DID YOU KNOW:
THERE ARE PILE DRIVING ANALYZERS IN CURRENT USE IN MORE THAN 40 COUNTRIES THROUGHOUT THE WORLD?

Pile Dynamics, Inc.

GRL engineers, inc. Dynamic Measurements and Analyses

Testing Self-Consolidating Concrete

E. Attiogbe[1] and F. Rausche[2]

Drilled shafts are massive concrete structures often designed with reinforcement cages consisting of densely spaced steel bars. Commonly performed integrity tests of drilled shafts have shown that the high concentration of reinforcement bars may hamper concrete flow, which can be detrimental to drilled shaft quality. Self-Consolidating Concrete (SCC) has superior flow properties that reduce the possibility of voids, incomplete concrete cover around the reinforcing bars and other potential drilled shaft defects.

Two extensive tests series were jointly conducted by Degussa Admixtures (formerly Master Builders), Inc. and GRL Engineers, Inc. The experiments aimed to demonstrate the attractive flow properties of SCC and how the resulting concrete quality can be verified with the commonly employed Cross-hole Sonic Logging (CSL) and Low Strain integrity testing methods for drilled shafts. The experiments further intended to verify if integrity testing could take place sooner on SCC shafts than when conventional concrete is used. The integrity tests were performed with the Cross Hole Analyzer (CHA) and Pile Integrity Tester (PIT), both manufactured by Pile Dynamics, Inc.

Twenty-four concrete specimens composed of twelve concrete mixtures were prepared. The specimens were large enough to simulate drilled shafts under field conditions. In preparation for Cross Hole Sonic Logging, two tubes, 940 mm long with 50 mm outer diameter and 5 mm wall thickness, were placed in each specimen form at approximately 70 mm from the edges of the form prior to casting. The concrete mixtures included conventional concrete, SCC with a polycarboxylate-based high-range water-reducing (HRWR) admixture to achieve high slump flows of up to 700 mm, and a mix with a viscosity-modifying admixture to stabilize the high slump flow. A hydration control admixture was added to two of the mixtures to purposefully retard setting for approximately two hours. To further evaluate the effectiveness of using standard integrity testing methods on shafts where SCC is used, two of the mixtures were purposely segregated by using a dosage level of HRWR admixture higher than the manufacturer's maximum recommended dosage. Low slump concrete specimens were also included in the study for comparison with the SCC specimens.

The concrete strength, static elastic modulus and wave speed of each mixture were measured, the latter with the CHA and/or PIT, at various times during hydration, starting after a few hours. This yielded correlations between strength, static and dynamic elastic moduli and sonic wave speed, all as a function of time.

The study showed that conventional concrete would not flow satisfactorily through the gap between the inspection tubes and the form (see photo) whereas high-slump flow SCC flowed well and produced specimens with very good surface finish. This is an indication that similar flow behavior would occur in the field around the reinforcement cage, and could therefore contribute to the quality of drilled shafts. In addition, it was found that commonly used integrity tests such as the ones performed with the CHA and the PIT are as suitable for SCC testing as they are for more conventional mixtures. In fact, the experiment indicated that it should be possible to perform meaningful quality assurance tests on SCC shafts as early as 24 hours after concrete placement.

Eric Mack (left), Cleveland State University and Brent Robinson, formerly a GRL engineer who is currently at North Carolina State University, conducting CHA testing on a specimen of conventional concrete.

The next step in the implementation of SCC to drilled shafts would be to perform actual field comparisons between conventional and SCC mixtures placed in shafts with demanding properties (e.g., high degree of reinforcement) and partially excavating the shafts to demonstrate the difference in quality. Continued use of Cross-hole Sonic Logging and Low Strain integrity testing would ensure that severe integrity problems are avoided in the application of the different types of concrete mixtures.

The researchers will present their findings this year at various conferences. Please contact either of the two authors for further information.

[1] Director, Technical Services, Degussa Admixtures, Inc., 23700 Chagrin Blvd., Cleveland, OH 44122, USA

[2] President, GRL Engineers, Inc., 4535 Renaissance Parkway, Cleveland, OH 44128, USA