

FRC

FIBER TESTING

**ICBO – ES AC32 TESTING
MONOFILAMENT POLYPROPYLENE FIBERS**

DOSAGE RATE: 1.0 lbs / cyd
TESTING LAB: STORK – TWIN CITIES TESTING
DATE: REVISED MAY 13, 2004

FRC
FRC INDUSTRIES

107 Bulldog Road • Freeport, FL 32439 • USA
Telephone: (850) 259-0317 • Fax: (850) 835-4700



ENGINEERING TEST COVER PAGE

Test:	ICBO Acceptance Criteria	Dosage:	1.0 lbs / cyd
Product:	MATRIX Monofilament Fibers	Project:	032059
Method:	ICBO – Multiple Test Methods	Date:	August 8, 2002
Lab:	Twin City Testing Corp / St. Paul, MN	Manufacturer:	ABC Polymer Industries
Summary:	Summary Results – See Below		

INTRODUCTION:

The attached report presents the results of our laboratory testing of concrete with monofilament fibers. The scope of the testing was as follows:

1. Perform laboratory concrete trial batching of concrete with and without fiber for comparison as follows:
 - A. Compressive Strength
 - B. Flexural Strength
 - C. Freeze/Thaw Durability (Method A)
 - D. Bond Strength with Reinforcing Steel
 - E. Plastic Shrinkage Cracking
 - F. Impact Resistance
 - G. Compatibility with concrete

2. Prepare written report stating whether the product meets applicable portions of the ICBO Acceptance Criteria Synthetic Fiber-Reinforced Concrete.

SUMMARY OF TEST RESULTS:

Based on the completed test results, the Fiber, at a dosage of 1.0 lbs / cyd meets the ICBO AC 32

Test	Control	Fibers	%of control	ICBO Criteria
Compressive Strength	5,470 psi	5,580 psi	102%	>= control
Flexural Strength	530 psi	620 psi	116%	>= control
Freeze/ Thaw Durability	65.7	77.7	118%	>= control
Bond Strength	1,240 psi	1,330 psi	107%	>= control
Plastic Shrinkage	—	—	87.6% (reduction)	min 40%
Impact Resistance				
7 days	3 blows	7 blows	233%	200%
28 days	6 blows	11 blows	183%	150%

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TESTING OF CONCRETE WITH SYNTHETIC FIBERS

SUMMARY OF TEST RESULTS: (cont.)

<u>Test</u>	<u>Test- (Fibers)</u>	<u>ICBO Criteria</u>
Compatibility with Concrete	No Fiber Deterioration Observed	No Fiber Deterioration

CONCLUSIONS:

Based on the test results, the fibers do not adversely affect the concrete performance in the following areas

- Compression Strength
- Flexural Strength
- Bond Strength to Reinforcing Steel
- Freeze-Thaw Resistance

In addition, the fibers are compatible with concrete and assist in inhibiting plastic shrinkage cracking and increase the impact resistance.

TEST PROCEDURES:

The testing was initiated on April 30, 2002 and subsequent dates, using applicable portion of the above referenced ICBO Acceptance Criteria AC32 (Section V. Test Program). Based on our understanding of Section V. Test Program, the comparative test mixes and procedures are those outlined in ASTM:C494 Sections 11 through 15. The mix design used is included in the Concrete Materials section of this report along with the other pertinent information.

Additional ASTM procedures were also used in conjunction with the ICBO Criteria. These procedures are outlined in the Test Results section of this report.

SYNTHETIC FIBER DATA:

Synthetic Fibers - ABC Monofilament Fiber (Denier - 15)

Date Submitted - February 21, 2002

Application/mixing - Min. 4 minutes

CONCRETE MATERIALS:

Materials

Cement

Type I Portland Cement (ASTM:C150)

Fine Aggregate

Shiely Aggregates Inc. Meeting the grading requirements of ASTM:C494 and C33.

Coarse Aggregate

Shiely Aggregates Inc. Meeting the grading requirements of ASTM:C494 and C33

Admixtures

DARAVAIR by W.R. Grace (ASTM:C260)

ABC Monofilament Fibers

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CONCRETE MATERIALS: (cont.)

Concrete Trial Mixtures

Mix Number	1	2
Mixture Type	Control	Fiber
Cement Content, lbs.	517	517
Slump, in.	2-3	2-3
Nominal Coarse Aggregate size, in.	¾	¾
Air Content, %	5 - 7	5 - 7
Minimum Compressive Strength, psi	4,000	4,000

Batch Weights, per yd³

Mix Number	1	2
Mixture Type	Control	Fiber
Portland Cement, lbs.	517	517
Admixtures:		
DARAVAIR ¹ , oz.	4.1	4.1
ABC Monofilament Fibers, lbs.	—	1.00
Fine Aggregate, lbs.	1,365	1,365
Total Coarse Aggregate, lbs.	1,750	1,750
Net Water, lbs.	290	290

Mix numbers 1 & 2 were used in casting of all samples

¹The air entrainment admixture was omitted for the plastic shrinkage testing.

TEST RESULTS:

CONCRETE TEST DATA

Flexural Strength, Freeze/Thaw, and Bond Strength

Mix Number	1	2
Mixture Type	Control	Fiber
Slump, in.	4	3-3/4
Air Content, %	6.6	7.3
Temperature, °F	70	70
Unit Weight, lbs/ft ³	143.2	139.2

Compressive Strength, Impact Strength, and Compatibility with Concrete

Mix Number	1	2
Mixture Type	Control	Fiber
Slump, in.	4	3-3/4
Air Content, %	6.9	7.6
Temperature, °F	73	73
Unit Weight, lbs/ft ³	142.1	140.0

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TEST RESULTS: (cont.)

Plastic Shrinkage Cracking

Mix Number	1	2
Mixture Type	Control	Fiber
Date	5/1/02	5/1/02
Slump, in.	3	2-1/2
Air Content, %	2.0	3.0
Temperature Initial, °F	70	70
Unit Weight, lbs/ft ³	148.8	148.0
Moisture loss, lbs/ft ² /h	0.30	0.28

Plastic Shrinkage Cracking

Mix Number	1	2
Date	5/1/02	5/1/02
Slump, in.	4	3-1/2
Air Content, %	1.8	2.0
Temperature Initial, °F	72	72
Unit Weight, lbs/ft ³	147.4	147.0
Moisture loss, lbs/ft ² /h	0.31	0.29

Plastic Shrinkage Cracking

Date	5/2/02	5/2/02
Slump, in.	4	3
Air Content, %	1.9	2.1
Temperature Initial, °F	71	71
Unit Weight, lbs/ft ³	147.5	147.3
Moisture loss, lbs/ft ² /h	0.33	0.31

Compressive Strength - ASTM:C39

Sample Type	Control	Control	Control
Mix Number	1	1	1
Diameter, in.	6.00	6.00	6.00
Height, in.	12.00	12.00	12.00
Area, in ²	28.27	28.27	28.27
Days Moist Cured-ASTM:C192	27	27	27
Age of sample at test, days	28	28	28
Type of Fracture	Shear	Shear	Shear
Load at Failure, lbs.	153,220	159,280	151,680
Strength, psi	5,420	5,630	5,370

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TEST RESULTS: (cont.)

Compressive Strength - ASTM:C39

	Fiber	Fiber	Fiber
Sample Type	2	2	2
Mix Number	2	2	2
Diameter, in.	6.00	6.00	6.00
Height, in.	12.00	12.00	12.00
Area, in ²	28.27	28.27	28.27
Days Moist Cured-ASTM:C192	27	27	27
Age of sample at test, days	28	28	28
Type of Fracture	Shear	Shear	Shear
Load at Failure, lbs.	156,710	157,980	158,710
Strength, psi	5,540	5,590	5,610

*Sulfur capping compound was used on all samples.

Flexural Strength - ASTM:C78

	Control	Control	Control
Sample Type:	1	1	1
Mix Number:	1	1	1
Width, in:	6.10	5.90	5.85
Depth, in:	6.05	6.00	6.00
Span, in:	18.0	18.0	18.0
Days Moist Cured-ASTM:C192:	27	27	27
Age of sample at test, days:	28	28	28
Location of Fracture:	Middle Third	Middle Third	Middle Third
Load at Failure, lbs:	6,200	6,550	6,200
Modulus of Rupture, psi:	500	560	530

	Fiber	Fiber	Fiber
Sample Type:	2	2	2
Mix Number:	2	2	2
Width, in:	6.20	6.25	6.10
Depth, in:	6.00	6.00	6.00
Span, in:	18.0	18.0	18.0
Days Moist Cured-ASTM:C192:	27	27	27
Age of sample at test, days:	28	28	28
Location of Fracture:	Middle Third	Middle Third	Middle Third
Load at Failure, lbs:	8,060	7,250	7,690
Modulus of Rupture, psi:	650	580	630

No shims were used and equation 8.1 from ASTM:C78 was used for the calculations.

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TEST RESULTS: (cont.)

Freeze/Thaw Durability - ASTM: 666 Method A

Sample Type:	Control	Control	Control
Mix Number:	1	1	1
Fundamental Transverse Frequency Before 301 Cycles:	0.53	0.52	0.50
Fundamental Transverse Frequency After 301 Cycles:	0.42	0.40	0.41
Durability Factor:	70.6	59.2	67.2
Sample Type:	Fiber	Fiber	Fiber
Mix Number:	2	2	2
Fundamental Transverse Frequency Before 302 Cycles:	0.50	0.52	0.49
Fundamental Transverse Frequency After 302 Cycles:	0.46	0.45	0.42
Durability Factor:	84.6	74.9	73.5

Bond Strength - ASTM:C234

Sample Type	Control	Control	Control
Mix Number	1	1	1
Days Moist Cured-ASTM:C192	27	27	27
Age of sample at test, days	28	28	28
Load at Failure, lbs.	17,120	16,890	18,780
Area, in ²	14.14	14.14	14.14
Load, psi	1,210	1,190	1,330
Failure Type	Concrete Failure	Concrete Failure	Concrete Failure
Sample Type:	Fiber	Fiber	Fiber
Mix Number:	2	2	2
Days Moist Cured-ASTM:C192	27	27	27
Age of sample at test, days	28	28	28
Load at Failure, lbs.	18,400	17,340	20,560
Area, in ²	14.14	14.14	14.14
Load, psi	1,301	1,230	1,450
Failure Type	Concrete Failure	Concrete Failure	Concrete Failure

All mixing and casting procedures followed ASTM:C234. The yield strength (pounds) of the #6 reinforcing bars used during the test was documented at 26,880 lbs. This correlates to a tensile strength of 61,100 psi. A test fixture along with a hydraulic ram and digital load cell were used to apply the test loads. The load was applied at an approximate rate of 4000 lb/min. The load cell calibration was traceable to NIST. No capping compound was used during the testing.

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TEST RESULTS: (cont.)

Plastic Shrinkage Cracking - ICBO Annex A**

Mix Number	1	2
Mixture Type	Control	Fiber
Date - 5/1/02		
Cracking Value in. ²	0.843	0.060
Cracking Ratio		7.2%
Crack Reduction		92.8%
Date - 5/1/02		
Cracking Value in. ²	0.740	0.075
Cracking Ratio		10.1%
Crack Reduction		89.9%
Date - 5/2/02		
Cracking Value in. ²	0.749	0.150
Cracking Ratio		20.0%
Crack Reduction		80.0%

The size of panels tested was a nominal 22 - 11/16" in length by 13 - 5/16" in width with a riser as described in appendix B.

Impact Resistance - ICBO AC32 Annex C-2

7 Days Test

Test Number	Control		Fiber	
	1st Crack Blows	Final Failure Blows	1st Crack Blows	Final Failure Blows
1	2	3	3	6
2	2	3	4	7
3	2	4	3	8
4	2	3	3	6
5	1	3	5	7
Average	2	3	4	7

28 Day Test

Test Number	Control		Fiber	
	1st Crack (Blows)	Final Failure (Blows)	1st Crack (Blows)	Final Failure (Blows)
6	4	5	7	10
7	5	6	6	9
8	6	7	7	11
9	4	7	8	12
10	5	7	9	13
Average	5	6	7	11

The height of the drop hammer was 18 inches. All of the samples were 6-inch diameter samples.

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TEST RESULTS: (cont.)

Compatibility with Concrete – ICBO AC32 Section 5.6.1

Two concrete cylinders were placed in a moist environment (72°F and 100% humidity) for two years. At the conclusion of the two years, fiber samples were removed from the cylinders and examined using PMG-3 microscope at a magnification of 1500 times. No deterioration of the fibers was observed.

REMARKS:

The samples were discarded at the completion of testing.

If you have any questions concerning this report, or if we may be of further assistance, please contact me at (651) 659-7340.

STORK TWIN CITY TESTING CORPORATION


John D. Lee, P.E.
Senior Staff Engineer
Construction Materials Department
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