Florida Department of Transportation Research

Evaluation of Self-Consolidating Concrete and Class IV Concrete Flow in Drilled Shafts

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Current Situation

Construction of drilled shaft foundation elements involves drilling a hole the size and depth of the desired shaft, placing a steel reinforcing cage in the hole, and filling the excavation with concrete. A slurry made from clay powder (or highly engineered polymers) and water is added to the hole as it is drilled to maintain the integrity of the soil wall stability. Concrete is placed into the hole, from the bottom up, where the lighter slurry is collected as it is displaced by the concrete. The concrete should flow through the steel cage to make contact with the soil wall and to fill the space between the cage and the wall. However, in some cases, the surfaces of recovered shafts have shown a quilted surface pattern, indicating that the concrete did not completely surround the steel and make complete contact with the soil wall. Shafts that exhibit this "mattressing effect" may not perform as designed.

This recovered drilled shaft shows the mattressing effect caused by concrete flowing radially through the reinforcing cage.

Research Objectives

University of South Florida researchers conducted laboratory and field experiments to determine causes and effects of mattressing in drilled shafts and to recommend construction practices that would help prevent this effect.

Project Activities

Previous FDOT research on this problem established that concrete flows radially out through the reinforcing cage and does not rise vertically through the region between the cage and soil wall. It was also found that creases formed when mineral slurry was used in large-scale laboratory shaft specimens where the concrete was placed by a tremie (filling from bottom up). In this project, researchers identified the extent of crease formation in both laboratory and field conditions and the effects of their presence on concrete strength and durability.

Fifty-nine large-scale shaft specimens were cast in the laboratory using mineral slurry (bentonite or attapulgite), one of three polymer slurry products, or water. After casting, the shafts were examined for the presence of creases, the effect of creases on the concrete strength, bond to rebar, and the corrosion resistance or durability. Results showed that use of mineral slurry significantly affected rebar bond, the length of rebar required to develop the desired strength, corrosion resistance or durability provided by the cover concrete, and the concrete strength of the cover. Polymer slurry showed similar rebar bond effects but less frequently affected concrete durability. The presence of water during concrete placement had no adverse effects.

The field component of the project involved underwater inspection of five bridges representing shafts cast in water, bentonite, or attapulgite slurry. Results were similar to laboratory findings: the most damage was found where bentonite slurry had been used and less where attapulgite had been used. Little or no damage was found where water had been present during casting.

Project Benefits

This project provides greater understanding of an important and frequently used construction technique.

For more information, please see dot.state.fl.us/research-center