

FRC

FIBER TESTING

**ICBO-ES AC32 TESTING
FIBRILLATED POLYPROPYLENE FIBERS**

DOSAGE RATE: 1.5 lbs / cyd
TESTING LAB: STORK – TWIN CITIES TESTING
DATE: MAY 13, 2004

FRC
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ENGINEERING TEST COVER PAGE

Test:	ICBO Acceptance Criteria	Dosage:	1.5 lbs / cyd
Product:	MATRIX Fibrillated Fibers	Project:	99-09552, 032059
Method:	ICBO – Multiple Test Methods	Date:	May 13, 2004
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	4,920 psi	4,920 psi	100%	>= control
Flexural Strength	560 psi	580 psi	104%	>= control
Freeze/ Thaw Durability	87	90	103%	>= control
Bond Strength	1,160 psi	1,200 psi	104%	>= control
Plastic Shrinkage	—	—	79.1% (reduction)	min 40%
Impact Resistance				
7 days	4 blows	8 blows	200%	200%
28 days	6 blows	10 blows	167%	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 September 15, 1999 and subsequent dates as well as April 29, 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. However, the water to cement ratio was increased for the plastic shrinkage tests to help precipitate crack formation. 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 Fibrillated Polypropylene Fibers (Denier – 1500)
Date Submitted – September 9, 1999 and 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 Fibrillated Polypropylene Fibers

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CONCRETE MATERIALS:

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, oz.	4.1	4.1
ABC Fibrillated Polypropylene Fibers, lbs.	---	1.50
Fine Aggregate, lbs.	1,365	1,365
Total Coarse Aggregate, lbs.	1,750	1,750
Net Water, lbs.	257	257

Mix numbers 1 & 2 were used in casting the compressive strength, flexural strength, freeze/thaw, bond strength, impact resistance, and compatibility samples.

Mix Number	3	4
Mixture Type	Control	Fiber
Cement Content, lbs.	517	517
Slump, in.	5 - 6	5 - 6
Nominal Coarse Aggregate, in.	¾	¾
Air Content, %	n/a	n/a

Batch Weights, per yd³

Mix Number	3	4
Mixture Type	Control	Fiber
Portland Cement, lbs.	517	517
Admixtures:		
DARAVAIR	n/a	n/a
ABC Fibrillated Polypropylene Fibers	---	1.50 lbs
Fine Aggregate, lbs.	1,428	1,428
Total Coarse Aggregate, lbs.	1,750	1,750
Net Water, lbs.	310	310

Mix numbers 3 & 4 were used in casting the plastic shrinkage samples.

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TESTING OF CONCRETE WITH SYNTHETIC FIBERS

TEST RESULTS:

CONCRETE TEST DATA

Compressive Strength, Freeze/Thaw, and Impact Strength

Mix Number	1	2
Mixture Type	Control	Fiber
Slump, in.	3- ³ / ₄	2- ¹ / ₄
Air Content, %	6.5	5.9
Temperature, °F	76	75
Unit Weight, lbs/ft ³	147.0	147.3

Bond Strength

Mix Number	1	2
Mixture Type	Control	Fiber
Slump, in.	3- ¹ / ₂	3
Air Content, %	6.3	6.0
Temperature, °F	76	76
Unit Weight, lbs/ft ³	146.8	147.0

Flexural Strength and Compatibility with Concrete

Mix Number	1	2
Mixture Type	Control	Fiber
Slump, in.	5	3
Air Content, %	6.0	5.2
Temperature, °F	72	72
Unit Weight, lbs/ft ³	147.6	148.0

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TESTING OF CONCRETE WITH SYNTHETIC FIBERS

TEST RESULTS: (cont.)

CONCRETE TEST DATA

Plastic Shrinkage Cracking

Mix Number	3	4
Mixture Type	Control	Fiber
Date	9/27/99	9/27/99
Slump, in.	6-½	5-¾
Air Content, %	1.8	1.9
Temperature Initial, °F	76	76
Unit Weight, lbs/ft ³	148.0	148.4
Moisture loss, lbs/ft ² /h	0.32	0.30

Plastic Shrinkage Cracking

Mix Number	3	4
Date	9/29/99	9/29/99
Slump, in.	6-½	6
Air Content, %	1.8	1.9
Temperature Initial, °F	76	76
Unit Weight, lbs/ft ³	148.4	148.8
Moisture loss, lbs/ft ² /h	0.36	0.35

Plastic Shrinkage Cracking

Date	9/30/99	9/30/99
Slump, in.	6	5-½
Air Content, %	1.7	1.9
Temperature Initial, °F	76	76
Unit Weight, lbs/ft ³	148.8	149.2
Moisture loss, lbs/ft ² /h	0.35	0.36

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.	136,920	140,170	140,010
Strength, psi	4,840	4,960	4,950

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TESTING OF CONCRETE WITH SYNTHETIC FIBERS

TEST RESULTS: (cont.)

Sample Type	Fiber	Fiber	Fiber
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.	141,790	138,800	137,010
Strength, psi	5,010	4,910	4,850

*Sulfur capping compound was used on all samples.

Flexural Strength - ASTM:C78

Sample Type:	Control	Control	Control
Mix Number:	1	1	1
Width, in:	5.90	6.00	6.05
Depth, in:	6.00	6.05	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:	6,840	6,590	6,660
Modulus of Rupture, psi:	590	540	520

Sample Type:	Fiber	Fiber	Fiber
Mix Number:	2	2	2
Width, in:	5.90	5.95	6.05
Depth, in:	6.15	6.15	6.10
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:	7,190	7,250	7,250
Modulus of Rupture, psi:	580	580	580

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 302 Cycles:	1.51	0.28	0.33
Fundamental Transverse Frequency After 302 Cycles:	1.50	0.26	0.29
Durability Factor:	99	86	77
Weight Before 302 Cycles, gms:	10,107.6	9,999.5	10,146.3
Weight After 302 Cycles, gms:	10,047.2	10,017.2	10,171.8
Change, %:	-0.6	0.2	0.3

Sample Type:	Fiber	Fiber	Fiber
Mix Number:	2	2	2
Fundamental Transverse Frequency Before 302 Cycles:	0.34	1.20	1.46
Fundamental Transverse Frequency After 302 Cycles:	0.30	1.15	1.46
Durability Factor:	78	92	100
Weight Before 302 Cycles, gms:	10,163.6	9,935.2	10,186.0
Weight After 302 Cycles, gms:	10,161.5	10,074.7	10,148.2
Change, %:	0.0	1.4	-0.4

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.	16,700	17,010	15,580
Area, in ²	14.14	14.14	14.14
Load, psi	1,180	1,200	1,100
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.	16,550	17,470	16,990
Area, in ²	14.14	14.14	14.14
Load, psi	1,170	1,240	1,200
Failure Type	Concrete Failure	Concrete Failure	Concrete Failure

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TEST RESULTS: (cont.)

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.

Plastic Shrinkage Cracking - ICBO Annex A**

Mix Number	3	4
Mixture Type	Control	Fiber
Date - 10/27/99		
Cracking Value in. ²	0.149	0.025
Cracking Ratio		16.8%
Crack Reduction		83.2%
Date - 10/29/99		
Cracking Value in. ²	0.298	0.081
Cracking Ratio		27.2
Crack Reduction		72.8%
Date - 10/30/99		
Cracking Value in. ²	0.133	0.025
Cracking Ratio		18.8%
Crack Reduction		81.2%

The size of panel 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	3	4	5	8
2	2	3	5	8
3	3	4	5	8
4	3	5	7	9
5	4	5	7	9
Average	3	4	6	8

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TEST RESULTS: (cont.)

Impact Resistance - ICBO AC32 Appendix C-2

28 Day Test

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

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.

Chemical Analysis

See attached report

REMARKS:

The compressive strength, freeze/thaw, bond strength, plastic shrinkage, and impact resistance were conducted with the fibers received on September 9, 1999. All of the testing was conducted in the fall of 1999. The flexural strength and compatibility with concrete testing were conducted with the fibers received on February 21, 2002. The testing was conducted in the spring of 2002. The chemical analysis testing was conducted with fiber samples obtained from the September 9, 1999 submittal and February 21, 2002 submittal. The samples were discarded at the completion of testing. If you have any questions about this report please feel free to contact us at (651) 659-7340.

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