Test Data: Effectiveness of Nycon ConTrolPC*F* as Concrete Reinforcement

Overview

In March 2000, a testing program was undertaken to determine the compliance of Nycon ConTrolPC*F* fibers with ICC Engineering Services, Inc. (ES), acceptance criteria (AC) for concrete reinforced with synthetic fibers. A joint committee of ICC ES personnel and synthetic fiber industry representatives established acceptance criteria to evaluate the performance of synthetic fibers in plastic shrinkage reinforcement and secondary/temperature-shrinkage reinforcement. The criteria for each required a specific set of tests to be conducted at an approved testing laboratory; the specific tests can be found in AC 32. The testing program, identified as Project # 00-030026, was conducted at Stork Twin City Testing Corporation in St. Paul, Minnesota. Test results demonstrated the effectiveness of Nycon ConTrolPC*F* fibers as a plastic shrinkage reinforcement as defined in AC32, Section 4.1.1, and as a secondary/temperature-shrinkage reinforcement as defined in AC32, Section 4.1.2.

Material Description 0.75" (19mm) Fibrillated Virgin Polypropylene Fiber

Matrix Dosage Rate 1.5 pounds/cubic yard (0.9 kg/cubic meter) of concrete

ICC Test Procedure	Plain Concrete	ConTrolPC*F* Reinforced Concrete	% of Plain Concrete	ICC Specs
Compressive Strength	35.4 MPa (5,130 psi)	36.30 MPa (5,260 psi)	102.5%	≥Plain Concrete
Flexural Strength	3.9 MPa (560 psi)	3.9 MPa (560 psi)	100.0%	≥Plain Concrete
Freeze/Thaw Durability	62.5%	72.0%	115.2%	≥Plain Concrete
Bond Strength	63.6 kN (14,300 lbs)	63.7 kN * (14,320 lbs)	100.1%	≥Plain Concrete
Plastic Shrinkage Cracking		86.1% reduction		40% Minimum
Impact Resistance 7 Days 28 Days	 3 blows 6 blows	 8 blows 11 blows	 267% 186%	 200% Minimum 150% Minimum
Post-Peak Flexural Strength, MPa (psi)		3.1 (450)	N/A	1.0 (145) Minimum

Compatibility with Concrete	4 Weeks Testing in Progress	8 Weeks Testing in Progress	16 Weeks Testing in Progress	32 Weeks Testing in Progress	52 Weeks Testing in Progress

*These data are for vertically cast specimens of both plain and ConTrolPC*F* modified concrete.

Standard Test Methods Used In Program

Compressive Strength	ASTM C39
Flexural Strength	ASTM C78
Freeze/Thaw Durability	ASTM C666 Method A
Bond Strength	ASTM C234
Plastic Shrinkage	ICC ES AC 32 Appendix B
Impact Resistance	ICC ES AC 32 Appendix C-2
Post-Peak Flexural Strength	ICC ES AC 32 Annex C-1
Compatibility with Concrete	ICC ES AC 32 Annex B-2

Specimens Per Test Set

- Three specimens were fabricated per test set for compressive, flexural, freeze/thaw, bond strength, plastic shrinkage, post-peak flexural strength, and compatibility with concrete.
- Five specimens were fabricated per test set for impact strength.

Performance Criteria

- ### Compressive, Flexural, and Bond Strength

  These tests insure that the synthetic fibers do not compromise the performance of reinforced concrete when compared to plain concrete.

  #### Test Results

  Compression, flexural, and bond strength test results for the Nycon ConTrolPC*F* specimens exceeded the performance of plain concrete, demonstrating that ConTrolPC*F* fibers enhance the soundness of the concrete matrix, and their three-dimensional distribution in the matrix provides for the distribution of load over a greater volume of concrete.

- ### Freeze-Thaw

  This test insures that the synthetic fibers do not compromise the performance of reinforced concrete when compared to plain concrete.

  #### Test Results

  Freeze-thaw results showed that ConTrolPC*F* fibers reduce permeability, which translates into more durable concrete in a natural environment.

- ### Plastic Shrinkage

  This test is required to show that Nycon ConTrolPC*F* fibers do, in fact, provide a reduction in measurable plastic shrinkage crack formation and growth. A minimum reduction in measurable plastic shrinkage of 40% is required.

  #### Test Results

  The plastic shrinkage test showed that ConTrolPC*F* provides a major reduction in measurable cracks. The reduction in plastic shrinkage cracking was 86.1% when compared to plain concrete, exceeding the 40% minimum reduction specified. The reduction in plastic shrinkage is significant and proves the ability of ConTrolPC*F* to distribute stresses over a greater volume of concrete. If there are fewer cracks created during the plastic and initial hardening phases and crack widths are smaller, then concrete will be less

permeable. This translates into greater resistance to freeze/thaw, which is doubly proven by the testing; it also translates into improved fatigue strength.

- **Impact Resistance**

  This test is required to show that the synthetic fibers do, in fact, hold the concrete together after it cracks, which is the sole performance requirement of secondary/temperature-shrinkage reinforcement. Again, a minimum performance level is required. AC 32 calls for comparing plain concrete specimens and fiber-reinforced specimens at a cured age of 7 and 28 days. The comparison factor of plain to fiber-reinforced specimens is the number of blows to total failure. The minimum improvement at seven days is 200%. When specimens are 28 days old, the improvement is 150%.

  Test Results

  Nycon ConTrolPC*F* fibers exceeded both the seven- and 28-day requirements. The impact resistance data show the superior ability of ConTrolPC*F* to bond with concrete, thus providing resistance to the cracked concrete's propensity to separate or move apart. The test results demonstrate ConTrolPC*F*'s ability to yield benefits beyond secondary reinforcement—the most prominent of which would be in seismic-resistant structures reducing their potential of suffering catastrophic failure.

- **Post-Peak Flexural Strength**

  This test is used to quantify the ability of three-dimensional fiber reinforcement to carry load after the concrete cracks. This uni-axial test provides a means to look at the contribution of dosage level, fiber length, fiber configuration, and fiber type. The test method is listed as AC32, Annex C-1, which is a version of ASTM C1609.

  Test Results

  The results of this test method show that ConTrolPC*F* performed extremely well, which reflects the excellent mechanical bond achieved with the product's lattice pattern. The specification calls for a minimum of 1.0 MPa (145 psi), which is the value that would be attained by a specimen with no fibers. In this program the post-peak flexural strength for the ConTrolPC*F* was reported at 3.1 MPa (450 psi).

- **Compatibility with Concrete**

  This is an accelerated aging test used to show whether the synthetic fiber chemically reacts with the mortar matrix and/or loses strength. ASTM C1609 is the test method for evaluating performance, specifically residual strength, which is a calculated number for the toughness index generated by the test results. Beams are tested at 4, 8, 16, 32 and 52 weeks of accelerated aging. Data generated must be equal to or greater than 85% of the unaged data.

  Test Results

  Accelerated aging testing for compatibility of ConTrolPC*F* with concrete is in progress. Nevertheless, polypropylene fibers have been used successfully in concrete since the early 70's with no evidence of lost strength or chemical incompatibility, thus demonstrating their value-added to concrete.

Conclusions

The results of this testing program validate the benefits of Nycon ConTrolPC*F* fibers in concrete and demonstrate that ConTrolPC*F* reinforced concrete meets or exceeds the performance criteria of ICC ES AC 32, Sections 4.1.1 and 4.1.2, Synthetic Fibers as Plastic Shrinkage Reinforcement in Concrete and Secondary/Temperature-Shrinkage Reinforcement in Concrete respectively.

Nycon, Inc. 101 Cross Street Westerly, RI 02891 Web
www.nycon.com E-mail nycon@nycon.com
Phones 800 456 9266 401 596 3955 Fax 401 596 4242