

## The Turkey Flat, California site response experiment

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**ABSTRACT:** The Turkey Flat site response experiment was established near Parkfield, California during 1986 in the region of the predicted Parkfield earthquake. The experiment is a unique coupling of an array of specialized instrumentation and thorough geotechnical measurements at the site by several geotechnical groups. Although the Parkfield earthquake that the project is designed for has not occurred yet, important results about the measurement of medium properties and about the response of the site to very weak motion have been obtained.

### INTRODUCTION

Several factors led to the establishment of a site response experiment near Parkfield, California. The experiment is based on the installation of a specialized geotechnical array and on the extensive geotechnical studies at the site. This paper reviews the project in anticipation of the expected strong motion data and highlights the decision process and lessons learned so they may contribute to future instrument arrays and site response experiments.

The Turkey Flat array is instrumented by the California Strong Motion Instrumentation Program (CSMIP) and contains downhole and surface instruments at alluvium and rock sites. Extensive probe measurements of the subsurface properties were performed at the site by several geotechnical groups, coordinated by the California Division of Mines and Geology (Real and Tucker, 1988). These measurements will be used in the prediction of strong motion at the site. Advisory committees have provided critical input through the entire project. Two key aspects in planning the experiment, selecting the site and planning the prediction phase, are reviewed here.

### SITE SELECTION FACTORS

The selection of the site for the Turkey Flat site response array was based on several factors:

#### 1. *Ground motion likelihood*

For the installation of an array to be effective, it is important that there be a reasonably high likelihood of significant ground shaking in the near future. As

an example, an objective could be that there be a probability of 50% or greater that strong motion will occur at the site during the lifetime of the instrumentation. Useful instrument life is hard to estimate, but for planning purposes a lifetime of say, 20 years could be assumed.

Another approach is to consider the length of time until the problem the array is to help solve would be solved without the array. For example, it might be estimated that adequate data would exist within 5 years without this specific array. If an earthquake is unlikely to occur within that time at the site, the array may not be an effective investment. This consideration becomes secondary if the installation can be made somewhat mobile so that the array could be removed and reinstalled at another location, perhaps focused on a different problem.

In the case of the Turkey Flat site, the prediction of an earthquake near Parkfield, California was the key element in the selection of a site in the area. An apparent interevent time of about 22 years led to the prediction by the U.S. Geological Survey of an earthquake that would occur, with high probability, during the late 1980's or early 1990's.

#### 2. *Site geologic conditions*

The near-surface geology is a key factor in considering prospective locations. If the objective of an array is to measure the effects of surface geology, then the geologic conditions play an overriding part in comparing the value of several sites. In this case, geologic conditions are sought which most closely correspond to the specific focus of the experiment. For some experiments, soft sediment and a high water table may be important; for others, stiff sediments underlain by high velocity rock may be

important. In still others, site conditions similar to those in certain urban or industrial environments may be targeted.

If the array is not focused on measuring the effects of surface geology, the site geology is still important, but now it should have a transparent role and not affect the wavefield across the dimensions of the array. The search for specific site conditions must be tempered by the reality that ideal conditions are usually impossible to find. Site selection involves an optimal trade-off among non-ideal conditions.

At the Turkey Flat array, planned to measure the effects of surface geology, a flat-lying site with shallow alluvium over rock was found. A site with less stiff alluvium might have been preferable, but during field searches no other sites were found without other shortcomings.

### 3. Topographic conditions

Like near-surface geology, topography is always a factor in site selection. If an experiment is being planned specifically to measure topographic effects, a location with severe topography of a specific geometry may be sought. At that site, geologic conditions should be as uniform as possible across the site. On the other hand, if the array is being planned to measure site geology effects, then a site with the appropriate subsurface geology but with flat topography would be sought. It must be borne in mind that the subsurface, as well as the surface, topography of a site must be considered.

The Turkey Flat array is an area with relatively flat topography. The rock site at the south edge of the alluvial valley is nearly at the same elevation as stations at the center.

### 4. Location within and complementing existing arrays

Instrumenting to study the effect of local geology or topography usually means that an array is physically small in dimension (order of 1 km or less). This means that regional properties of the wave field will not be discernable by the array. To understand how the records obtained at the site fit into the pattern of ground motion around the earthquake, it is best if the array is within a larger scale network that records the motion outside the boundaries of the array. A common feature in the records from the array may arise from the common nature of the site conditions at the array stations, and not from a source phase or deep path phase.

The Turkey flat array was located within the large Parkfield array (McJunkin and Shakal, 1983) already in place. The 50-stations of that network will make it possible to differentiate local from regional and source effects in the recorded data.

## COMPONENTS OF THE EXPERIMENT

Several key components of a successful experiment on the effects of surface geology were identified and planned before the experiment was underway:

### 1. Ground motion prediction

The overall goal of the experiment is the prediction, using various methods, of the strong motion from a specific future event. With the predictions in hand, they may be compared in standardized ways with one another, and methods (not investigators) yielding unusually low or high values may be compared to the norm. Finally, the predictions can be compared to the actual motion which occurs during the expected earthquake. This experimental plan can be simply stated but involves significant components to be dealt with. Two key elements deal with the geotechnical measurements at the site and the ways the site can be characterized.

### 2. Measurement of medium parameters

Prediction of ground motion at a site is strongly dependent on the parameter values used to characterize the medium. A modelling method may be accurate but yield poor predictions because of inadequate medium parameters. To address this problem, the measurement of medium properties was treated separately in the Turkey Flat experiment. Various geotechnical companies and groups performed measurements at the site that they considered appropriate, and determined seismic velocity profiles and other medium parameters. These estimates were brought together for comparison. The commonalities and differences were studied, and these are summarized in Real and Cramer (1992) and are discussed in a companion report (Stepp, 1992, this volume). An average site characterization was adopted from the estimates, and this was used to standardize the prediction in the section above. Only with use of this common, standard model could modelling differences be isolated. Of course, individual investigators could use models besides the average model in their work, but the common use of the standard model is an important feature.

### 3. Methods of predicting strong ground shaking

A selected standard input can be used to compare predictions of ground shaking using different methods. This can proceed in the absence of the earthquake which is expected but has not yet occurred. In this comparison, the results of 1-D models can be compared to the more complex 2-D or 3-D models. Another experiment that can be

performed is to use measured, though very weak, ground motion data from small earthquakes to compare the predictions. Cramer and Real (1992) and the companion paper by Stepp (1992) discuss the results of such comparisons.

## CONCLUSION

A carefully planned experiment is underway at Turkey Flat, near Parkfield California, in anticipation of a predicted earthquake. The instrumental component of the experiment is comprised of a specialized array with surface and downhole sensors at soil and rock sites. In the absence of strong shaking, comparative studies have been performed with very weak motion measured from small local earthquake. The results of this comparison are discussed by Stepp (1992).

One of the most interesting results of the Turkey Flat experiment so far is the large variation in medium property estimates as determined by different methods and investigators. There are large variations from method to method, but also within methods. The difference in predictions arising from variations in measured properties may be greater than the differences due to modelling methods.

Although the awaited Parkfield earthquake has not occurred, the Turkey Flat site response experiment has already provided several significant results about medium characterization, modelling techniques, and the response to very weak motion.

## ACKNOWLEDGEMENTS

Thorough planning and preparation is an important part of the success of an experiment like this. The contributing investigators are the real key to a prediction experiment, and their work is appreciated and acknowledged. The several committees that have met repeatedly to work out details of approach and procedure are also very important and appreciated. Finally, it is important to acknowledge the cooperation of the local ranch owner and the efforts of the technical staff involved in installing and maintaining instruments and in performing the geophysical and geotechnical measurements.

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