Lymon C. Reese & Associates

LCR&A Consulting Services – Crosshole Sonic Logging (CSL)

The Crosshole Sonic Logging (CSL) was originally developed by the French National Construction Industry Research Center (CEBTP) during the late 1960's. The method is now widely used to check the integrity of bored piles or drilled shafts.

In order to perform the CSL test, access tubes must be pre-installed prior to the placement of concrete. The access tubes are normally PVC pipes attached to the rebar cage extending to the full depth of the drilled shaft and installed at equal spaces around the diameter of the cage. The CSL test is based on the length of time for an ultrasonic wave to be propagated between any two of the selected tubes. The velocity of the propagated wave depends on the material through which the wave is transmitted. The "standard" velocity is observed if sound concrete exists between the two tubes and the velocity is changed if a void or defective concrete exists between the two tubes that were selected. By performing tests using pairs of tubes the quality of concrete between the tubes can be surveyed around the entire shaft from top to bottom.

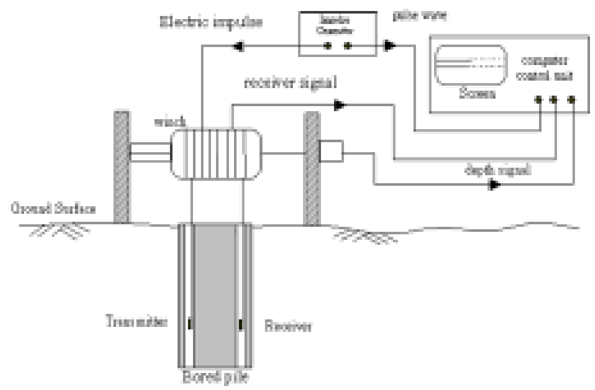

Fig. 1 Diagram of Crosshole Sonic Logging Method

As shown in Fig. 1, the transmitter probe is lowered into one of the tubes while the receiver probe is lowered by the same distance in the second tube. Both probes are simultaneously lowered into the bottom of the tubes at the beginning of each test. The tubes are completely filled with water to act as an acoustic-coupling agent between the probe and the tube wall. The transmitter probe sends out an acoustic pulse at 10 times per second. As the testing begins, the two probes are raised in unison by use of a calibrated winch, which measures the depth of the probes within the tubes. The signals from the receiver probe and which are processed while the probes are being raised. The resulting sonic profiles of the transmission characteristics, as a function of depth, are then displayed in the computer screen. The data on the profiles that are developed are stored in computer memory and a backup diskette.

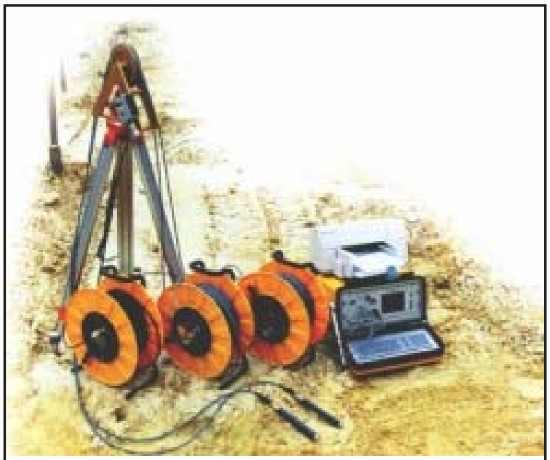

Fig. 2 Crosshole Sonic Logging CS 97 Apparatus

The resulting profiles should show consistent transmission time and signal amplitude with depth. If a material with a much lower modulus than normal concrete is placed between the straight lines of the probes, the acoustic signal will be diffracted and transmission time will be greater resulting in a distortion in the plot shown in the computer screen. The transmission time increases with increases in length of the acoustic path or with lower wave speed of material between the tubes, resulting in a decrease in amplitude of the signal reaching the receiver. An abnormal signal is called generically as a transmission anomaly, and reflects a defect in the concrete of the drilled shaft.

The propagation velocity of a sonic wave through concrete depends on the Young's modulus and the density of concrete; thus, the velocity is a measure of the quality of concrete in a drilled shaft. A suggested rating for the quality of concrete based on the velocity of a compression wave (which may be termed P-wave) is provided in Table 1 (Malhotra, 1976). The rating scale shown in Table 1 is based on ultrasonic pulse tests that were used to measure the velocity of P-waves through concrete. The velocity of the propagation of waves in a rod, assuming the wavelength is greater than the diameter of the rod, differs from the velocity of propagation of waves in a continuous medium of an identical material. The reduction is approximately ten percent for a Poisson's ratio of 0.25 (Harrell and Stokoe, 1984). Therefore, velocities reduced by 10% are also listed in the second column of Table 1 so that they can be compared with wave velocities determined by the CSL-test method.

Fig. 3 CSL Testing performed in the field

TEST EQUIPMENT

The typical CSL-test equipment includes the following items:

1) Portable computer with a signal amplifier.
2) Probes: one transmitter probe and one receiver probe.
3) Winch: used to measure the depth of the probes.
4) Signal cables: used to carry signal from the probes.

Table 1 Suggested Compression wave velocity rating for concrete from ultrasonic test (from Malhotra, 1976, Harrell and Stokoe, 1984)

Compression wave velocity, m/sec (by Malhotra)	Compression wave velocity in a rod, m/sec (by Harrell and Stokoe)	General conditions
> 4570	> 4120	Excellent
3660 ~ 4570	3300 ~ 4120	Good
3050 ~ 3660	2750 ~ 3300	Questionable
2130 ~ 3050	1920 ~ 2750	Poor
< 2130	< 1920	Very Poor

(1 m/sec = 3.28 ft/sec)

SAMPLE OUTPUT

Samples of time history of wave transmission through concrete are shown in Fig. 5. The propagation velocity of compressive wave in a normal drilled shaft generated during the CSL test is shown in Fig. 6.

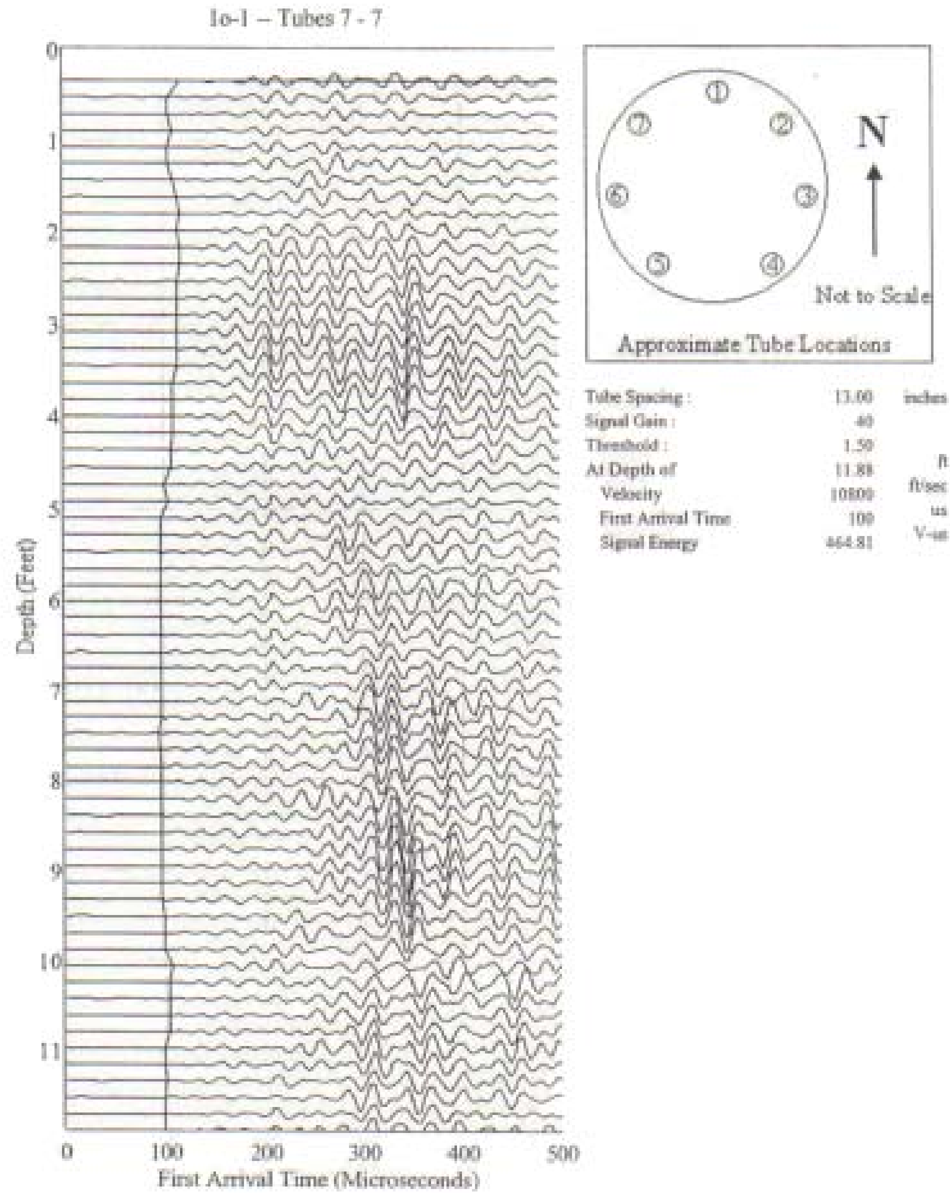

Fig. 5 Wave propagation records

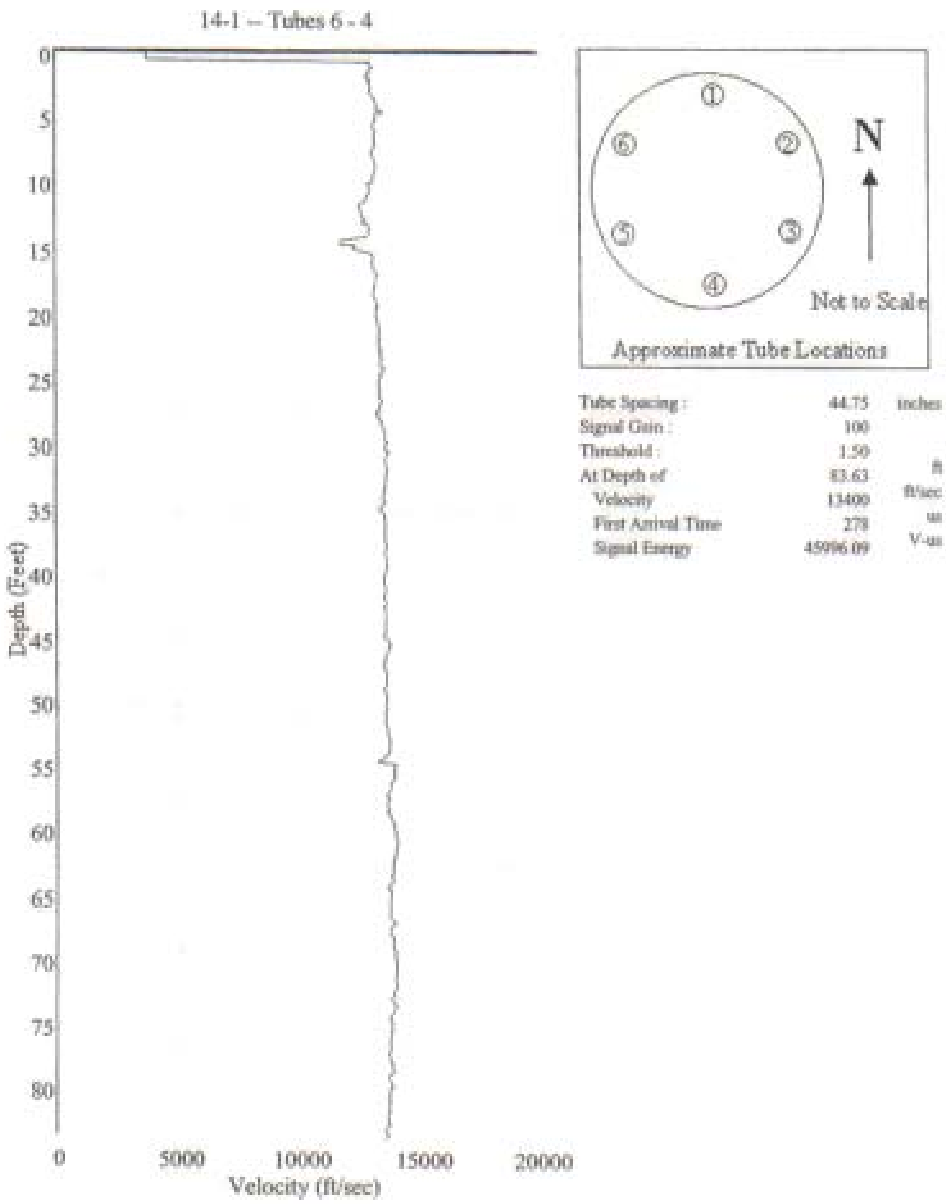

Fig. 6 Compressive wave velocity in a normal drilled shaft