GROUT VOLUME DURING PLACEMENT

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Introduction

When a deep foundation element is used to support a building, bridge, or other structure, ensuring an adequate, appropriate, and predictable vertical and lateral performance of the deep foundation elements is paramount. Cast-in-place piles that are installed in openings created in the ground during the installation process, but not inspected from the ground surface to the bottom of the opening, are permitted by the 2021 International Building Code. Generally, measuring grout volume during installation ensures that the installed element meets the dimensional assumptions made by the geotechnical and structural engineer when designing the pile.

2021 International Building Code Requirements for Grout Volumes

The only requirements for grout volumes in the 2021 International Building Code are for hollow-stem augered, cast-in-place piles often referred to as auger cast piles. Section 1810.4.8 states that "…grout volumes shall be measured to ensure that the volume of concrete or grout placed in each element is equal to or greater than the theoretical hole created by the auger." In normal cases, 110% or more of the theoretical grout volume is installed during auger cast pile construction. Note that there is no specific requirement that the diameter of the auger cast pile be uniform and the measured volume is often related to the porosity of the soil surrounding the opening made by the auger.

The code's 100% minimum grout volume requirement for auger cast piles has a clear geotechnical and structural basis. The geotechnical engineer calculates their nominal vertical and nominal lateral resistance using pile models with a selected diameter. If the actual pile diameter is less than the assumed pile diameter, the geotechnical nominal vertical and nominal lateral resistance will be decreased. Regarding lateral load resistance, the smaller pile diameter effectively decreases the surrounding soil stiffness and the pile moment of inertia such that pile deflections will increase.

The structural engineer also bases their nominal vertical and lateral strength calculations on a known constant diameter. Since the code requires 3 in. of cover for reinforcement used for auger cast piles, any decrease in actual diameter will result in concrete cover less than 3 in. and may result in steel corrosion issues over time. In addition, cross-sectional analysis of the auger cast pile is based on a distance between tension and compression forces acting on the cross-section which are not appropriate if the actual cross-sectional area is less than assumed. Finally, it should be noted that the detailing of confinement reinforcement in auger cast piles is directly related to the geotechnical engineer's lateral analysis results for the pile. These results (usually shear, moment, and deflection plots for fixed and free headed piles) are incorrect if the wrong pile diameter is used.

Section 1810.4.10 of the 2021 International Building Code discusses grout diameter requirements for micropiles. Specifically, this section specifies that the minimum design diameter of the drill hole be verified by a "suitable device during grouting."

Grout Volume Requirements for Fuller Piles

The 2021 International Building Code requirements for grout volumes as discussed above and applicable to auger cast piles do not apply to Fuller Piles. Fuller Piles are hybrid piles and the grout installed outside of the steel pipe element is used to provide cover protection for the pipe element, to serve as a skin friction surface area, and to increase the projected area over which the surrounding soil provides stiffness in response to lateral movement of the pile. Although grout volumes are measured and recorded during all Fuller Pile installations, Fuller Piles are conservatively designed assuming lower bound and upper bound effective outer grout diameters that are a percent of the patented digger plate diameter used to create the opening. This range of effective diameters is site specific and based on Fuller Pile design team experience installing thousands of piles across the United States. Both the geotechnical nominal axial resistance and the geotechnical nominal lateral resistance values specified for Fuller Piles consider the maximum, minimum, and average pile effective diameters such that the most conservative

geotechnical response is captured. For example, assume a 12 in. digger plate is used to construct a given Fuller Pile. The range of effective diameters considered by the geotechnical engineer could be 8.5 to 11 inches with a target grout volume during installation specified as 100% of the smaller diameter considered during design. Where more lateral stiffness is needed in the upper 10 ft of the pile, preaugering with target 100% grout volume can be specified for this zone of the pile.

The structural design and detailing of the Fuller Pile assumes no outer grout surrounding the steel pipe and is always conservative. Where corrosive conditions are present, the minimum grout cover to mitigate the corrosion potential is verified. Where desired by the engineer of record or required by project specifications, the upper elements of the fuller pile can be hot dip galvanized for added corrosion protection.

A few final notes are warranted. Although previously discussed and not applicable to the Fuller Pile, Section 1810.4.10 of the 2021 International Building Code is satisfied by the digger plate used to create the hole. The digger plate is a “suitable device used during grouting” and the minimum diameter is considered in design and specified as a target grout volume. Also, to maximize the uniformity of the grouted column surrounding the steel pipe, two methods of grout placement are used to construct Fuller Piles. In most cases, top grout placement is used where the grout is gravity fed into the opening created by the digger plate during pile installation. In special cases (i.e., longer piles where necking of the grout is a more likely possibility), pressure grouting (i.e., bottom feed grouting) is used during pile installation.