Florida Department of Transportation Research

Bottom Side Grouting of Drilled Shafts Prior to Tip Grouting

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Drilled shafts are common foundations in urban areas, used to avoid vibration or to accommodate a limited right-of-way. But in typical Florida soils, with their sands and silts, axial resistance of drilled shafts is often lower than similarly sized driven piles. Post grouting is being used more often in Florida to increase axial resistance, but tip grouting alone just preloads the tip and may result in flow upward along the shaft during grouting, reducing critical side friction.

In this project, the Florida Department of Transportation (FDOT) contracted University of Florida researchers to improve the axial capacity of drilled shafts in cohesionless soils by developing cavity expansion pressures on both the shaft side and tip. For this, a side and tip grouting system was developed, which was integrated into the pile's reinforcing steel. Membranes constrain the grout flow. Three full-scale test shafts were constructed and tested to investigate this dual grouting system.

Rebar cage fitted with grouting system and side membrane is lowered into a prepared hole prior to concreting.

The first test shaft (6-ft × 36-in) was used to verify construction and implementation of the dual grouting system. Researchers used this shaft to show development of cavity expansion pressures during side and tip grouting processes and to ensure proper operation of system components. The shaft was excavated after post grouting and visually examined to assess the effectiveness of the grout system and any areas of concern. Of great interest was the flow direction of the grout during the side and tip grouting phases.

The next test shaft (25-ft × 36-in) was constructed in a test chamber; force-deformation and soil stresses were measured, and the excavated shaft was examined. Tests on this shaft validated side and tip grouting processes at stress states typical in the field. Of great interest was soil stress state before, during, and after grouting, as well as mobilized side and tip resistance. A top-down load test assessed the axial response to static loading under service loading conditions. Internal strain and shaft displacement were monitored to quantify the load-displacement behavior of the side- and tip-grouted shaft. Following the load test, the shaft was excavated and examined.

The final shaft (25-ft × 42-in) was constructed in the field by a contractor and tested both statically and dynamically. Researchers used this shaft to test the dual grouting process under field conditions, monitoring soil stress around grout zones and internal strains along the shaft during all phases. A top-down (static) load test was performed to assess axial response to static loading. The internal strain and shaft displacement were monitored to quantify load-displacement behavior. For this test, two reaction drilled shafts (55-ft × 48-in) and a two-million-pound jack were used. Of great interest was mobilized side and tip resistance obtained from internal strain data. An additional, dynamic test (Statnamic) was performed on the field shaft. Foil strain gauges and a tip accelerometer were post installed.

The result of this very careful and thorough project was the demonstration of a valuable new adjunct to drilled shaft construction. The researchers found that the side- and tip-grouted shaft could be conservatively estimated to have three times the bearing capacity of a conventional drilled shaft.

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