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Discussion: Site effects experiments (Turkey Flat and Ashigara)

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In the conference registration packets that we all received yesterday afternoon there was a copy of an old 1756 manuscript, together with an English translation, describing the causes of earthquakes. In the introduction to the translation there was a quotation which seems particularly appropriate to the problems we are discussing today. The quotation suggested that in Earthquake Engineering it is possible "to drown in information and to starve for knowledge." Despite the somewhat mixed metaphors the quotation astutely describes the problem we have with the results of the Turkey Flat and Ashigara site effects experiments. We have sets of experimental results from the different participants in abundance but are somewhat at a loss to distill useful information from these results.

The Turkey Flat experiment in California was established following the prediction that there would be a repeat of a magnitude 6 earthquake similar to one which occurred in the same location in 1966. Unfortunately the event did not occur so an experiment was set up using recorded micro-motions instead. The results of the prediction of different motions knowing motions at other locations was not particularly fruitful, perhaps because with such small ground motions minor perturbations in site properties and topography can have a proportionately larger influence. The work done by the California Division of Mines and Geology (CDMG) staff in compiling the submittals did provide a valuable foundation upon which the Ashigara experimental results were able to build. The most apparent conclusion from the Turkey Flat experiment is one of simplicity. A comparison of the transfer function between the motion at the surface of the rock site and the motion at the bottom of the boring shows a constant factor of two for the higher frequency motions, representing wave reflection at the free surface.

The Ashigara experiment was more fortunate by being able to record motions from a larger earthquake soon after its completion. The symposium held during March in Odawara presented the results of all the individual experimenters results together with a statistical summary of the overall results. Detailed examination of specific analysis results and methodologies was not done and future follow up reviews are not intended. Detailed review and analysis of the specific approaches used by different investigators was not attempted at that time and I understand that further studies are not planned. It is recognized that cultural differences are perhaps the primary reason why the detailed review of analyses is not being pursued. This is particularly unfortunate as many of the major advances in individual and group learning come from a review of failed structures, failed experiments and failure tests. Knowing why a particular procedure did not work may often provide more enlightenment than examination of another procedure which gives a closer answer.

Following the receipt of the recorded motions at the base of the deep boring we used these motions and the recommended soil profile to compute the two components of motion at the surface. The spectra of these computed motions are compared with the recorded surface spectra and our predicted spectra on Figure 1. The spectral comparison is an interesting one in that it shows that the original prediction where the rock surface motion was estimated from a site at some distance is at least as good as a computation made with the known rock motion.

Presentation of the results of the experiment were almost exclusively done using logarithmic plots. This was probably done for ease in including wide variations of results. Unfortunately, logarithmic plots also tend to make disparate results look much closer than they actually are. This problem was mentioned in the closing remarks of Dr. Iwan at the Odawara workshop when he noted the order of magnitude difference between the predictions and can be readily demonstrated. If the results shown in Figure 1 are plotted to the scale of an arithmetic spectrum with the ordinate representing the spectral acceleration as Figure 2 the appearance of agreement has disappeared.

Site response analyses and their results, using either one or two dimensional models, are frequently recommended for use in design. The basis for justifying the validity of the analyses comes primarily from sites with distinct simple profiles, usually with a layer of soil much softer than most of the profile. Where the distinction between the properties of different layers is less clear the verification of the analytic method against data is more difficult. The Ashigara experiment has demonstrated this difficulty. This limitation notwithstanding, the one dimensional analysis method is a relatively reliable model for the analysis of most soil deposits under various levels of ground shaking. It is important to note that the characteristics of the input motion are a major factor in any ground response analysis.

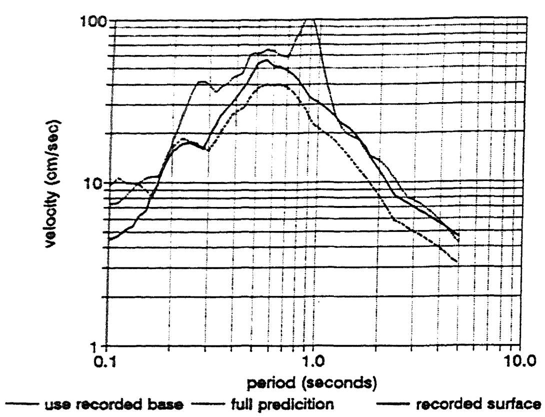

Figure 1a surface spectra (component 0)

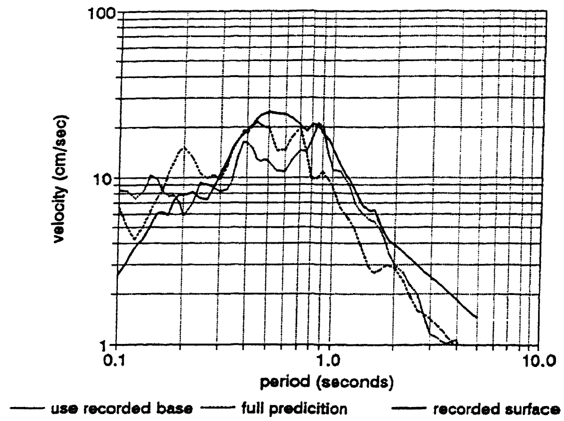

Figure 1b surface spectra (component 90)

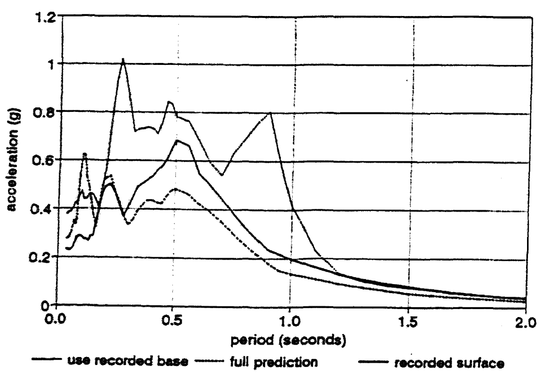

Figure 2a surface spectra (component 0)

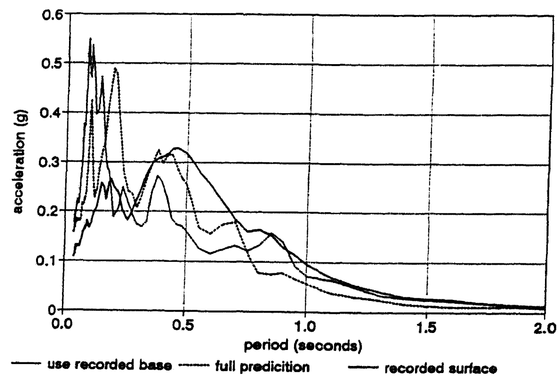

Figure 2b surface spectra (component 90)