SEISMIC PROOF TESTS USING EXPLOSIVES TO PRODUCE STRONG GROUND MOTION

G.B. TAYLOR, C.B. SMITH

Applied Nucleonics Company, Inc., Los Angeles, California 90024, U.S.A.

A. KLOPFENSTEIN

Southern California Edison Company, Rosemead, California, U.S.A.

SUMMARY

When performing seismic tests of large structures or equipment, it is often desirable to produce responses in the range of 0.5 to 5 g's in the frequency range of 1 to 30 Hz. For massive structures this can not be done with mechanical vibrators.

For equipment weighing 100 metric tons or less, high level tests can be performed using vibrators or large shake tables. However, such laboratory tests often fail to simulate realistically the soil effects, soil-foundation interaction, and the effects of supports, appurtenances and adjacent equipment. For these reasons it is useful to have a convenient economical method for in-situ testing of large structures.

Recent research we have performed indicates that blast tests using explosive charges buried in the soil can be employed to produce response spectra with a predetermined amplitude and frequency content.

Semi-empirical methods are utilized to formulate ground motion spectra which produce the desired response in the structure. The spectral input is a function of charge distance, depth, soil characteristics, multiple charge time sequencing, and charge size. These parameters can be combined to control the spectrum and amplitude input to the structure, resulting in a controlled "earthquake".

The duration of ground motion can be made arbitrarily long using multiple delayed blasts. In our procedure we attempt to simulate the 5 to 10 seconds of intense shaking present in typical strong motion earthquake time histories. Our research indicates that responses of up to 30 seconds can be achieved if the damping is not too high.

The procedure for performing a test is first to compute response spectra for a site as a function of the charge size, distance, depth, etc. To do this we measure soil parameters such as shear wave velocity and the depth of soil layers. These data along with information concerning the types and placement of explosives are used as inputs for a computer program developed by us. This program, called ANBLAST, computes peak soil responses, frequencies, and determines response spectra for various values of damping.

Several types of instruments were used in the measurement of ground, foundation and instrument motion. These include unbonded strain gage accelerometers, a strong motion seismograph, a passive mechanical peak shock recording device, triaxial borehole seismometers, and geophones to measure seismic velocities in the soil. All the instrument outputs were recorded with a wide-band FM tape recorder. Subsequent Fourier Transform spectra and time response data were obtained from the original tape recordings. The resulting instrument responses agree satisfactorily, showing excellent correlation in measurements made at similar locations using different instruments. In addition, the reduced data and resulting response spectra agree with the expected values obtained from analytical studies.

In conclusion, we feel that tests using strong ground motions produced by explosives allow seismic studies to be made at peak amplitudes and durations approaching those of strong motion earthquakes and open a new dimension in in-situ testing of massive devices and structures.