Quality Assurance for Continuous Flight Auger / Augered Cast-In-Place Piles*

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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) under pressure is pumped into the hole 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 if soil conditions are adequate for their use.

Until recently, the observation and control methods historically used 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 coordination 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 United States' 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 types of soil and phenomena such as soil mining and subsidence. It also has recommendation 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.

GEC8 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 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 auger withdrawal rate.

GEC 8 also recommends developing a pre-production testing plan including 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 insure production piles will also 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 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, has in its line of products an Automated Monitoring Equipment (PIR), the Pile Driving Analyzer® + CAPWAP® system to perform dynamic load tests on CFA/ACIP according to ASTM D4945, and two instruments for integrity testing: CHAMP for single hole sonic logging according to ASTM D6066 and 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 the publication of the recommendations of the Federal Highway Administration.

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 1200 ACIP piles with diameter 457 mm and 610 mm, with depths up to 20 m. Simone Jardine of foundation contractor Gordon Winter CO Ltd, explained that ACIP piles were chosen due to the extremely hard consolidated clay on site. All piles were monitored with the PIR, that, according to Jardine, "proved to be an invaluable tool; particularly with respect to QC auditing and technical reviews, which, by extension, saved QC personnel onsite. 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 reduce pile lengths.

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, composed of tar (or asphalt) so sticky that it has been entrapping thousands of animals and plants since the Ice Age. Fossils found in during construction included saber tooth tigers, turtles, and falcons all dating to the last Ice Age. The foundation for the museum expansion consists of 125 ACIP piles with diameter 610 mm, with lengths up to 18 m. "The project could not have been done without the (automated monitoring equipment) PIR", said Jason Weinstein P.E., Vice President of Shoring Engineers, who installed the piles. "It took away the guess work as there was no way to go by feel" 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.

The 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 highway but on many other projects. ■

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تعود تسمية الركائز المحفورة في مكانها (ACIP) إلى نوع الثقب المستخدم في تجهيزها. ويتألّف التجهيز بثقب حفرة في الأرض بجهاز حفر مجوّف دائم الطيران. وعند إستخراج الجهاز، يضخّ ملاط الإسمنت (أو الخرسانة في أوروبا وأستراليا) تحت الضغط إلى الحفرة عبر عنق الحفرة الجوفاء. مثاليّاً، يعادل حجم الملاط المضخّ إلى الحفرة، على الأقلّ، حجم المثقب. ويمكن تجهيز التقوية عندما يكون الملاط بشكله السائل. ويكون هذا النوع من الأساسات عادة نحيلاً، وهو يعتبر، بشكل عام، حلّ ذو سعر تنافسيّ في حال توفّرت الشروط المناسبة للأرض لاستخدامه. تقدّم هذه المقالة، الحلّ الأنسب والأكثر دقّة في عملية التأكّد من النوعية لهكذا نوع من الركائز الذي يتمثّل باستخدام معدّات المراقبة المأتمتة خلال تجهيز الركائز بالتلازم مع اعتماد اختباريّ السلامة والحمل الديناميّ بعد التجهيز.

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