REMR TECHNICAL NOTE CS-ES-1.2

SONIC PULSE-ECHO SYSTEM FOR DETERMINING LENGTH AND CONDITION OF CONCRETE PILES IN SITU

PURPOSE: To provide information on a pulse-echo system for use in nondestructive testing of concrete piles.

APPLICATION: Performing rapid nondestructive tests of concrete piles in situ. Piles can be tested from the end that is accessible with a minimum of instrumentation.

ADVANTAGES: The test is nondestructive and avoids expensive and time-consuming load tests.

LIMITATIONS: Knowledge of wave propagation theory and experience with the test are necessary for proper interpretation of results. There is a 30:1 upper limit on length-to-diameter ratio of piles which may be tested and a 5:1 lower limit.

AVAILABILITY: The Waterways Experiment Station maintains the capability to perform sonic pulse-echo tests on concrete piles in situ.

COSTS: Costs will be job-specific, depending on such factors as number of piles to.be tested, on-site support furnished to the surveying team, transportation of equipment and personnel, etc.

REFERENCES:

a. Development of procedures for nondestructive testing of concrete structures; feasibility of sonic pulse-echo technique. A. M. Alexander. US Army Engineer Waterways Experiment Station, Vicksburg, MS, Apr 1980. Miscellaneous Paper C-77-11, Report 2. (NTIS No. AD A085 598).

b. State-of-the-art review of acoustic evaluation techniques. T. N. Claytor, W. A. Ellingson, R. Henneke III, H. Berger. Argonne National Laboratory, Argonne, IL, Nov 1983. ANL/FE-82-23.

FIELD PERFORMANCE: The system has been successfully used in a number of applications as described in Ref a.

BACKGROUND: Measurement of the time required for a pulse of sonic energy to pass from one boundary to another and back to the original boundary is used to determine the thickness of concrete with only one accessible surface. The reflection, or echo, from the opposite boundary will occur because of the difference in impedance of the concrete compared with air, water, or soil at the reflecting surface. The impedance of a material is defined as the product of the density and propagation velocity of the disturbance in the material. This reflection technique is referred to as pulse echo.

The pulse-echo technique of measurement uses the accurate time base of an oscilloscope to measure the time required for the echo to return from a boundary to the surface where the energy was introduced by mechanical impact. A sonic pulse travels at the longitudinal wave velocity; for a long, thin member, such as a pile, the velocity is equal to $\sqrt{E/D}$, where E is the modulus of elasticity and D is the mass density.

DESCRIPTION: The components of the sonic pulse-echo system are a digital processing oscilloscope (DPO), hammer, accelerometer, camera, filter, and associated signal-conditioning equipment. In this technique, the longitudinal wave of vibration is excited, and the total mass of the pile is placed in motion at its resonant frequency. The damping of the surrounding soil limits the pile dimensions to a 30:1 length-to-diameter ratio. The waves travel at the bar velocity ($\sqrt{E/p}$) for long thin members. The pile should be at least 5 times longer than its diameter to keep the velocity constant. The wavelength of the input energy must be about 10 times the diameter of the pile to maintain the constant bar velocity.