Florida Department of Transportation Research

Development of Laboratory Test Method to Replace the Simulated High-Temperature Fluidity Test

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Concrete's remarkable role in construction depends on its marriage with reinforcing steel. Concrete is very strong in compression, but weak in tension, so reinforcing steel is added to increase tensile strength, yielding structural components capable of much longer spans. Even greater strength and spans can be gained by using pre and post-tensioning cables that run through the concrete and are stressed tight. Greater spans means fewer columns, pilings, and components and shorter construction time.

In post-tensioned concrete, ducts are cast within concrete elements. Once cured, the elements are assembled, and steel cables are run through the ducts, anchored at both ends and tensioned with hydraulic jacks. Space remaining in the ducts is filled by injecting grout through a port in the anchor. The grout hardens, helping to protect the cables from corrosion and to link tension in the cables to the concrete component. There can be no voids in the grout, which would provide a site for corrosion, weakening the structural capacity and possibly leading to failure.

The dynamic shear rheometer, a tabletop device, can simplify testing the temperature performance of grout.

Grout must retain its fluid properties over a range of temperatures, considering the heat it will encounter during pumping inside concrete components baking in Florida's sun. To ensure that prepackaged grouts maintain fluidity during grouting in summer heat, the high temperature grout fluidity test (HTGF) was developed.

In the HTGF, mixed grout is circulated through a 400-ft hose (1-in diameter) for one hour; fluidity is evaluated using the flow cone. The HTGF must be conducted at 90°F, requiring equipment and procedures uncommon in testing laboratories, making the test costly and burdensome.

In this project, University of Florida researchers developed a replacement for the HTGF test using a dynamic shear rheometer (DSR). Several DSR methods and geometries were evaluated, leading to the adoption of the apparent viscosity test (AVT) with a cup and ribbon geometry. The shear rate (50 s^{-1}) used was based on the literature and on the calculated shear rate at a flow cone's nozzle.

In addition to DSR test development, four pre-packaged commercially available post-tensioning (PT) grouts were tested with HGTF. Grout temperatures increased an average of 7°F during HGTF circulation. Line pressures measured at the pump during circulation ranged from 100 to 350 psi.

AVT results measured during the HTGF test were correlated to performance of the PT grouts. AVT results compared well with flow cone results (R^2 = 0.85). From these data, performance classifications were developed based on the results of the testing.

Finally, for comparison of AVT results produced at UF, DSR testing was conducted at the University of Minnesota-Duluth and the National Institute of Standards and Technology. Trends in AVT results compared well, but absolute magnitudes varied somewhat, perhaps due to the sensitive nature of the mixing and conditioning process. Additional performance classifications were developed based on the findings of these studies.

Because grout is a critical component of any PT installation, a more readily available and standard test method will promote more regular testing, resulting in more reliable and durable PT concrete construction.

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