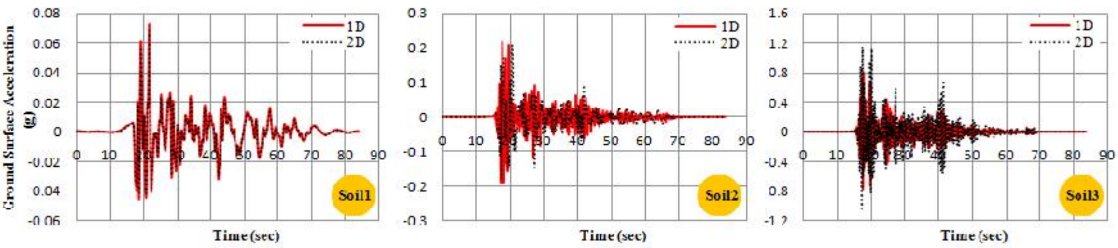

Figure 2. Ground surface acceleration response for nonlinear soil at 1D and 2D simulation

According to this investigation, the 2D wave propagation analysis of soil medium give slightly different results than the 1D analysis for a vertically propagating ground motion (S-H wave) even though the soil has the linear behaviour. The analysis results denote the importance of Poisson's ratio effect on this response. The free field ground displacement is more for the softer soil, but the ground surface acceleration is inversely significant in the stiffer soil at the linear and nonlinear behaviour of medium. The comparison between linear and nonlinear analyses showed that the free field ground acceleration for the linear soil is more than the similar nonlinear soil due to the hysteretic behaviour.

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