

	<p>Test Data: Effectiveness of Nycon ProConM as Concrete Reinforcement</p>
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Overview

In March 2000, a testing program was undertaken to determine the compliance of Nycon ProConM 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 as temperature-shrinkage reinforcement in concrete, i.e., AC 32, Section 4.1.2. The testing program, Project #00-030026, was conducted at Stork Twin City Testing Corporation in St. Paul, Minnesota. These test results demonstrated the effectiveness of Nycon ProConM fibers as secondary temperature-shrinkage reinforcement in hardened concrete.

Material Description

0.75" (19mm) Monofilament Virgin Polypropylene Fiber

Matrix Dosage Rate

1.0 pounds/cubic yard (0.60 kg/cubic meter) of concrete

ICC Test Procedure	Plain Concrete	ProConM-Reinforced Concrete	% of Plain Concrete	ICC Specs
Compressive Strength	34.4 MPa (4,990 psi)	34.80 MPa (5,050 psi)	101.2%	≥ Plain Concrete
Flexural Strength	3.8 MPa (550 psi)	3.8 MPa (550 psi)	100.0%	≥ Plain Concrete
Freeze/Thaw Durability	62.7	72.6	115.8%	≥ Plain Concrete
Bond Strength	62.5 kN (14,040 lbs)	62.7 kN * (14,090 lbs)	100.4%	≥ Plain Concrete
Plastic Shrinkage Cracking		85.1% reduction		40% Minimum
Impact Resistance 7 Days 28 Days	4 blows 5 blows	9 blows 10 blows	225% 200%	200% Minimum 150% Minimum
Post-Peak Flexural Strength, MPa (psi)		3.8 (550)	N/A	0.345 (50) Minimum

* These data are for vertically cast specimens of both plain and ProConM-modified concrete.

Compatibility with Concrete	104 Weeks	ICC Criteria
	No fiber deterioration observed	No Fiber Deterioration

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	ASTM C1609
Compatibility with Concrete	ICC ES AC 32 Annex B-2

Specimens Per Test Set

- Three test specimens were used per test set for compressive, flexural, freeze/thaw, bond strength, plastic shrinkage and compatibility with concrete.
- Five test specimens used 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 ProConM specimens exceeded the performance of plain concrete. These data confirm that Nycon ProConM 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

Testing in progress.

- **Plastic Shrinkage**

This test is required to validate that Nycon ProConM fibers do, in fact, provide a reduction in measurable crack formation and growth. A minimum reduction in measurable shrinkage of 40% is required.

Test Results

The plastic shrinkage test results show a major reduction in measurable cracks of 85.1% when compared to the plain concrete, exceeding the 40% minimum reduction specified. The value of ProConM can best be stated as a durability enhancement: If there are fewer cracks created during the plastic and initial hardening phases and crack widths are smaller, then the 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 fiber holds concrete together after it cracks, which is the sole performance requirement of temperature-shrinkage reinforcement. Again, a minimum performance level is required. For tests comparing number of blows to total failure when synthetic fiber specimens have been aged for seven days, the minimum improvement compared to plain concrete at the same age is 200%. When specimens are 28 days old, the improvement is 150%.

Test Results

Nycon ProConM fibers exceeded both the 7- and 28-day requirements. Impact resistance data show the superior ability of ProConM to bond with concrete, thus providing resistance to the cracked concrete's propensity to separate or push apart. Test results illustrate the ability of the fibers to hold concrete together after it cracks, demonstrating their ability to yield benefits beyond secondary reinforcement, the most prominent of which would be in seismic-resistant structures.

- * **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. AC32 calls for a minimum of 50 psi or 20% of the MOR, whichever is less.

Test Results

The results of this test show that ProConM performed well. In this program the post-peak flexural strength of the ProConM was reported at 3.8 MPa (550 psi), which exceeds the minimum required, 50 psi.

- **Compatibility with Concrete**

The test method requires that concrete cylinders containing the fibers be placed in a controlled environment room where the temperature is 72 degrees F and the relative humidity is 100%. The concrete cylinders are retained in this room for 2 years. At the conclusion of the test period the concrete cylinders are broken and samples of the fibers are recovered and viewed using a PMG-3 Microscope at a 1500 magnification.

Test Results

No deterioration was observed in any of the fibers recovered from the cylinders.

Conclusions

This testing program validates the benefits of Nycon ProConM fibers in concrete and confirms that ProConM-reinforced concrete meets or exceeds the performance criteria of ICC ES AC 32, Section 4.1.1, Synthetic Fibers as Plastic Shrinkage Reinforcement, and 4.1.2, Synthetic Fibers as Temperature-Shrinkage Reinforcement in Concrete.



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