A Primer on Augercast Piles

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In many parts of the country, augercast piles have become a popular choice where deep foundation solutions are required. This popularity is owed to their relative cost, quick installation time, and versatility over a wide range of soil conditions when compared to other deep foundation alternatives.

What are they?

Augercast piles are typically 12 to 24 inches in diameter, but diameters of 36 inches have been used successfully. Grout strengths usually range from 3,000 to 5,000 psi, and contain up to 12 sacks of cement per cubic yard. Similar to conventional drilled shafts, augercast piles can derive resistance from both side friction and end bearing. Allowable vertical axial load capacities typically range from about 40 to 150 tons, depending on the pile size and soil conditions.

How are they built?

Augercast piles are constructed using a continuous flight hollow stem auger that is powered by a drill motor. The auger and drill motor (leads) are usually suspended by crane, as shown on *Figure 1*.

The piles are installed by drilling the auger to a prescribed depth or until bearing is achieved. Grout is then pumped under pressure down the hollow stem of the auger flight through a hole at the base. To help this hole from becoming plugged by drill spoils, a sacrificial plug is inserted at the base of the auger before drilling and is blown out when the grout pumping begins.

As the grout is pumped, the auger is withdrawn (while spinning) at a slow rate, leaving a continuous column of grout. About 5 to 15 feet of grout head should be maintained above the base of the auger while the auger is extracted so that the grout has a displacing action, forcing the loose drill spoils to the surface of the hole where they are removed from the flights of the auger by laborers. The spoils are usually removed from the area of the augercast pile as they pile up, but nonetheless, augercast pile installation is a messy operation!

In seismic regions, pre-assembled rebar cages should be lowered into the grouted pile soon after the drilling equipment is removed from the grouted hole (*Figure 2*). The cages typically consist of vertical bars surrounded by spiral reinforcement in the upper 10 to 30 feet. The length of the cage containing the spiral reinforcement is usually limited to 25 to 30 feet, because it can be difficult to insert longer cages as the grout can become relatively viscous. Whether in a seismic region or not, it is considered good practice by many engineers to install at least one central, vertical bar the full length of the pile. Additional full length bars may be required if the piles will be used to resist uplift forces.

After the grout sets, the upper portion of the piles is exposed by excavating the surrounding soil. The grout is then chipped away, exposing the pile reinforcement so that it can be cast in place with the pile cap or grade beam (*Figure 3*). Alternatively, if soil conditions permit, the "wet" grout above the final bottom of pile cap/grade beam elevation can be removed before the cage installation to avoid subsequent grout chipping.

IBC 1810.3.3 requires a minimum spacing of at least 6 pile diameters center-to-center for piles installed within 12 hours, unless approved by the building official. One of the pitfalls of installing piles too closely too soon is that the piles may damage the integrity of "green" adjacent piles. This is usually evidenced by a drop in the grout level of the adjacent pile. If this occurs, IBC requires that the suspect pile be replaced.

When should they be considered?

Augercast piles are best suited for sites with soft to medium dense soil conditions. They can be socketed into dense soil or weak rock to achieve higher end bearing, but the amount of embedment into these layers can be limited, since the downward drilling force imposed during drilling is generally limited by the self weight of the auger and drill motor suspended from the crane. Therefore, these piles may not be appropriate where significant embedment is required into dense soil or rock.

Augercast piles are particularly advantageous over drilled shafts in cases where groundwater or loose soil conditions cause sloughing, since drilled shafts would require slurry or casing to keep the holes open. Such measures add cost and slow construction of drilled shafts.

They also offer advantages over driven piles where hammer impact noise and vibrations are a concern. Thus, augercast piles are a popular choice in urban settings or where pile installation is required in close proximity to existing buildings or other structures that may be sensitive to settlement.

Augercast piles can be used in low over-head clearance conditions by adding and then removing segments of auger during drilling. To help ensure continuity of the grouted hole during this process, it is typical (and required by IBC 1810.3.3) to re-drill and grout at least 5 feet every time a segment of auger is removed since the process involves arresting grouting to remove the auger segments. The minimum head clearance required will depend on the specific drilling equipment; however, some contractors claim that augercast piles can be installed in less than 10 feet of head clearance.

Figure 1: Crane with Drill Leads
(Photo courtesy of McDowell NW, Inc.)

Figure 2: Reinforcement gage being lowered into a grouted hole

Drawbacks

One of the biggest disadvantages of augercast piles is that the construction method inherently does not allow inspection of the finished, installed product. Potential problems, such as pile necking in overly soft soil conditions, cannot be readily observed. Pile bulging can also occur in very weak soil zones (i.e. peat) along the pile as the pressurized grout consolidates or compacts the very weak soil. In addition, sites with flowing underground water can affect the integrity of augercast piles. However, some of this risk can be mitigated by using reputable and experienced contractors with well-maintained drilling equipment, implementing sufficient quality control procedures, and by using qualified, experienced inspectors.

The capacity of augercast piles can be evaluated by pile load testing. Relevant testing includes: compressive tests (ASTM D1143), tension tests (ASTM D3689), and lateral load tests (ASTM D3966). Dynamic low strain impact load testing (ASTM D5882) is a common non-destructive method for evaluating augercast piles. Dynamic axial high strain impact load testing (ASTM D4945) is another non-destructive test method.

Structural Design Issues

IBC provides specific requirements for augercast piles, unlike previous model codes. A summary of some of the provisions for structural requirements for augercast piles includes the following:

Allowable stresses

Per IBC 1810.3.1, the allowable design stress in the concrete shall not exceed 25 percent of the 28-day specified compressive strength. The allowable compressive stress of reinforcement shall not exceed 34 percent of the yield strength of the steel or 25,500 psi. These values may be exceeded if a soils investigation and pile load test is submitted to the building official, per IBC 1808.2.10.

Dimensions

IBC 1810.3.2 requires the minimum diameter to be 12 inches. The length shall not exceed 30 times the average diameter unless the design and installation of the pile are under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pile foundations.

Reinforcement

Reinforcement in the pile is typically driven by lateral force resisting requirements. For structures in Seismic Design Category C (per IBC 1616), a minimum longitudinal reinforcement ratio of 0.0025 is required in the greater of:

- The upper ⅓ of the pile;
- 10 feet below the ground; or
- that required by analysis.

As an additional requirement, the minimum reinforcement ratio or that required by rational analysis shall also extend through the flexural length of the pile. IBC 1808.1 defines the flexural length of the pile as the length from the first point of zero lateral deflection to the underside of the pile cap or grade beam. A minimum of 4 longitudinal bars are required with minimum No. 3 closed ties (or equivalent spirals) at 16-longitudinal-bar diameter maximum spacing along the pile. Within three pile diameters of the bottom of the pile cap, the spacing of the ties shall be 6 inches or 8-longitudinal-bar diameters, whichever is less.

For structures in Seismic Design Category D, E, or F (per IBC 1616), the above requirements for Category C shall be met except that a minimum longitudinal reinforcement ratio of 0.005 is required in the greater of:

- The upper ½ of the pile;
- 10 feet below the ground; or
- the flexural length of the pile.

In this case, the flexural length of the pile is taken as the length to a point where 40 percent of the concrete section cracking moment strength exceeds the required moment strength at that point. A minimum of four longitudinal bars are required with transverse confine-

Figure 3: Grout being chipped from the cage

ment reinforcement per Sections 21.4.4.1, 21.4.4.2, and 21.4.4.3 of ACI 318 within three pile diameters of the bottom of the pile cap. Except in Category E, F, or potentially liquefiable sites, spiral reinforcing may be used with a ratio of half that required in Section 21.4.4.1(a) of ACI 318 (See IBC 1808.2.23.2.1 for tie requirements for Category E, F, or potentially liquefiable sites). For the remainder of the reinforced section, the tie spacing shall not exceed 12-longitudinal-bar diameters, ½ the pile diameter, nor 12 inches. Ties shall be a minimum of No. 3 bars for pile diameters up to 20 inches, and minimum of No. 4 bars for larger piles.

IBC 1810.3.4 requires the minimum cover to be at least 2.5 inches.

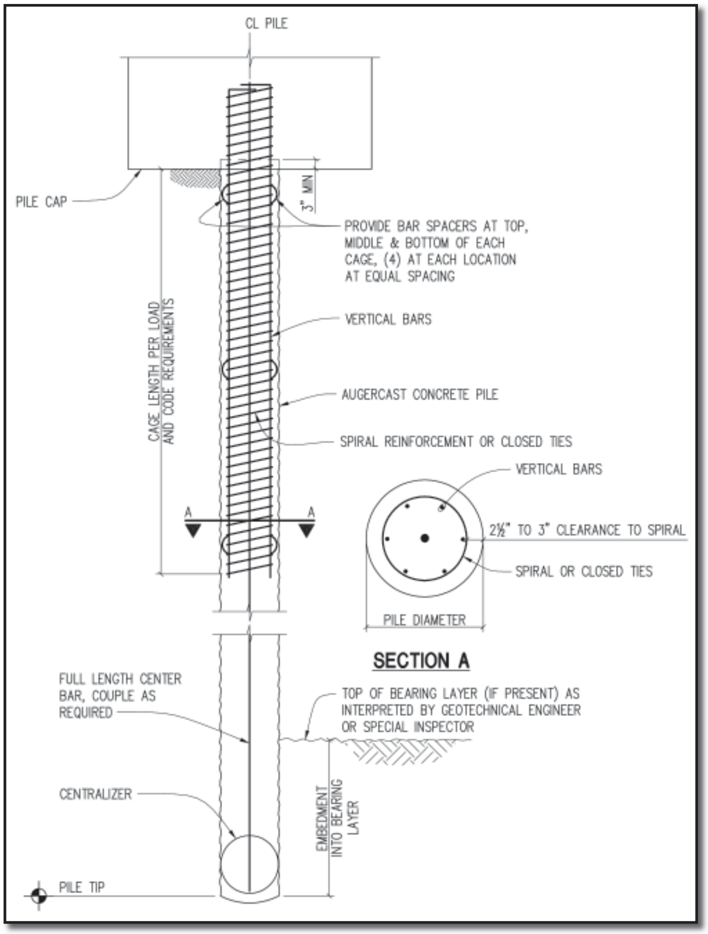

Figure 4: Typical augercast pile detail

Tolerances

Based on this author's experience, reasonably achievable construction tolerances for augercast piles include specifying piles to be within 3 inches of plan location, and 2 degrees of plumb for vertical piles. If an impassable obstruction is encountered while drilling, it is typical to slightly relocate the pile and attempt redrilling until a satisfactory pile is achieved. In these cases, pile caps and/or grade beams may have to be modified or redesigned for the revised pile configuration.

A typical augercast pile detail is shown in *Figure 4*.

Inspection requirements

IBC 1704.8 requires that a special inspector be present while piles are being installed and during load testing. Special inspectors should record the following for each pile:

- Final installed pile location and sequence of installation relative to the other piles
- Pile length, including pile tip and cut-off elevations
- Date and time of pile installation, including drilling and grouting durations
- Drilling action, depth to bearing stratum, and observed soil conditions
- Grout pressure
- Actual to theoretical grout volumes (this ratio should be 1.10 to 1.15 minimum)
- Reinforcement type and length

Summary

Augercast piles have been proven successful on many projects. They are a viable alternative where deep foundations are required, and are particularly attractive in urban settings where noise is a concern or where conventional pile driving equipment may cause vibration induced settlement of adjacent buildings. They are best suited to soft to medium dense sites where socketing into dense soil or rock is not required. Augercast piles are particularly advantageous over drilled shafts in cases where groundwater or loose soil conditions cause sloughing conditions that would require casing to install drill shafts. Above all, their popularity is probably most due to their economy!▪

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