



**ICBO-ES AC32 TESTING OF  
MONOFILAMENT FIBERS  
AT A DOSAGE RATE OF (1.0 lbs/yd<sup>3</sup>)  
STORK TCT PROJECT NO. 032059  
MAY 13, 2004**

**BAXIM<sup>®</sup> - REGISTERED BRAND LABEL  
SPECIALTY CONSTRUCTION PRODUCTS  
BAXI-FIBER P100: MONOFILAMENT PP FIBER  
MANUFACTURED FOR BAXIM PRODUCTS**

**DATE:** August 8, 2002  
**REVISED:** May 13, 2004  
**TO:**

Material Testing • Non-Destructive Testing  
Product Evaluation • Construction Materials

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**PROJECT:** MONOFILAMENT FIBERS  
**BAXI-FIBERS P100**

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**TESTING OF CONCRETE WITH SYNTHETIC FIBERS**

**INTRODUCTION:**

The scope of our testing was as follows:

1. Perform laboratory concrete trial batching of concrete with and without fiber for comparison in the following areas:
  - 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 a written report stating whether the product meets applicable portions, i.e. tested areas, of the ICBO Acceptance Criteria For Synthetic Fiber-Reinforced Concrete.

**SUMMARY OF TEST RESULTS:**

Based on the completed test results, the Monofilament fiber, at a dosage of 1.0 lbs/yd<sup>3</sup>, meets the ICBO AC 32 - "Acceptance Criteria for Concrete with Synthetic Fibers" in the following areas. The following is a summary of the test results:

<u>Test</u>	<u>Control</u>	<u>Test- (Fibers)</u>	<u>% of Control</u>	<u>ICBO Criteria</u>
Compressive Strength	5,470 psi	5,580 psi	102.0%	≥ Control
Flexural Strength	530 psi	620 psi	116.9%	≥ Control
Freeze/Thaw Durability	65.7	77.7	118.3%	≥ Control
Bond Strength	1,240 psi	1,330 psi	107.3%	≥ Control
Plastic Shrinkage Cracking	---	---	87.6% (reduction)	Min. 40%
Impact Resistance				
7 days	3 blows	7 blows	233*	200
28 days	6 blows	11 blows	183*	150

\*Based on rounded numbers due to significant figures.

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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 - Monofilament Fiber  
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) 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 yd<sup>3</sup>**

Mix Number	1	2
Mixture Type	Control	Fiber
Portland Cement, lbs.	517	517
Admixtures:		
DARAVAIR <sup>1</sup> , 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

<sup>1</sup>The 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 <sup>3</sup>	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 <sup>3</sup>	142.1	140.0

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**TESTING OF CONCRETE WITH SYNTHETIC FIBERS**

**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 <sup>3</sup>	148.8	148.0
Moisture loss, lbs/ft <sup>2</sup> /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 <sup>3</sup>	147.4	147.0
Moisture loss, lbs/ft <sup>2</sup> /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 <sup>3</sup>	147.5	147.3
Moisture loss, lbs/ft <sup>2</sup> /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 <sup>2</sup>	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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**TESTING OF CONCRETE WITH SYNTHETIC FIBERS**

**TEST RESULTS:** (cont.)

**Compressive Strength - ASTM:C39**

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 <sup>2</sup>	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**

Sample Type:	Control	Control	Control
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

Sample Type:	Fiber	Fiber	Fiber
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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**TESTING OF CONCRETE WITH SYNTHETIC FIBERS**

**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 <sup>2</sup>	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 <sup>2</sup>	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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**TESTING OF CONCRETE WITH SYNTHETIC FIBERS**

**TEST RESULTS:** (cont.)

**Plastic Shrinkage Cracking - ICBO Annex A\*\***

Mix Number	1	2
Mixture Type	Control	Fiber
Date – 5/1/02		
Cracking Value in. <sup>2</sup>	0.843	0.060
Cracking Ratio		7.2%
Crack Reduction		92.8%
Date – 5/1/02		
Cracking Value in. <sup>2</sup>	0.740	0.075
Cracking Ratio		10.1%
Crack Reduction		89.9%
Date – 5/2/02		
Cracking Value in. <sup>2</sup>	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
<b>Average</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>7</b>

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
<b>Average</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>11</b>

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

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**TESTING OF CONCRETE WITH SYNTHETIC FIBERS**

**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**

A handwritten signature in black ink, appearing to read "John D. Lee", is written over a large, light-colored scribble.

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