



Research Project Highlight

Strength Enhancement of Low Viscosity Cementitious Grout Using Micro-fibers

In a recent research, the TTC has studied the effect of micro-fiber additives on the strength enhancement of cementitious grouts used in grout-in-place lining applications. Cementitious grout in these applications is injected under pressure into the annular space between the host pipe and the liner, to make the two bond and act as a composite structure. Because the grout serves the function of transferring loads from the host pipe onto the liner, its flexural strength and ability of controlling the propagation of tensile cracks are limiting factors in the design of grout-in-place liners.

The addition of fibrous reinforcement in the form of micro-fibers (e.g., steel fibers, glass fibers and synthetic fibers) can enhance the tensile and flexural strengths of cementitious grouts, as well as significantly improve their ductility and fracture toughness. Grouts used in grout-in-place lining applications are commonly required to meet strict low viscosity and workability values due to pumping distances, restricted flow area within the annulus and limitations imposed by the injection equipment. Any change in flow characteristics of the grout due to excessive addition of fibers can lead to disruption of flow, blockage or uneven distribution of grout throughout the liner.

Keeping this in mind, the TTC selected to study micro-fibers as strength enhancement additives rather than longer fibers that have been customary studied and used in other construction applications such as

bridge deck construction.

Four different micro-fiber types were utilized in the study, i.e., polypropylene fibers, polyvinyl alcohol fibers, glass fibers and carbon fibers, with an average fiber length of 6 mm and diameters ranging between 0.02 to 0.006 mm. The fibers were added as predetermined weight percentage fraction (0.05 to 0.5 percent), with respect to the dry weight of the cementitious material. The fiber percentage addition to the cementitious grout was optimized by performing extensive viscosity and flow tests on the grout-fiber mixture, to ensure that a minimum viscosity value threshold is maintained.

Standard tensile and bending tests (ASTM C 307 and ASTM C 580) were performed on the grout-fiber sample specimens. Results from both, tensile and flexural tests suggest that adding even a minor amount of micro-fibers could have a significant impact on the grout strength. For example, adding a mere 0.1 percent (by weight of dry cementitious powder) of polypropylene fibers resulted in nearly 40 percent increase in the grout tensile strength and 110 percent increase in its flexure strength when compared with control specimens. Additional work included the evaluation of crack propagation patterns of composite grout-fiber-liner specimens subjected to bending loads.

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Fig 1. Tensile testing of a fiber-reinforced briquette



Fig 2. 3-Point Bending test of a grout-fiber-liner specimen

TTC Enters New Era

With the May 2009 retirement of long-time TTC Director Dr. Ray Sterling, the TTC has entered a new era in its management structure. Previously the TTC has utilized a fairly standard director-associate director hierarchical management structure with Sterling and Dr. Erez Allouche (Associate Director) sharing the Center's leadership roles. In September, Dr. Rob McKim returned to Louisiana Tech University and the TTC to act as a co-director with Allouche. The co-directorship structure was implemented to utilize the strengths of both Allouche (research) and McKim (industrial outreach) and to launch the Center into a new decade of growth and development.

One of TTC's strengths has always been its ability to connect directly with industry and undertake not only traditional academic research but to undertake focused research to address specific industry concerns. This approach has been successful largely through the use of the TTC's Industry Advisory Board, which consists of a cross-section of the trenchless industry and is responsible to help guide and direct the Center's Research and Development efforts. Another key to the Center's strengths is its long-term stability as a focus for the trenchless industry to undertake research and effectively disseminate the results. The Center is celebrating its 20th year in operation and during that time has had only two directors and two co-directors. This slow turnover of leadership, along with the retention of key individuals such as Jadranka Simicevic (research engineer) and administration staff (such as Sandi Perry), has provided a stable platform for the Center and allowed the TTC to undertake projects that take years to complete knowing that there will be a continuity of personnel.

2010 Spring Municipal Forum Program

The TTC Municipal Users Forum program for trenchless technology will get under way in April for the 2010 spring season. The forum is designed to allow local/regional municipalities or utility agencies to share information on their experiences in using trenchless techniques and in dealing with other issues related to the construction and management of buried utilities. The forum is designed as a one-day program with low participation cost (typically under \$50 to municipal participants). The Colorado, Northwest, and Ohio forums will be held in April, and the Louisiana, Minnesota and New York forum will follow in May. Additional forum details can be found at the TTC Web site, www.ttc.latech.edu. The fall schedule is still being set but the following forum locations are expected: Colorado, Northwest, Alberta, Boston, California, Dallas and Virginia. Enquiries about making presentations at forum meetings or municipal participation in the forums are welcomed and can be made by contacting the TTC.

TTC IAB Meets at UCT

Thanks largely to Robert Carpenter (UCT organizer), the TTC held its January 2010 Industrial Advisor Board meeting during the UCT Conference in Tampa. The strong turnout of 22 industrial members, plus Dr. Ray Sterling (retired) and Dr. Jeong of Oklahoma State University, reviewed the activities of the Center and helped plan the path forward. IAB chairman Joe Barsom directed the meeting along with Administrative Director Dr. Rob McKim and reviewed the recent organizational changes in the Center. The meeting was based around an informal lunch. This informal atmosphere is a trademark of the TTC and allows a free-flowing exchange of ideas and is an essential element in the way the TTC conducts business. Some of the specific topics covered were a review of the ongoing and planned research activities, the ongoing Municipal Forum series and the need to expand the National Trenchless Technology Research Facility at TTC by up to 50 percent to accommodate the high volume of research activities the TTC is presently managing. The 90-minute meeting ended with the scheduling of the next IAB meeting for Tuesday, May 4, in Nirvana C at the annual No-Dig show in Chicago.

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