A Study for Efficient Modeling Procedure of Sedimentary Layer Structure

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Introduction

It is usually expected that by realistic modeling of the basin structure it is possible to make simulation of strong ground motions with high accuracy, but this is threatened with a hypertrophy of the necessary data. From another hand, by a simplifying of information that has low effect on the strong ground motion waveforms, it is possible to cut down unnecessary data. This kind of structure model that allow accurate simulation, is named efficient model. In this study, we study the generation of a coda-wave by fine (with the detail around 1m) structure, and develop a methodology of a more effective modeling of the sedimentary layer structure.

Scattering of S-waves in the Sedimentary Layers

At Higashinada, Kobe, using data of the 1.6km depth borehole it become possible to model velocity and density of sediments in 1612 pitches of 1m depth each (Kagawa et al., 2004). Calculations for this one-dimensional model show, that in case of vertically incident S-wave pulse, a coda-wave with the same polarity as direct pulse appears during the about 0.5 sec after the direct pulse. It seems that this coda-wave was formed by a trapping of the incident pulse in the low-velocity layers of the alternating velocity structure and then by transmitting it to the surface. In fact, the above-mentioned coda-wave doesn't appear in a smooth, monotonically increasing with depth, velocity structure.

After calculating the waves, scattered in each layer separately, we recognized that such coda-wave was mainly generated in the vicinity of the surface. Probable reason of why the deeper parts don't generate clear coda-wave is the fact that in deeper part velocity is large, and scattered waves, even being generated, are mainly overlap with the direct pulse.

Efficient Modeling

The same coda-wave can be reproduced by a simpler model in which the upper 100-200m has the same structure as mentioned above 1612 layer model, but lower part is replaced by a uniform model. Moreover, uniform model itself is not able to reproduce (underestimates) spectrum in frequency range above 1Hz, but when combined with the fine model in the upper 100-200m, it become able to reproduce realistically peaks of the spectrum in a frequency range around 4-6Hz.

In turn, model with fine upper part and uniform lower part underestimates spectrum in frequency range below 1Hz. In this case, if we replace lower uniform part by a rough model with a few contrast layers, for example by the sedimentary model of the Osaka basin of Kagawa et al. (1998), or by the 7 layer model derived from the borehole logging data at the Higashinada site using the AIC criterion (Kagawa et al., 2004), it is become possible to reproduce low-frequency part of the spectrum too.

Conclusions

For simulations below 1Hz, a simple average model of the sedimentary layer structure is enough. But for the accurate simulations above 1Hz it seems that it is possible to use fine model with velocity and density alternations in the upper surface part. In future work we plan to confirm these results using other borehole data and to continue development of the efficient modeling methodology.

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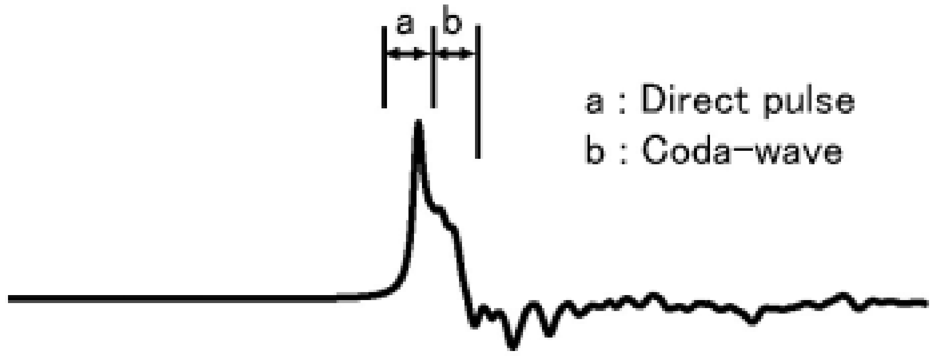

Fig.1 Illustration of definition of coda-wave used in this study.

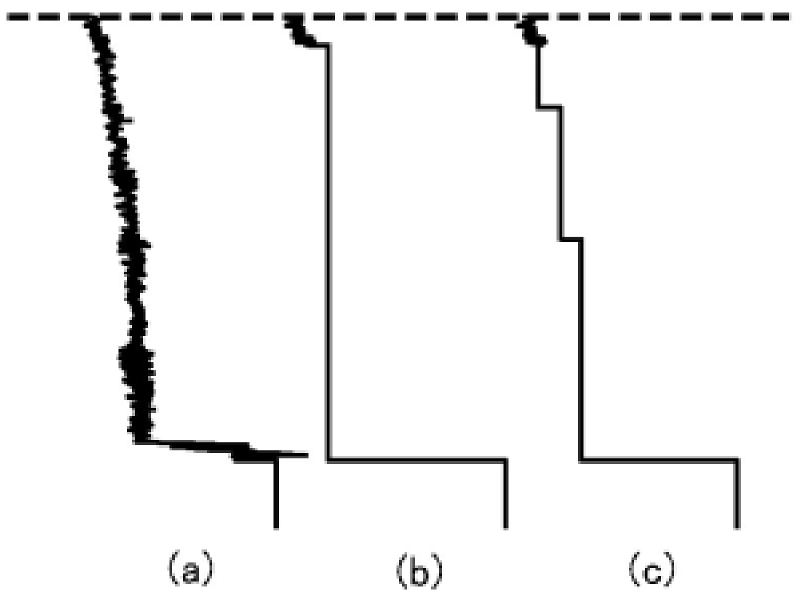

Fig.2 Sedimentary layer structure models :
(a) fine structure model (Kagawa et al., 2004) ;
(b) with fine upper part and uniform lower part ;
(c) with fine upper part and rough lower part.