STATISTICAL ANALYSES OF VERTICAL GROUND MOTION CHARACTERISTICS

by

S.D. Werner[I] and H.S. Ts'ao[II]

This paper reports results from an investigation of vertical ground motion characteristics, based on statistical analyses of more than 200 sets of free-field strong-motion records that had been processed at the California Institute of Technology (CIT) over the past several years.[III] These data were divided into several groups for studying effects of such factors as soil conditions, ground motion intensity, and specific earthquake events. For each group, the correlation between horizontal and vertical ground motion was studied and the statistics of the 5% damped vertical response spectrum shapes were compiled. Results from the study[IV] are as follows:

a. Correlations of vertical to horizontal response were carried out based on ratios of peak displacements, peak velocities, peak accelerations, and root-mean-square (rms) accelerations. Of these parameters, the rms acceleration exhibited the smallest, and therefore most favorable, coefficient of variation. The peak acceleration provided the next best correlation, followed by peak velocities and peak displacements.

b. The probability that the ratios of vertical acceleration to horizontal acceleration exceeded 2/3 was 23% when all CIT data were considered. The probability of exceedance was smaller when the records used in the statistical analysis were stronger in intensity (as measured by the peak horizontal acceleration). For records with peak horizontal accelerations greater than 0.2g, the probability of exceedance falls to 10%.

c. Within the frequency range of primary interest for nuclear plant design (1 to 10 Hz), amplitudes of the 5% damped vertical response spectrum shapes developed from this study fell below those from *Regulatory Guide 1.60*[V] by as much as 50 to 100% in some cases.

d. Data derived solely from the 1971 San Fernando earthquake did not, on a statistical basis, depart significantly from the data derived from the entire set of free-field records in the CIT library.

e. Statistical analysis of data classified according to estimated local site conditions indicated that the vertical spectrum shapes from rock outcrop records had amplitudes that fell below those for records from soil sites, at frequencies below about 5 Hz. No clear trends were observed between spectra from various classes of soil sites, possibly owing to a lack of definitive subsurface soils data at many accelerograph stations.

I Principal Engineer, Agbabian Associates, El Segundo, California, U.S.A.

II Member of Technical Staff, Agbabian Associates.

III *Strong Motion Earthquake Accelerograms,* Vols. I-IV, Parts A-Y, CIT Earthq. Eng. Res. Lab., Pasadena, CA, 1969-1975.

IV *An Investigation of Vertical Ground Motion Characteristics for Nuclear Plant Design Purposes,* TOP-AA108, Agbabian Associates, El Segundo, Dec. 1975 (draft).

V U.S. Atomic Energy Commission, "Design Response Spectra for Seismic Design of Nuclear Power Plants," in *Regulatory Guide 1.60,* Rev. 1, Washington, D.C., Dec. 1973.