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Summary and some comments on results of Ashigara Valley blind prediction test

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ABSTRACT: After the symposium on the Ashigara valley blind prediction test, short notes on written discussion were submitted by twenty predictors. Summarizing the panel discussion and written discussion, we discuss some influences of input motion, geotechnical data, methodology of simulation, and nonlinearity of soil upon the predicted results and discuss future research needs for Ashigara valley blind prediction test.

1 INPUT MOTION

Seismic ground motions at KR1 were provided to use as an input motion to predict seismic ground motions at sites of KS1, KS2, and KD2. The KR1 site is on the outcrop. The ground motion recorded at the site, however, might be a response affected by the site topography and the geological structure, because the site lies on the steep slope and the surface part of the rock may be weathered. So, it is needed to remove these effects of local site conditions from the recorded KR1 ground motion, if they are not negligible, in order to get an input motion assumed to be common to the test area. There are some studies in the submitted predictions in which tried is the deconvolution procedure for an input motion using a 2-dimensional model of the site topography and described is that the effect is not negligible.

But in most of the submitted predictions, the observed KR1 motion was used as it was for the input motion to the sedimentary site models. This may be because provided information concerning the topography and geological structure of the KR1 site was not sufficient compared with that of the sediment site KS1 and KS2.

In Table 1, we show various procedures to estimate the incident wave field.

On the other hand, it was pointed out that there exists an inevitable variability of ground motion, even on rock sites where effects of soil layers and topography can be neglected, because of the heterogeneity of deep ground, as stated by Toksoz(1992) in his invited lecture of this symposium. For the proper evaluation of an input motion, array observations of ground motions at several rock sites around the area are needed as well as detailed geological information. Also presented was a comment that more information for the earthquake source should be needed for the prediction using a fault model.

2 GEOTECHNICAL DATA

For the weak motion blind prediction, records at one of the sedimentary sites(KS1) was released together with those at the rock site(KR1). The preliminary analyses of KR1 and KS1 weak motions led several predictors to modify the standard geotechnical model. Some of them preferred the model based on logging data rather

Table 1. Number of predictions by incident wave field (Sasatani, 1992).

Incident wave field	Number
KR1 records	27
Deconvolved motion from KR1 records	10
Seismic source effects	
Haskell source model	1
Ben-Menahem source model	1
Gaussian white noise (Boore model)	2
Barrier model	1

Table 2. Primary classification of prediction methods (Sasatani, 1992).

Wave Propagation Methods	Total 42
Classification Items	
Structure of the sedimentary layers: 1D/2D/1D+2D/3D	
Medium: Continuum / Discrete	
Constitutive relationships:	
Linear / Nonlinear (Equivalent-linear / True nonlinear)	
Incident wave field	
Non Wave-Propagation Methods	Total 2
Statistical method	
Microtremor method	

Table 3. Number of predictions by method (Sasatani, 1992).

Wave Propagation Methods	Number
1D Methods	Total 28
Plane wave propagation methods	
Transfer matrix methods (equivalent-linear)	17
Kennett propagator (L: linear)	1
Haskell method (L)	6
Finite difference method (NL: hysteresis)	3
Pseudospectral method (viscoelastic)	1
2D Methods (AA' section = 6; BB'/CC' section = 6)	Total 13
Finite element methods	
Elastic	1
Equivalent-linear	3
Elastoplastic	3
Finite difference methods	
Elastic	1
Non-linear hysteretic model	1
Pseudospectral method (viscoelastic)	1
Discrete wavenumber method (L)	2
Hybrid method based on the Riccati Matrix equation and the boundary integral method	1
(1D + 2D) Methods (AA' section = 1; BB'/CC' section = 2)	Total 4
1D (equivalent-linear) + 2D (discrete wavenumber)	2
1D (Haskell method) + 2D (theoretical method for Love waves)	1
1D (discrete wavenumber) + 2D (finite element)	1
3D Methods	Total 1
Two dimensional finite elements + mass-spring-damper system(equivalent-linear)	1

than the standard model. According to the statistical analysis, predictions based on the preferred geotechnical model showed better agreements with observations(Midorikawa, 1992).

3 METHODOLOGY

The Ashigara Valley Blind Prediction has different features from the Turkey Flat Blind Prediction: 1) the valley has fairly thick sedimentary layers and the structure is considerably complex; 2) strong motions (about $100cm/s^2$ at the rock site were released; and 3) weak motions at the rock and one of sedimentary sites were also released. Considering these features, the predictors utilized various methods.

Among the methods submitted, the wave propagation methods were mostly utilized on the basis of continuum and discrete (finite element and finite difference type) solutions (Table 2). We classified the wave propagation methods according to the following aspects: 1) structure of the sedimentary layers (1D, 2D and 3D), 2) constitutive relationships of the soil medium (linear or nonlinear), and 3) incident wave field. On the other hand, non wave-propagation methods were also applied: statistical method and microtremor method. These methods evaluated no seismic waves propagating through the sedimentary layers.

The wave propagation methods submitted are summarized in Table 3. Some predictors considered that the inclination of the interface beneath the sedimentary sites(KS1 and KS2) was very small, although they recognized that the Ashigara Valley had the complex structure. Another predictors examined the effect of 2D geological structure based on the given cross sections, but they could not found any considerable effects. Then these predictors finally decided to utilize 1D methods. In the 1D methods, transfer matrix method(SHAKE) involving nonlinear effects by the equivalent-linear method was most widely utilized.

Predictors who utilized 2D methods really recognized that the Ashigara Valley had the complex structure. However, they had to select the cross section that induced strong 2D structural effects: AA'(East-West section) or BB'/CC'(North-South section)(JESG, 1991). Some 2D methods have computational limitations such as instability at high frequencies. Then a few predictors utilized the hybrid methods (1D + 2D): 1D methods for high frequencies and 2D methods for low frequencies. They set the frequency limit at about 2 Hz. Only one 3D method was utilized in the Ashigara Valley Prediction. In spite of these efforts, Midorikawa(1992) concluded that no significant difference could be found between predictions based on 1D methods and on 2D/3D methods, from the statistical analysis of submitted predictions for the Ashigara valley blind prediction test.

Some predictors tried to simulate seismic motion using not only 2D model but also 1D model and they compared with each other. They found that the difference between them is small and attributed these results to the lack of lateral heterogeneity of the site. It is noted that some predicted results based on 1D method as well as the same geotechnical model show the large variation, often reaching to a level of two or three times of the average value. This large variation will remain to be further investigated.

4 NONLINEARITY

The strong motion record at KR1 shows a maximum amplitude of about 100 cm/s^2. Then many predictors took nonlinearity of dynamic soil behavior into account by the true-nonlinear or equivalent-linear method. In fact, a comparison of the observed spectral ratios of KS2/KR1 for strong-motion and for weak-motion exhibited some nonlinear effects(Midorikawa, 1992). As shown in the comparison of spectral ratios between predicted weak motions and strong motions in the statistical analysis report, periods of peaks are longer and their amplifications are smaller for the strong motion than those for the weak motion.

On the other hand, in the spectral ratios of the observed motions, these tendencies do not seem to be clear. One of the reasons for this may be the uncertainty of the rock site motions for the input motions to the sediment sites, as described in the preceding section. It is naturally considered that we could make a more detailed and effective investigation on the nonlinear behavior of soil by the use of a down-hole record just beneath the sediment site as an input motion rather than by the use of a record of a rock site away from the sediment site.

The equivalent linearization technique was extensively employed in the submitted predictions, probably because it is a simple and convenient technique to take the nonlinear effect of soil into account in the analysis. But, it should be noticed that the equivalent linearization technique is an approximate method. So, it is essential to investigate its validity and applicability by comparing its results with analytical results by means of a rigorous method utilizing a nonlinear stress-strain relation directly, and with observed results during strong earthquakes.

5 SOME HURDLES FOR BLIND PREDICTION TEST

Some expert research groups who published numerous papers on evaluating site effects applied for the Ashigara valley blind prediction test and three groups of them adopted one-dimensional wave propagation method. One of them described the reason about that as follows:" After a study of the site topography and geology we realized the problem is fully three-dimensional and the list of assumptions needed to apply some of our tools grew too much so we considered, at the departure that such way was hopeless. Therefore, we decided to do the simplest analysis: One-dimensional wave propagation using the Thomson-Haskell technique."

As one of many predictors, we were puzzled over how our predicted results could be confirmed. When we evaluate seismic motion of subsurface irregular soil media for the first time using a numerical algorithm, we usually try to make our computation results veri-

Table 4. Blind prediction test versus numerical simulation.

	PREDICTION	SIMULATION
MODEL	Real(Complex)	Idealized(Simple)
METHOD	Application-oriented	Theory-oriented
VERIFICATION	Difficult	Easy
EXPENSE	Costly	Within budget
AWARD	?	Original paper
APPLICABILITY	Truly tested	?

fied comparing our results with the exact solutions or some numerical results previously analyzed with different methods. But for the blind prediction test there are not such common bench mark tests as those.

A blind prediction test could be classified as a forward problem, but it seems to be more complicate than an ordinary forward problem as if it were regarded as an inverse problem (Table 4).

6 FUTURE RESEARCH NEEDS

From the panel discussion and written discussion, we can summarize a short list of future research topics for Ashigara valley blind prediction test as follows:

1) Even for the one dimensional prediction results, every predictor provided a different results, often varied to a level of two or three times of the average value. Why there comes the difference?
2) Why there is no difference between 1D and 2D or 3D predicted results, while there exists two or three dimensional effect based on observed data? An accurate determination of the stratigraphy and of the incident signal appears to be by far more important than a sophisticated (2D or 3D) modeling of the Ashigara Valley geological cross-sections (e.g., Faccioli and Paolucci, 1992).
3) It was pointed out that there exists an inevitable variability of ground motion, even on rock sites where effects of soil layers and topography can be neglected, because of the heterogeneity of deep ground, as stated by Toksoz(1992) in his invited lecture of this symposium. What are the key parameters to incorporate in modeling the effects of surface geology on seismic motions?
4) What kind of simulation technique should be developed to be applicable for real media?

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