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Lessons from the Ashigara Valley experiment and the Odawara Symposium on the effects of surface geology on seismic motion

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What we learned

Variability of observation:
A report by Kudo and Wang(1992) points out that observed spectral ratios between soft soil site KS2 and hard rock site KR1 for 20 events have large scattering as shown in the left side of Fig.1. The spectal ratio KS2/KR1 is one subject of the blind tests required for estimating from ground motion data at KR1 and geotechnical data around these sites.
One question is that a unique answer for such problem exists or not. We can see in Fig.1 large variability of a factor of more than 5. The origins of such variability might come from deterministic conditions and intrinsic indeterminacy in the wavefields. The former means differences of incident angles and azimuths for incoming waves, probably 2D and 3D effects. The latter includes randomness of heterogeneity in propagation media. The former effects will be estimated if we can have perfect geotechnical data and appropriate estimation method. However, we cannot reduce the variability from the latter effects. We need to define another parameters to give such variability.

Variability of prediction:
The variability of blind prediction by many participants for only one event with respect to spectral ratio KS2/KR1 is shown in the left of Fig.1 (Midorikawa,1992). The prediction variability looks comparable to the observation variability. However this coincidence is scientifically not meaningful. One origin of this variability is naturally from estimation methods adopted in prediction. Another origin might be the geotecnical model, although estimations are made based on the standard model. Participants did modify the model to be adaptable to their methods. So the variability comes partly from uncertainty of geological structure and input conditions. However there are no significant differences between 1D and 2D/3D model predictions. Some errors in modeling and/or in calculation might cause such variability. In either case the most important point to reduce the prediction variability is to reduce uncertainty for the geotechnical model.

Remained problems and future researches

Determination of reliable geotechnical model:
From the blind test results of both the Turkey Flat and the Ashigara Valley we could not succeed to test and compare methods of estimating surface geology effects. The accuracy of calculation seems to depend not on adopted methods but more on geotechnical model. We need to develop more effective methods to determine the geotechnical model. One of them may be inversion analysis for subsurface structure from ground motion array data.

Effects from lateral heterogeneity:
The results of prediction showed no significant differences between 1D and 2D/3D model. The peak amplitudes are significantly affected by very local structure. One of the reasons is attenuation effect. The responses at high frequencies are calculated approximately using 1-D model since seismic waves generated by horizontal heterogeneity are less effective because of attenuation. On the other hand, the responses at lower frequencies are more affected by horizontal heterogeneity as shown by several observational report in basin areas such as Tokyo and Osaka. We need to study ground motion in broader frequency range using broadband strong motion data.

Non-linearity of site response:
Variability of observed spectral ratios between soft soil site and hard rock site is very large between event and event as mentioned before. So it is very difficult to distinguish whether the difference in spectral ratio comes from non-linearity or lies in the range of intrinsic variability. From the report by Kudo and Wang the spectral ratios KS2/KR1 (KS2:soft soil surface, KD1: downhole -100m beneath KS2) have much less variability. Borehole observation will be very available to confirm nonlinear effects.

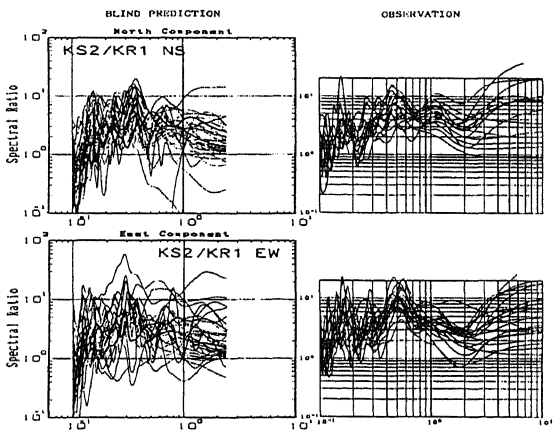

Fig.1. Comparison between the predicted spectral ratios KS2/KR1 for strong motion data from an events using the Standard Geotechnical Model and the observed spectral ratios KS2/KS1 from 20 events.

Future activity

a) Further study should be continued of both international test sites, the Ashigara Valley and the Turkey Flat. In the Odawara symposium we learned importance of effects of surface geology to seismic motion in mitigating future earthquake damage. Also we learned existing of a lot of unsolved problems. To test and understand such problems, we have not enough data yet. We need to keep research community and promote interest in this activity among scientists, engineers and public policy makers.
b) New test sites should be created to examine different aspects of surface geology effects. For the above international test sites the 1-D amplification effects may dominate from the last blind test. It is desirable to prepare other sites which are surrounded by different scale of horizontal and vertical heterogeneity.

REFERENCES

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