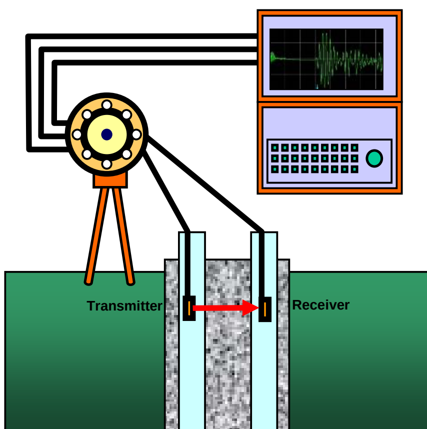
FOUNDATION TESTING DATA SHEET 2
Sonic Logging

TESTCONSULT
TESTING AND CONSULTING SERVICES

In homogenous concrete, free of defects and variations in quality, the velocity ultrasonic waves is constant and in the order of 4000 m/sec. Concrete containing soil inclusions, gravel, bentonite or honeycombing etc., has a much lower propagation velocity so that the presence of these irregularities is immediately obvious. Sonic Coring is based on measuring the propagation time of an ultrasonic sonic signal between two vertical tubes cast into the pile during construction These tubes are filled with water to act as a coupling medium.

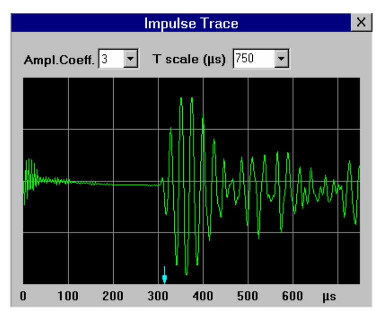
The test is by no means new, and was developed in the 1960 by the French. However, since then there have been many improvements to both the hardware and software, the main ones being the rapid digitisation of signals and digital storage of all data. More recently 2-dimensional and 3-dimensional tomographic software has been developed to give a quick visualisation of areas with anomalies.

Methodology



Testconsult uses the very latest sonic logging equipment – the SC-XT2000, developed by Testconsult Equipment. The system comprises a rugged site computer with a data acquisition module built in, an electronic, hand operated winch, which can control the whole system remotely, and piezo electric emitter and receiver probes on cables. A general arrangement is shown alongside.

To carry out a test, the probes are first lowered to the toe of the pile in adjacent tubes. Cables are then raised using the electronic logging winch. As the winch wheel turns, the emitter sends an ultra-sonic signal every 20mm of vertical movement, which travels between transducers in adjacent tubes. The signal, which is about 50 – 60KHz, is captured and stored as a time/amplitude trace every 2cm of the pile length. Thus for a 20m pile there would be over 1000 measurements.



Each trace will consist of a time lag followed by the received signal, the time lag representing the time taken for the signal to travel from the emitter to the receiver through the concrete between tubes, being dependent on the path length and the concrete property between the tubes.

Each signal is modulated to a series of black-and-white lines, to build up a waterfall plot or sonic profile of the pile over depth for each profile measured. Any defects show up as an increase in signal transit time, between the affected tubes. The operator can choose to display the first arrival time (FAT) and signal energy simultaneously if needed.

Testconsult Ltd
Ruby House, 40a Hardwick Grange
Warrington WA1 4RF
Tel: +44 1925 286880 Fax: +44 1925 286881
Email: iwan@testconsult.co.uk
Web Site: www.testconsult.co.uk

Testconsult Ireland Ltd
Materials Laboratory, Clonminam Ind Est
Portlaoise, Co Laois, Ireland
Tel: +353 502 64885 Fax: +353 502 64380
Email: tom@testconsult.ie
Web Site: www.testconsult.co.uk

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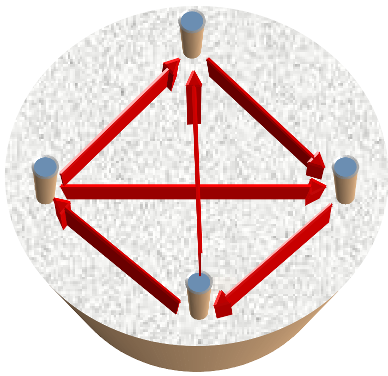
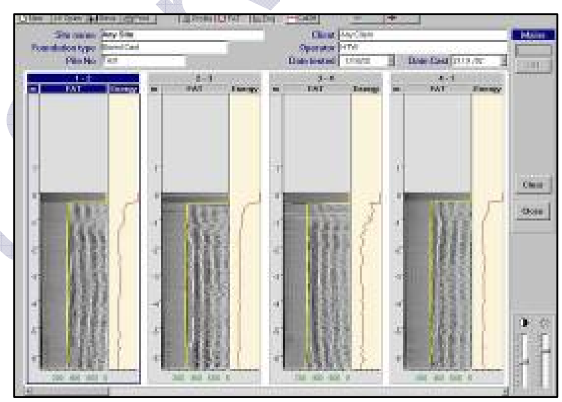


The number of tubes required is typically four for piles between 700 – 1200mm diameter. This enables six profiles to be taken, including two across the core of the pile. In smaller diameter piles however, the number of tubes is restricted and may be only allow three tubes to be used. It should be noted in this case that information about the core of the pile is limited.

The sonic coring test and it's theory is described comprehensively in CIRIA , Report 144, "Integrity Testing in Piling Practice" dated 1997. (ISBN 0 86017 4735).

Interpretation And Reporting



A knowledge of some concrete properties and simple formula are useful for both the testing engineer and the engineer who commissioned the test to understand the interpretation of test results.

The first arrival time can be used to determine the ultrasonic pulse velocity (V), if the distance between tubes is measured. V is related to concrete properties using the following formula

$$V^2 = E/p \quad (1 - \mu)/(1 + \mu)x(1 - 2\mu)$$

Where E is dynamic modulus of concrete, p is density of concrete and μ is poissons ratio.

C is the Longitudinal Wave velocity in the pile. The normal value for concrete is 4000 m/sec but will vary depending on the type of aggregate, amount of cement, density and other factors. Grout may be as low as 3200 m/sec and very high strength precast concrete can be up to 4500 m/sec.

$$C^2 = E/\rho$$

V is the Confined Ultrasonic pulse velocity. This is different to the longitudinal wave speed and depends on Poissons ratio as follows:

$$V^2 = E/\rho\ (1-\mu)/(1+\mu)\ (1-2\mu)$$

This value is higher than the C value by a factor of about 1.08

ρ Density of Concrete - Normal value would be about 2400 Kg/m3. Poor concrete would be 2300 Kg/m3 and badly voided or honeycombed concrete could be less than 2000 Kg/m3. The density of steel is 7800 Kg/m3 and does not vary significantly

E The dynamic modulus of concrete and varies from about 28 – 40 GPa.

μ Poissons ratio . This varies from about 0.16 – 0.25.

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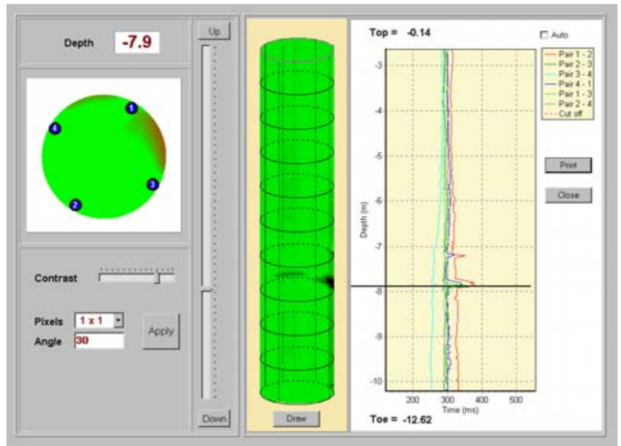
It is not generally advisable to use the first arrival time to try and calculate the wave speed in the concrete. Firstly, the signal is influenced by the access tube, the water and the interfaces between them. It is also rare that the exact spacing between the tubes (except at the very top of the pile) is known.

Testconsult has over 25 years experience with sonic logging and was the first company in the UK to utilise this method. We use the latest SC-XT2000 sonic logging system, which can view and store each individual impulse signal, display a waterfall plot, calculate and display first arrival time (FAT), calculate percentage increases in FAT and percentage relative change in signal energy. The software used can also produce Waterfall Plots. Pile cut-off level can also be marked on the plot to if it is known.



2D & 3DTomography : At discrete depths the software can view a 2D tomographic image through the pile section. In addition these can be combined to produce a full 3D tomographic image to highlight the vertical and horizontal extension of any anomalies.

References:

1997. Integrity testing in piling practice. CIRIA Report 144

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