Florida Department of Transportation Research

Attenuating Mass Concrete Effects in Drilled Shafts

BD544-39

Florida's roads and bridges require ongoing upgrades and replacement to keep pace with population change and more stringent design criteria. The ability to assess the condition of a structure containing a large mass of concrete, including columns, footings, and drilled shafts is vital prior to construction.

As cement, sand, and water mix together to form concrete, chemical reactions occur that produce heat. Any mass concrete structure is subject to cracking as a result of the differences in temperature as the concrete cures. The temperature can be regulated by internal cooling tubes or by adjusting the concrete mix. Until recently, drilled shafts were not considered large enough to exhibit this temperature effect mainly due to their small size, usually 4 feet in diameter. However, larger diameter shafts, such as the 9-foot diameter shafts used for some bridges, tend to exhibit the same effects found in mass concrete.

An alternative to controlling the temperature effect for large diameter shafts is to omit the less important core concrete. To demonstrate that the removal of the central core reduces internal temperatures, researchers from the University of South Florida constructed a 9-foot diameter drilled shaft 25 feet deep with a full length 4-foot diameter central void. The study found the benefits of casting larger diameter shafts with a central void included a reduction of concrete volume, onsite concreting time, and the need for internal cooling or recirculation systems. Furthermore, these benefits came with little or no adverse impact on structural capacity.

Although the temperature effect in mass concrete can be detrimental, temperature generation also provides a useful tool as it produces a distinguishable heat signature, which can be used to detect abnormalities in the poured concrete of shafts. Another aspect of this study involved thermal integrity testing using a newly developed thermal probe to collect field data.

Two 9-foot diameter drilled shafts at each pier support the John Ringling Causeway bridge in Sarasota, Fla.

Researchers conducted tests throughout the state on the concrete curing temperatures of 27 drilled shafts and other sites where large amounts of cementitious materials were being used. They recorded data into a thermal 3-D model and corroborated the model findings with the field measurements. The results showed that the model was able to predict the precise temperature traces for any location within a mass concrete structure cast in a wide range of conditions – soil, water, or air environments.

The use of thermal integrity testing in combination with the 3-D model provides an accurate way of predicting mass concrete conditions and enables engineers to assess the types of concrete mixes, environmental conditions, and shaft designs that can help mitigate mass concrete effects.

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