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TESTING EXISTING PILE FOUNDATIONS

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When old foundations are incorporated into new construction, a reanalysis of their strength is usually undertaken. Such analyses of existing structures may be for expansion, rehabilitation, seismic retrofit, or simply reuse of an existing foundation. Also, when bridges are to be recertified, foundations often have to be investigated for their ability to withstand the effects of scour.

In many cases, available as-built information is incomplete, unreliable, or unsatisfactory for reanalysis of new design requirements. In particular, details about pile lengths and pile installation may be unavailable. In other cases, the original structure or foundation may be damaged from impact, storm loading, decay or scour, and the integrity of the piles must be investigated. Dynamic testing and analyses with wave propagation methods may provide the information needed for the reexamination of pile foundations. Two dynamic methods, *high strain* and *low strain* tests, are available.

High Strain Testing

This approach requires restriking the pile with a pile driving hammer and measuring the response of the piles using a **Pile Driving Analyzer® (PDA)**. The method is particularly effective when it is possible to isolate the test pile(s) such that a ram impact induced pile set will not cause damage to the structure. The advantage of the *high strain* test over the low strain method is that it will not only provide answers as to pile length and pile integrity, but also pile bearing capacity. Furthermore, this method is usually not limited by pile length or high soil resistance as long as sufficient ram energy is provided. It is, however, less likely than the low strain method to find small cracks in the piles.

Low Strain Testing

Also called Sonic Pulse-Echo Test, this method is more common than high strain testing for existing foundations. The method is made very simple by the **Pile Integrity Tester™ (PIT)**, yet it provides information on length and integrity of timber, concrete piles, concrete shafts and concrete-filled pipe piles. In PIT, a hand held hammer generates an axial strain wave in the pile, and reflected waves are measured providing information about pile integrity and pile length.

PIT Test on an existing bridge foundation; photograph by Mohamad Hussein, GRL Florida

The simplest configuration for a PIT test involves both hammer impact and accelerometer measurement on the pile top surface. For existing structures it is often impossible or impractical to test on the pile top. Then, accelerometers may be attached to the side of the pile while the PIT hammer impacts the pile cap or other structural element, above the piles.

For an accurate calculation of pile length from PIT data, one must know or estimate the sonic wave speed in the pile. The wave speed may be estimated from experience with similar materials. For more accuracy, it is often possible to obtain site specific wave speed data and thus increase confidence in PIT results. For example, when piles extend significantly above the ground or water, then analysis of data from two measurement points separated by an axial distance of 5 to 10 ft will yield wave speed data. Also, known lengths of a few PIT test piles will allow for an accurate back-calculation of the wave speed.

It's the 10th ANNIVERSARY of the
GRL Newsletter
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BEST WISHES

for the holiday season and thanks to our clients, friends and readers for your continued interest in our work. As we in Cleveland prepare for another brutal Ohio winter, ***you*** *will hopefully enjoy peace, warmth, shelter, food, drink and merriment in good company during this time and in the year to come.*

Several factors influence the effectiveness of a PIT length and integrity evaluation. Good access to the pile, sound concrete or timber near the measurement location(s), and good transmission of energy from the impact surface to the pile are desirable. Multiple or complex interfaces or structural elements below the impact or measurement are undesirable. Energy losses due to high shaft friction reduce the strength of reflections and make analyses more difficult. Thus, in many cases, the length that can be effectively tested is limited to about 40 times the pile diameter. While length determination is simple in many instances, for complex cases (long piles, variable cross section), PIT data should be complimented by other supporting data and should not be the sole basis for pile evaluation.

The constraints and details of individual cases often require adaptation of the PIT method to make optimum use of the available information and measurement opportunities. For example, during pouring rains causing a flood which inundated a bridge in the State of Washington, successful PIT tests of bridge piles were made using impact and acceleration measurements on the concrete road deck because it was feared that scour would wash out the pile foundation. Both pile length and approximate embedment depth were assessed. After the water receded, the piles were accessed from a small boat, and measurements were made with accelerometers on the pile and hammer impact on the road surface. This second test series provided wave speed data to refine the initial PIT pile length estimates.

As engineers seek to extend the life and performance of existing bridges and other structures, both PIT and PDA tests will provide valuable data at a modest cost. PIT, though limited in scope, has the advantage of quick and low-cost execution and can be applied to any installed pile with only minimal preparation.