LESSONS LEARNED:

GEOTECHNICAL ENGINEERING

OBSERVATIONS AND LESSONS FROM THE SCHOOL OF EXPERIENCE

AUGERED CAST-IN-PLACE PILES

Augered cast-in-place piles, ACIP for short, (also known as CFA – continuous flight auger piles) are installed by drilling with a hollow-stem auger to a bearing stratum or design depth and pumping a concrete slurry under pressure through the hollow stem while slowly withdrawing the auger.

Typical augercast pile diameters are 12-inch, 14-inch, and 16-inch. Eighteen-inch-diameter piles are also feasible, but are less common. Some contractors have the capability to install larger piles up to 24 inches in diameter. In compression, augercast pile capacities typically range between 30 and 100 tons, depending on subsurface soil support conditions. However, higher capacities on the order of 150 tons are achievable with proper design. An augercast pile may be designed to function as an end-bearing pile (obtaining most of the load bearing capacity from the tip of the pile), a friction pile (obtaining most of the load bearing capacity through friction between the perimeter of the pile and the soil), or a combination of end-bearing and friction.

Reinforcing steel bars (rebars) are typically installed in the pile to provide resistance to lateral loads on the pile. The rebars typically are in the form of a cage with a diameter about 4 inches smaller than the pile diameter. The cage consists of strands of rebars with spiral ties. The geotechnical report will usually provide recommendations for the length of rebar to provide adequate resistance to lateral loads. In addition, piles that will be subjected to uplift forces typically have a single rebar extending the full length (depth) of the pile. A single bar the full lengths of the pile also provides a check on the continuity of the pile. This single large diameter rebar is typically installed separately from the rebar cage.

The following are some advantages of augercast piles:

- Economical compared to some driven piles
- Minimal vibration lessening the potential for damage to adjacent structures
- High skin friction capability due to augered pile surface
- Lengths can be adjusted easily without splicing or waste
- Can be installed in low headroom situations if necessary.
- Installation can be monitored by driller from crane cab with Automated Monitoring Equipment
- Displacement augercast piles produce no spoils for disposal
- Speedier installation than drilled piers or some driven piles

The following are some disadvantages of augercast piles:

- May be difficult to install in areas of thick peat because of the tendency of the grout to expand into the very soft peat
- Blow count-driving records not obtained to verify capacity of pile or soil stratum as with driven pile
- Quality of pile highly dependent on contractor workmanship
- Construction monitoring critical for verification of pile quality
- Can be a messy operation
- Cuttings brought to the surface may be contaminated
- Difficult to achieve batter piles
- May not penetrate certain hard strata

Design of Augercast Piles

A sufficient number of borings is necessary to determine depth of bearing strata for either friction or end bearing piles. Soil borings and proper analysis are up front project costs, but a thorough evaluation will result in a more economical design, particularly if the depth to the bearing strata varies across a site, which can be easily accommodated in the production pile phase.

Unlike driven piles where the energy required to drive the pile can be used to calculate the capacity of the pile, augercast piles provide no "feedback" during installation as to capacity. On larger projects or with higher capacities, load tests should be performed that will allow for a less conservative and more economical pile design. Often, the cost savings from the refined pile design can more than pay for the load test.

Monitoring the Installation of Augercast Piles

During installation of augercast piles, it is critical that qualified personnel verify that a continuous column of grout is maintained as the auger is withdrawn so that the pile will perform as designed. If, for example, the column of grout pinches out (i.e., the diameter decreases) at a certain depth, the capacity of the pile could be reduced and the pile may not provide the design capacity, resulting in the need for non-destructive testing.

Quality control (QC) is critical such that qualified personnel should observe the complete installation process and should understand the pile depth criteria (i.e. to a specified tip elevation, to a constant depth, or a penetration criterion such as feet into the bearing stratum). The QC representative should record and observe the following information (at a minimum) during the installation of each pile, or in accordance with the current guidelines of the Deep Foundation Institute (DFI). The drill rig should be equipped with Automated Monitoring Equipment, such as a Pile Installation Recorder (PIR).

1. Pile depth and/or penetration into bearing material, if the depth is determined based on penetration of a specified distance into a bearing stratum.
2. Auger spoils which indicate the type of soil being drilled while grout is being pumped and the auger withdrawn.
3. Grout pressure during the grouting portion of the installation, including uniform auger withdrawal rate (typically 4 to 8 feet per minute).
4. Grout head. The grout head refers to the length of auger still in the ground when grout appears at the ground surface outside the auger. In general, a grout head of at least 7 to 8 feet, or about 12 to 15 percent of the length of pile, whichever is greater, is satisfactory.
5. Volume of grout used for each pile and comparison of this volume with the theoretical volume of the pile (at least 115% is acceptable).
6. Installation of the rebar to see that it is placed in the hole without encountering an obstruction or hitting the side of the hole.
7. Previously cast piles should be checked to see that the grout level is maintained. In general, a minimum spacing of 5 to 8 pile diameters should be used when installing a pile near previously installed piles to minimize disturbance of the recently installed grout (less than 24 hours old).

Problems during Pile Installation

Common problems to watch out for when monitoring augercast piles include the following.

1. Installing piles through peat or very loose sandy soils beneath the water table. Peat can present problems because it is so soft that it allows the grout to form a large bulb, particularly if the auger is withdrawn too slowly. Therefore, the operator has to make sure that a continuous column of grout is being cast without a huge bulb developing in the peat or loose layer. The bulb may result in high downdrag forces on the pile.
2. The auger operator withdraws the auger in a non-uniform manner, pulling the auger very fast over a certain interval, then stopping, or going very slowly over a certain interval while still pumping grout.
3. The grouting process is interrupted during installation for some reason (ran out of grout and next truck is not on site yet, hose or pump broke, or a plug occurs in the supply lines or augers).
4. The rebar cage gets stuck in the hole above the intended elevation.
5. Lateral movement of the augers near the ground surface.
6. If there are questions about the installation of any pile, a Pile Integrity Test (PITWAP) can be performed to evaluate the quality of the pile.

We hope this *Lessons Learned* will be beneficial to you in the planning of your next project.

Respectfully,
ECS Corporate Services, LLC