A Method of Estimating Incident Wave Considering Nonlinear Response of the Non-uniform Surface Ground

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When a strong earthquake motion is the case, whether a seismometer is installed underground or on a ground surface, any information recorded through the seismometer should naturally reflect the influence of highly nonlinear mechanical behavior of a surface ground that usually exhibits non-uniform multi-layered system. In other words, every strong ground motion analysis cannot be performed without the use of soil mechanics that describes nonlinear mechanical behavior of a non-uniform surface ground system.

In recent years, the elasto-plastic finite deformation computation of a soil water coupled system[1)] is utilized for the analysis of surface ground behavior from deformation to failure including soil liquefaction that occurs during/after a strong 'quake. In this research, a method of estimating input earthquake motion at an engineering base surface is newly presented from the records of seismometer at the basement that should reflect nonlinear mechanical behavior of a non-uniform multi-layered surface ground.

In the presented method, the existence of a semi-infinite purely elastic ground is assumed blow the so-called “horizontal engineering base surface” along which viscous boundary[2), 3)] is introduced at the bottom of a surface ground system. The earthquake motion is input at the bottom of surface ground through the viscous boundary. Let E be the upward transmitting wave, while F, the downward wave. In the usual “viscous boundary analysis”, the E is assumed at the viscous boundary as an input data and the whole surface ground motion is solved. As the results, the E+F is obtained at viscous boundary. Therefore, in usual computation, by giving E, at a viscous boundary, E+F is calculated at any point on the boundary. This E+F will be recorded if a seismometer is installed at the engineering base surface. However, the input data E is always to be assumed. The recorded and then observed E+F cannot be the 2E, because F includes every influence of both nonlinear mechanical behavior of ground motion and non-uniform geometrical shape of a multi-layered surface ground system. In this research, a method is newly proposed of calculating E by the use of observed E+F as an input data.

It is naturally considered that incident wave E should be uniformly distributed on an engineering base surface. This constrained motion at the bottom of surface ground is introduced through a “method of Lagrange multiplier”, in which Lagrange multiplier is to give the constrained force. Therefore, E is solved, from time to time, by calculating Lagrange multipliers.

For the verification of the method, the need of measurement of E+F at many locations on/in the surface ground is particularly emphasized in this research.

References

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Keywords: incident wave, observed wave, engineering base surface, surface ground, nonlinear analysis, viscous boundary

