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Integrated velocity model of shallow and deep subsurface structure of sedimentary layers for strong-motion evaluation

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In order to evaluate strong ground motions based on physical models, information related to physical properties of underground structures is indispensable. Specifically, elastic wave velocity structures are important in strong ground motion evaluation. For strong ground motion evaluation, three underground structure models are currently used in modeling. These models are: crustal structure ranging from upper mantle to seismic bedrock (in which the S-wave velocity is approximately 3km/s); deep subsurface structure ranging from seismic bedrock to engineering bedrock (in which the S-wave velocity is approximately 400 to 700m/s); and subsurface structure ranging from engineering bedrock to surface.
The deep subsurface structure affects components of relatively long-period ground motions (1s or more) and is important in computing ground motions within the frequency range assessed by a deterministic approach, such as simulations by finite difference and finite element methods. For creation of the initial model for all over Japan, it is then important to focus on common denominators that the various modeling methods may contain. Following this principle, geological classifications were applied to determine velocity structure, and this procedure was employed by all regional areas. Since there is a sufficient amount of widely ranging and homogeneous data related to the geological information on Japan island, these geological structure data were used in creating the initial model.
For the physical properties applied to the initial model, which was created following the method above, it cannot be said, from the perspective of strong ground motion evaluations, that the physical properties were adequately verified. Therefore, following the procedure described below, a national deep subsurface velocity structure model was developed based on, and designed to improve, the initial model. To improve the model, with a focus on predominant periods, by comparing H/V spectral ratios with consideration to the H/V spectral ratio of seismic records (for M5.5 or greater) observed by the Kyoshin Network (K-NET) and KiK-net, and higher-mode Rayleigh waves obtained from velocity structure models, deep subsurface structure models have been modified nationwide through adjustment of layer thickness in order to match predominant periods.
The target frequency ranges for deep subsurface structure models are period of 1s or longer. Not enough information on short-period, a requirement for earthquake prediction, was included in the deep subsurface structure models.
On the other hand, layer structure models of most shallow subsurface structure models were created with borehole data collected at target regions where it was taken from no deeper than a few dozen meters and with the physical properties of each layer indirectly estimated from the N-values. Therefore, verification of physical properties, which was used to improve deep subsurface structure models, did not take place for most of these subsurface structure models.
To upgrade structure models for the purpose of strong ground motion evaluations, and to develop structure models that can evaluate characteristics of earthquake motions in a broad spectrum of 0.1s to 10s, it is then important to integrate the once-separately-conducted modeling of subsurface

structures and deep subsurface structures and develop it further so that observation records can be duplicated in a broad spectrum of improved models. In the development of subsurface/deep subsurface structure models, a wide range of borehole data needs to be collected to input appropriate physical properties, and structure models be created following detailed structure information. At the same time, it is essential to acquire data that are necessary to estimate physical properties of structures at various locations through microtremor observations.

Keywords: National Seismic Hazard Maps, strong-motion, velocity structure, sedimentary layer, integrated, model