Ensuring continuous auger quality

Quality assurance for continuous flight auger/ augered cast-in-place piles, by Gina Beim and George Piscsalko of Pile Dynamics

AUGERED cast-in-place (ACIP) piles (similar to continuous flight auger, or CFA, piles in some parts of the world) get their name from the type of auger used in their installation. The installation consists of drilling a hole into the soil with a continuous flight hollow auger. As the auger is extracted, cement grout (or concrete, in the case of CFA piles in Europe and Australia) is pumped into the hole under pressure through the hollow stem.

Ideally, the volume of grout pumped into the hole is at least equal to the volume of the auger. Reinforcement may be installed when the grout is still fluid. This type of foundation tends to be slender and is generally a competitively priced foundation solution, provided the soil conditions are adequate for its use.

Until recently, the observation and control methods that were used historically for this type of foundation consisted of the crane operator controlling the rate of auger withdrawal while another person counted the strokes of the pump that injected the grout into the hollow stem.

Although it is possible to estimate volume by counting pump strokes and using an assumed volume-per-pump stroke, this volume determination is generally inaccurate due to inconsistencies of the pump and inaccurate calibrations of pump-stroke volume. The co-ordination between the two individuals involved in this operation compounds the problem.

In recognition of the need for increased quality control of this type of foundation, the US Federal Highway Administration (FHWA) published Geotechnical Engineering Circular (GEC) #8 – 'Design and Construction of Continuous Flight Auger Pile Foundations' – in 2007. GEC 8 places certain requirements on rigs and equipment, and makes several recommendations related to the type of soil and phenomena such as soil mining and subsidence. It also has recommendations for drilling-penetration rates, rotation of the auger during grouting, control of the operation during grouting and after grout return is observed, and specific procedures to be followed if a problem develops during installation.

Dynamic load testing at the Brian Lara stadium, Trinidad

GEC 8 recommends that state agencies include the use of automated monitoring equipment as a contract requirement. As a minimum, the automated monitoring equipment should monitor and record the auger-tip depth (measured with a position sensor), incremental grout or concrete-volume (measured with an in-line magnetic-flow meter), delivered grout pressure (from an in-line pressure sensor), auger rotation from a sensor mounted on the gearbox, and the auger withdrawal rate.

GEC 8 recommends developing a pre-production testing plan that includes pre-production static-load tests, production static and/or dynamic load tests, and post-installation integrity tests in sufficient quantities to demonstrate that the installed piles meet the intended performance requirements. The contractor must then install production piles in the same manner and to the same standards as the test piles to ensure production piles will perform as well as the test pile. The automated monitoring equipment documents that each production pile is installed with the same care and volume as the test pile.

Various instruments are available to perform the automated monitoring, pre-production load-testing plans, and post-installation integrity tests mentioned in the FHWA document. Pile Dynamics Inc, based in Cleveland, Ohio, for example, offers automated monitoring equipment (Pile Installation Recorder, or PIR), the Pile Driving Analyzer and Case Pile Wave Analysis Program (CAPWAP) to perform dynamic load tests on CFA/ACIP, according to ASTM D4945.

Pile Dynamics also has two instruments for integrity testing: the cross-hole analyser Champ for single-hole sonic logging, according to ASTM D6066, and the Pile Integrity Tester for pulse echo tests, according to ASTM D5882. Tests on production piling verify design parameters, reduce uncertainties and increase reliability.

Automated monitoring, dynamic load tests and post-production integrity tests have been part of the practice in many projects around the world, even before publication of the FHWA recommendations.

The Brian Lara Cricket Academy in Trinidad was built to be practice grounds for the World Cricket Tournament in March 2007. It is among the largest cricket stadiums in the Caribbean, and rests on 1,200 ACIP piles with diameters of 457mm and 610mm, and depths up to 20m.

Simone Jardine of foundation contractor Gordon Winter Co Ltd explains that ACIP piles were chosen due to the extremely hard, consolidated clay on site. All piles were monitored with the PIR, which, according to Mr Jardine, "proved to be an invaluable tool, particularly with respect to quality-control auditing and technical reviews, which, by extension, saved quality-control personnel on-site. It was 100% reliable to the point where the torque per second was used as an indicative guide to clay hardness."

Static and dynamic load tests (the latter with the Pile Driving Analyzer) were performed. The dynamic tests showed very good agreement with the static tests and helped to reduce pile lengths.

Pile Installation Recorder

The expansion of the Los Angeles County Museum of Art in California was designed by renowned Italian architect Renzo Piano. Construction at this site continued without interruption, despite the ongoing discovery of ancient fossils on site. The museum rests on the LeBrea deposit, which is composed of tar (or asphalt) so sticky that it has been entrapping thousands of animals and plants since the Ice Age. Fossils found during construction include sabre-toothed tigers, turtles and falcons, all dating from the last Ice Age.

The foundation for the museum expansion consists of 125 ACIP piles with diameters of 610mm and lengths up to 18m. "The project could not have been done without the PIR," says Jason Weinstein, vice-president of Shoring Engineers, which installed the piles. "It took away the guesswork as there was no way to go by feel," he adds, due to the challenging soil conditions – a unique mixture of clay and tar sands. The integrity of the piles was later verified with the Pile Integrity Tester.

Use of automated monitoring equipment during CFA pile installation, along with integrity testing and dynamic load testing after installation, should provide sufficient quality control to allow the use of CFA piles not only on highways but on many other projects.

LA County Museum of Art