AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Fiber Reinforced Polymer (FRP) Composites Rebar

FDOT

June 15, 2016

John P. Busel, VP, Composites Growth Initiative
ACMA

3033 Wilson Blvd., Ste. 420 Arlington, VA 22201
w: www.acmanet.org | t: 703.525.0511 | f: 703.525.0743 | e: jbusel@acmanet.org

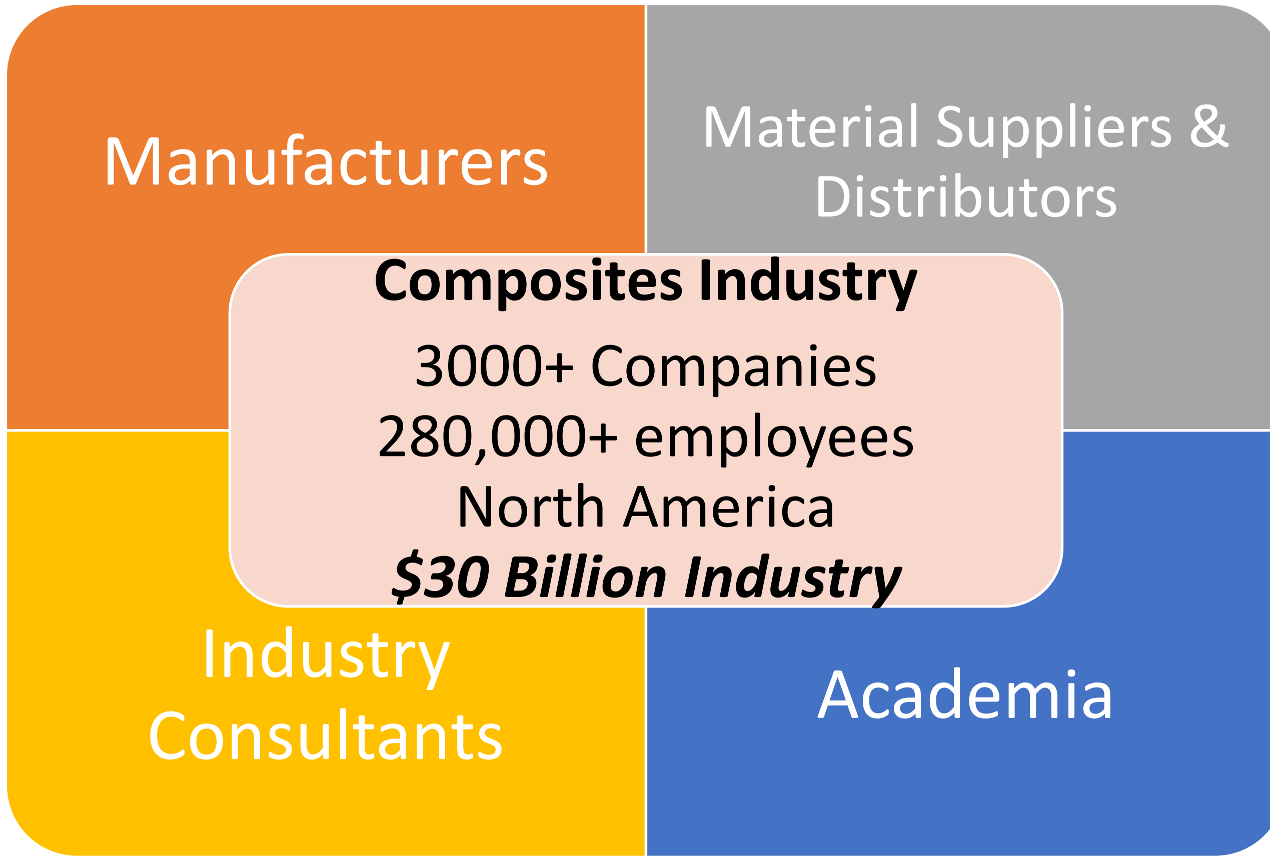
Outline

- About ACMA and Rebar Council
- Installations Today
- Durability
- Standards & Specifications
- Invitation to collaborate with FDOT

American Composites Manufacturers Association

About ACMA

- World's largest composites trade association representing the entire composites industry supply chain:



ACMA’s Industry Council

- Mission - Promote the use and growth of FRP reinforcement (rebar, tendons & grids) in concrete and masonry applications through development of quality procedures, industry specifications, performance standards, and field application guidelines.

FRP-RMC

FRP Rebar Manufacturers Council

ACMA

American Composites Manufacturers Association

FRP-RMC Manufacturers

- BP Composites (TUFF-Bar)
- C1 Pultrusions, LLC (XBar™)
- Composite Rebar Technologies, Inc. (HollowBar)
- Hughes Brothers, Inc. (AslanFRP)
- Marshall Composite Technologies, Inc. (C-Bar™)
- Pultrall, Inc. (V-ROD)
- Raw Energy Materials Corporation (RockRebar™)

ACMA
AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Concrete FRP "Community"

- FRP-RMC
- Individual producers (fabricators)
- Material suppliers
- Academia (Univ Miami, Sherbrooke, WVU, …)
- Colleagues in ACI 440
- International colleagues (academia, industry, suppliers)

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

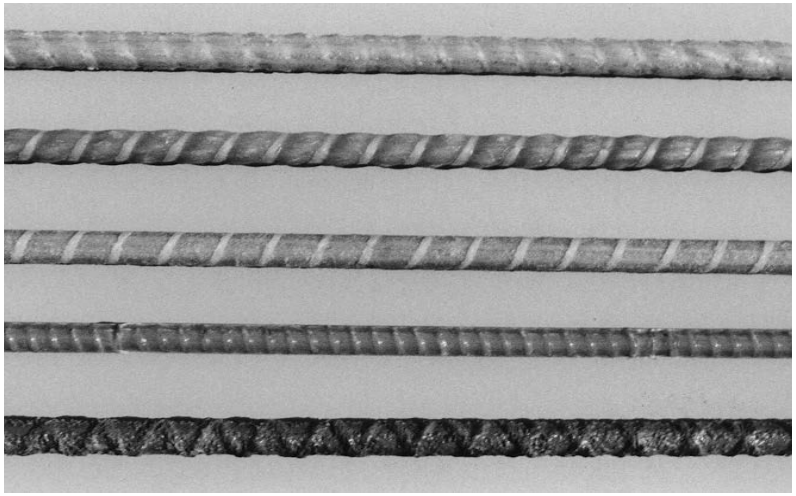
Applications: Transportation

- Cast in place bridge decks
- Precast deck panels
- Box Girders
- Barriers, parapets, sidewalks
- Box Culverts
- Rail (electrical mitigation)
- Tunneling / Soft-eye (SR99 Alaska Way)
- Structural strengthening of existing infrastructure
- Sea Walls, bulkhead caps,

American Composites Manufacturers Association

FRP Bar Types

- **Materials**
  - Glass/vinylester (most used)
  - Glass/polyurethane
  - Basalt/epoxy
  - Carbon/vinylester
- **Forms**
  - Solid
  - Round

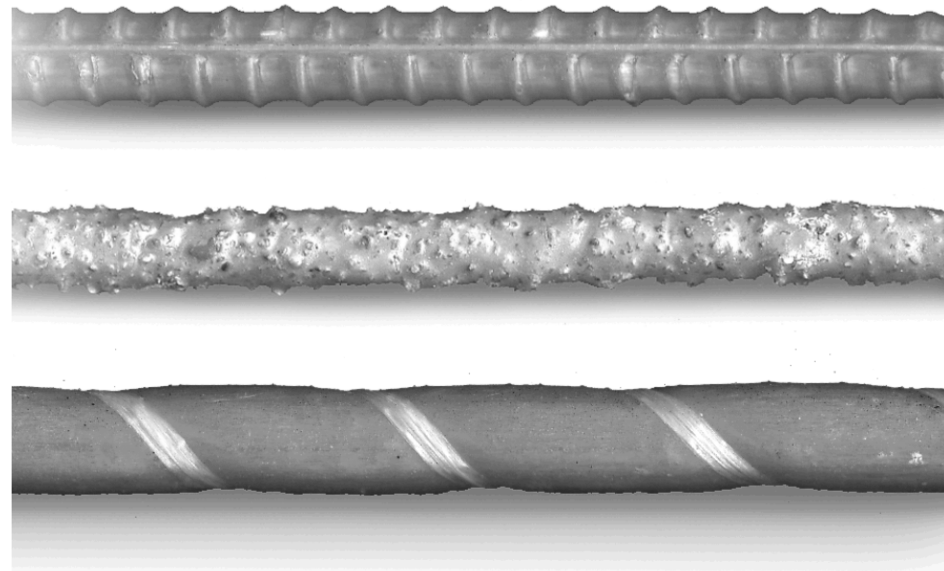


AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

FRP bar types

- **Surface**
  - ➢ Ribbed (a)
  - ➢ Sand Coated (b)
  - ➢ Helically Wrapped and Sand Coated (c)

a)
b)
c)



FRP Rebar Use in USA
67 Bridges – 27 States

not comprehensive

Colorado	2
Connecticut	1
Florida	8
Georgia	2
Indiana	1
Iowa	2
Kansas	1
Kentucky	2
Mass	1
Maine	4
Michigan	2
Minnesota	1
Missouri	6
Nebraska	1

New Hampshire	1
New York	3
North Carolina	1
Ohio	4
Oregon	1
PA/NJ	1
Pennsylvania	1
Texas	3
Utah	2
Vermont	1
Virginia	1
West Virginia	9
Wisconson	3

Applications		
Deck only	Deck, parapet, barrier, enclosure, and/or sidewalk	Parapet, barrier, enclosure, and/or sidewalk
54	8	3

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

FRP Rebar Use in Canada
211 Bridges – 4 Provinces

	Rebar	Deck only	Deck, parapet, barrier, enclosure, and/or sidewalk	Parapet, barrier, enclosure, and/or sidewalk
Bridges in Canada	211	172	25	14

McKinleyville, WV (1996)

1[st] Bridge with FRP Rebar

Courtesy of West Virginia Univ. CFC

ACMA
AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

McKinleyville, WV Bridge
Installed 1996

The McKinleyville bridge was the first vehicular bridge in the U.S. to be constructed with a concrete deck reinforced with FRP rebar. The bridge is 177 feet long by 30 feet wide and accommodates two lanes of traffic. Original surface, no repairs required in 20 years

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Photos courtesy of Dr. Hota GangaRao, Constructed Facilities Center, WVU

150 tons of GFRP = 1.2 million lbs of steel rebar or 30 truckloads
Largest “steel free deck”
Largest FRP reinforced bridge
8 truckloads of GFRP bar

GFRP in Marine & Waterfront Applications

Dry Dock rehabilitation Pearl Harbor

2001 - Dry Dock rehabilitation Pearl Harbor – Multiple Dry Docks !

2002 Sea Walls – Estee Lauder estate Palm Beach

Seawall & Road Side Barrier - Maui, HI
Honoapiilani Highway – built in 2001 with steel

Courtesy of Hughes Brothers

Seawall - Honoapiilani Highway 2012

Courtesy of Hughes Brothers

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Retaining Wall Rebuild – Maui, HI (2013)

- One-sided form using GFRP Form Ties and placement of GFRP rebar

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Courtesy of BP Composites

I-75- Tampa ~ Deck Replacement – NSM Stitching (repair / upgrade)

Courtesy of Hughes Bros.

ACMA
AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Box Girder / Column

ACMA
American Composites Manufacturers Association

Structural Strengthening – Bridge Cantilever – Old Florida Keys Bridge

Underside Cast in place repair with GFRP & CFRP bars

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Cast in place repair – CFRP & GFRP bars

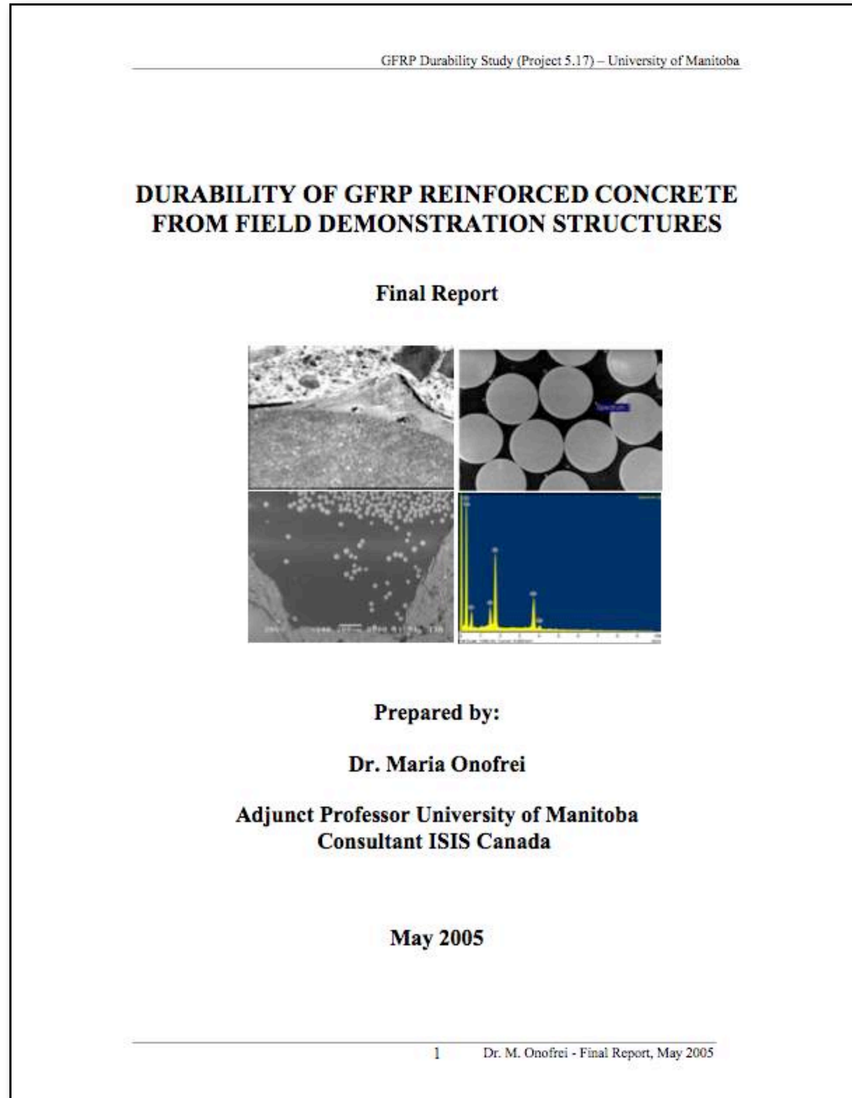
Heavy Rail – Miami MetroRail – MIA
2.4 Miles of elevated rail

- Rail Plinths 100% reinforced with GFRP Bars

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Durability - Canada

- ISIS Canada reports on Durability performance of GFRP bars in Bridge Decks in Service for 8-10 years
- Multiple reports from several institutions
- Follow-up reports after 15 years



GFRP Durability Study (Project 5.17) – University of Manitoba

DURABILITY OF GFRP REINFORCED CONCRETE FROM FIELD DEMONSTRATION STRUCTURES

Final Report

Prepared by:

Dr. Maria Onofrei

Adjunct Professor University of Manitoba
Consultant ISIS Canada

May 2005

1 Dr. M. Onofrei - Final Report, May 2005

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

NO Degradation of GFRP bars found !

Additional studies are being performed on US bridges with service over 15 years – Preliminary results – the same

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Composites in Construction 2005 – Third International Conference, Hamelin et al (eds) © 2005 ISBN xxxxx

Lyon, France, July 11 – 13, 2005

REPORT ON THE STUDIES OF GFRP DURABILITY IN CONCRETE FROM FIELD DEMONSTRATION STRUCTURES

A.A. Mufti, M. Onofrei, B. Benmokrane, N. Banthia, M. Boulfiza, J. P. Newhook, B. Bakht, G. Tadros, P. Brett

ISIS Canada, University of Manitoba
Agricultural & Civil Engineering Building, Room A250 – 96 Dafoe Road,
Winnipeg, Manitoba Canada R3T 2N2
muftia@cc.umanitoba.ca

ABSTRACT: In 2004, ISIS Canada studied the durability of GFRP in concrete by removing concrete cores containing GFRP from five Canadian field demonstration structures built during the last 5 to 8 years. Three teams working independently at several Canadian universities used a variety of analytical methods to (a) investigate whether or not the GFRP in concrete field structures had been attacked by alkali, and (b) compare the composition of GFRP removed from in-service structures to that of control specimens, which were saved from the projects and not exposed to the concrete environment. The analytical results have confirmed that the GFRP in concrete has not suffered any discernible damage during the last five to eight years. As a result of this study, the Technical Subcommittee of Fibre Reinforced Structures of the CHBDC has recommended that GFRP can now be used as primary reinforcement and prestressing tendons in concrete structures. The paper reports on the findings of the durability study conducted by the ISIS Canada Research Network.

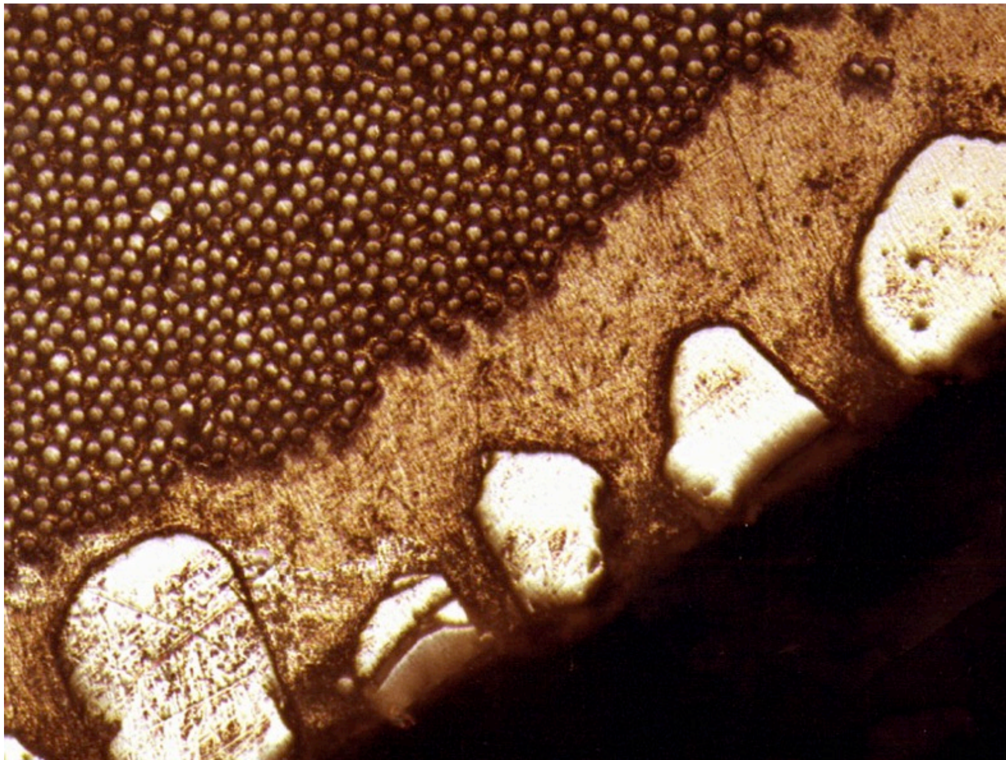
1. INTRODUCTION

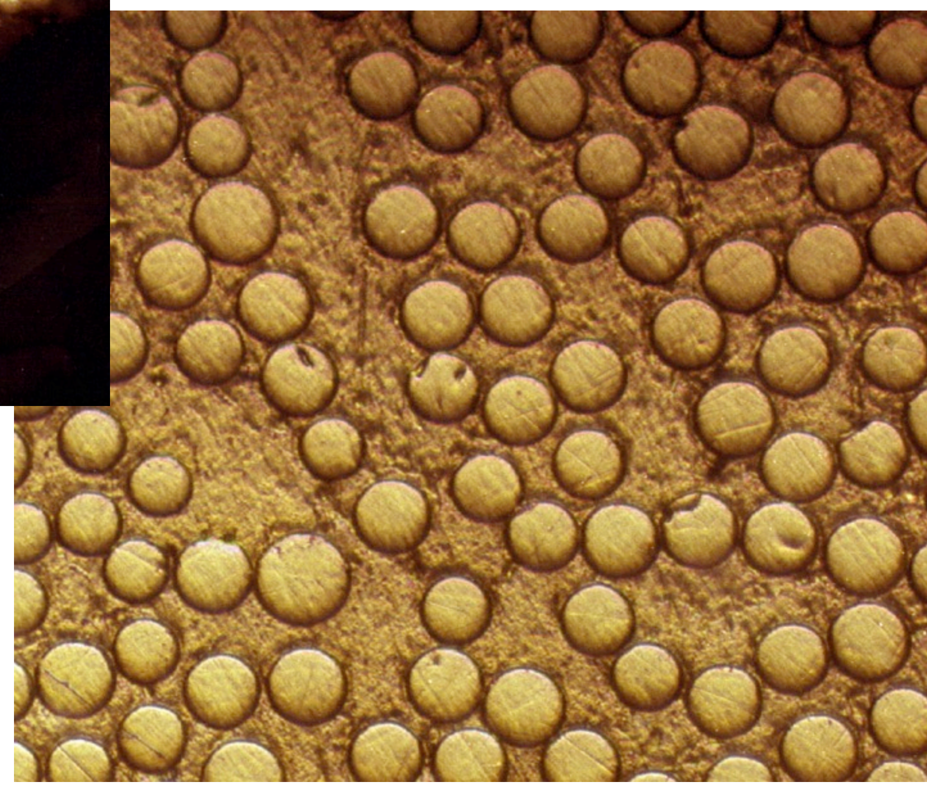
Recently, Professor U. Meier reviewed the activities of ISIS Canada [1]; he recommended that Canada, having invested significantly in innovative concrete structures with GFRP, should study the durability of GFRP in concrete. Following his advice, ISIS Canada initiated in 2004 a project, in which concrete cores containing GFRP were removed from five Canadian structures, and analyzed the GFRP for its composition at a micro level. Since previous simulated studies of the durability of GFRP in concrete [e.g., 2,3] had indicated that GFRP is not stable in the alkaline environment of concrete, the Canadian Highway Bridge Design Code (CHBDC) [4] restricted the use of GFRP as only secondary reinforcement. It has been argued in [5] that the simulated tests, whether accelerated or non-accelerated, were conducted in an alkaline environment, which is likely to be different from the concrete environment found in field structures. The objective of the study described in this paper was to provide data on the performance of GFRP in several Canadian concrete demonstration structures built during the past five to eight years. The paper reports on the findings of the durability study conducted by the ISIS Canada Research Network. The names of the authors are those of the project team that conducted the study with the President of the ISIS Canada Research Network as the project leader.

2. ANALYTICAL STUDIES

Five field demonstration projects were chosen for the study under consideration, these being the Hall's Harbor Wharf, the Joffre Bridge, the Chatham Bridge, the Crowchild Trail Bridge, and the Waterloo Creek Bridge; these structures, exposed to a wide range of environmental conditions, are well

…..a closer look



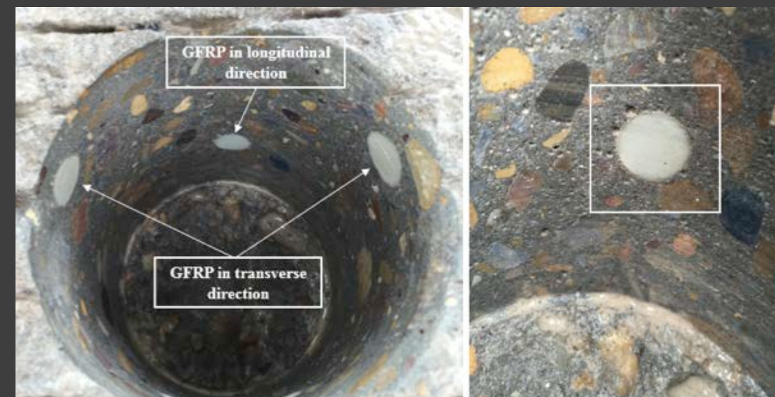


ACMA
American Composites Manufacturers Association

Durability – USA

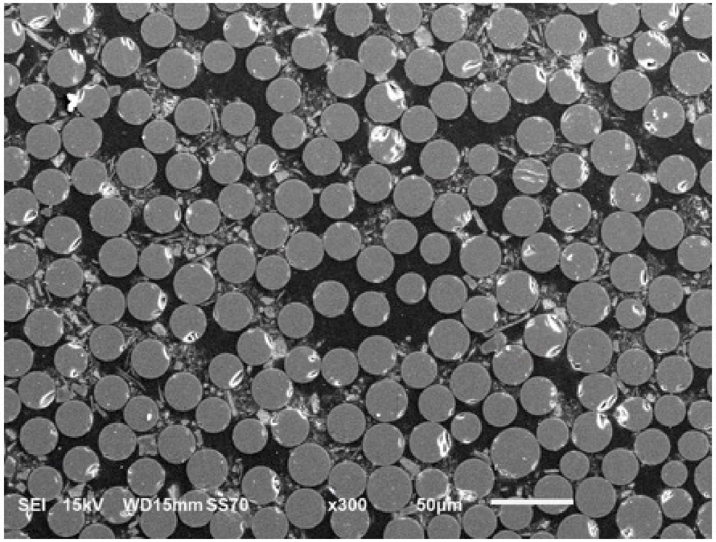
Sierrita de la Cruz Creek Bridge, Amarillo, Texas Constructed in 2000

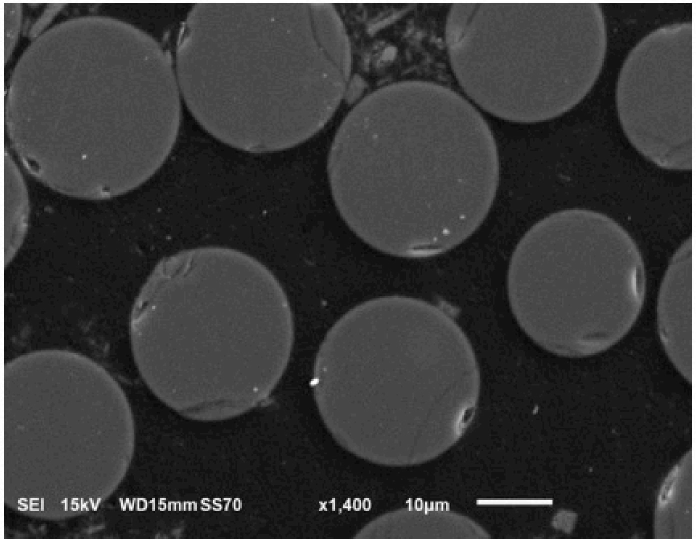
Material sampling following 15 years of use in 2015



ACMA
American Composites Manufacturers Association

Durability - USA





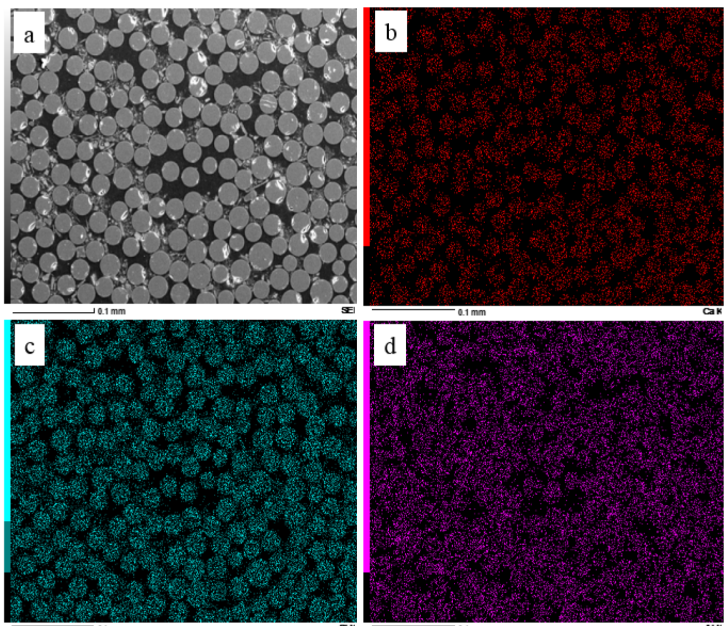
SEM analysis confirmed that there was no sign of deterioration in the GFRP coupons. Glass fibers were intact without loss of any cross-sectional areas. Fibers were surrounded by the resin matrix and no gap nor sign indicating the loss of bond between resin and fibers, was observed.

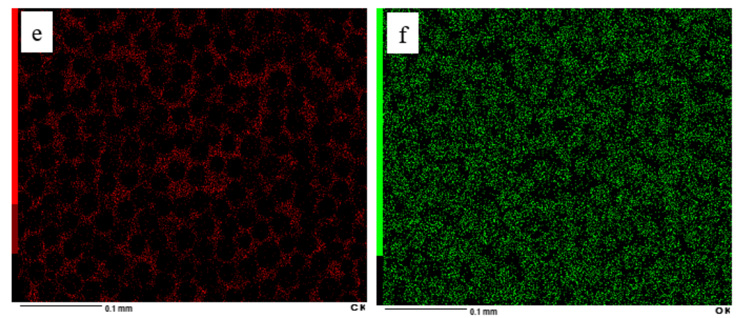
Long-term Durability of GFRP Reinforcement in Concrete: A Case Study after 15 Years of Service - O. Gooranorimi[1], **E. Dauer**[2], **J. Myers**[3], **A. Nanni**[4]
[1, 4] Dept., Civil, Architectural and Environmental Engineering, [2] Dept., Biomedical Engineering, University of Miami, Coral Gables, 33146, Florida, USA.
[3] Dept., Civil, Architecture and Environmental Engineering, Missouri University of Science and Technology, Rolla, 65409, Missouri, USA.

ACMA
American Composites Manufacturers Association

Durability - USA

Elemental scatter in GFRP bars after 15 years of service at magnification level of 300x: SEM image of GFRP (a) and elemental distributions of: Ca (b), Si (c), Al (d), C (e), and O (f)



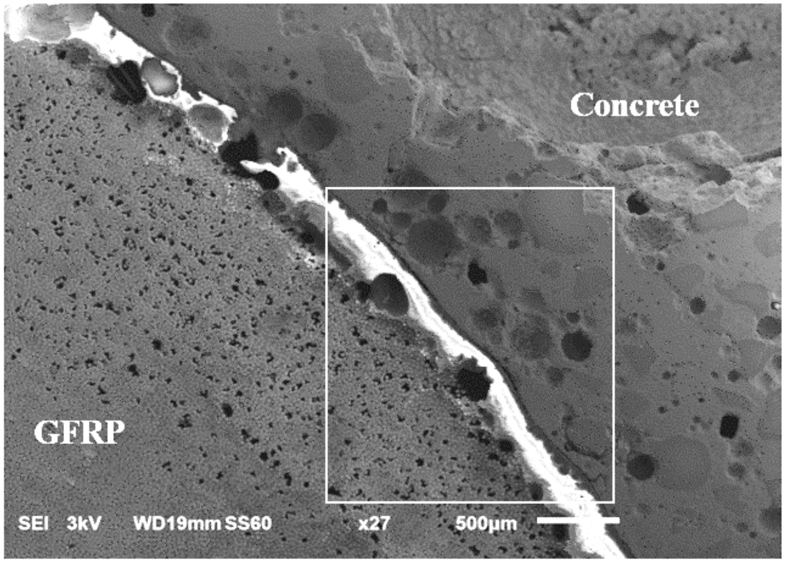


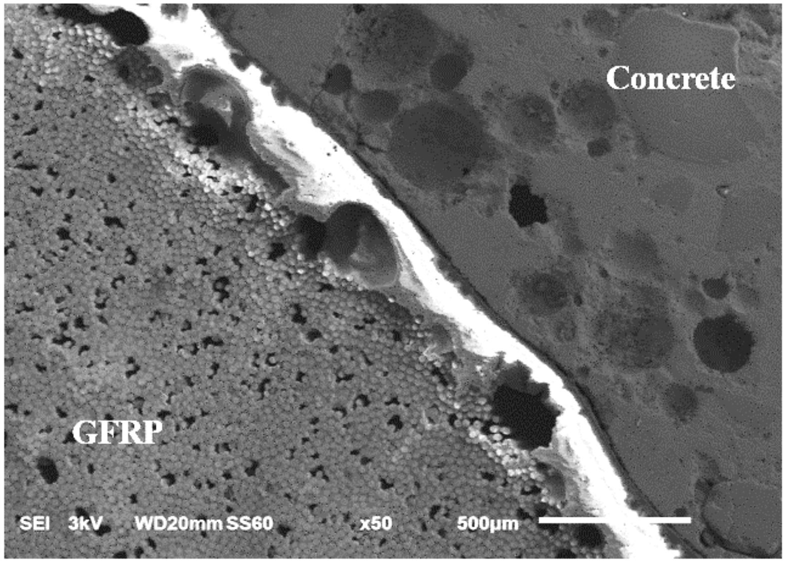
- Comparing the result of EDS analysis performed on the in-service and control samples confirmed that no change in chemical composition of fiber and matrix occurred after 15 years of service
- Silica was not dissolved in the alkaline environment of concrete

Long-term Durability of GFRP Reinforcement in Concrete: A Case Study after 15 Years of Service - O. Gooranorimi[1], **E. Dauer**[2], **J. Myers**[3], **A. Nanni**[4]
[1, 4] Dept., Civil, Architectural and Environmental Engineering, [2] Dept., Biomedical Engineering, University of Miami, Coral Gables, 33146, Florida, USA.
[3] Dept., Civil, Architecture and Environmental Engineering, Missouri University of Science and Technology, Rolla, 65409, Missouri, USA.

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Durability - USA





The GFRP to concrete interfacial bond was maintained properly and no sign of bond degradation nor loss of contact was observed after 15 years. The visible interfacial damage may be the result of sample preparation and drying in the SEM chamber [3].

Long-term Durability of GFRP Reinforcement in Concrete: A Case Study after 15 Years of Service - O. Gooranorimi[1], **E. Dauer**[2], **J. Myers**[3], **A. Nanni**[4]
[1, 4] Dept., Civil, Architectural and Environmental Engineering, [2] Dept., Biomedical Engineering, University of Miami, Coral Gables, 33146, Florida, USA.
[3] Dept., Civil, Architecture and Environmental Engineering, Missouri University of Science and Technology, Rolla, 65409, Missouri, USA.

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

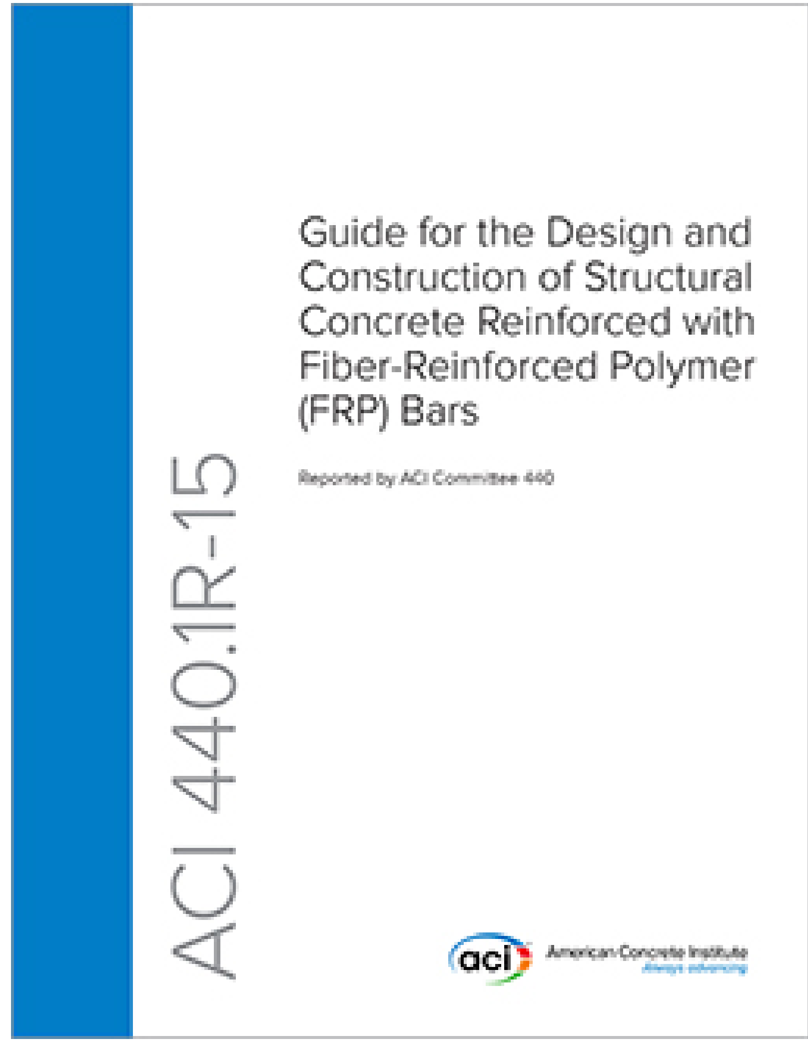
Review – Standards & Specifications

Translating research into industry standards

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

ACI – rebar design guideline

- Design principles well established through extensive research
- <u>Non-mandatory language</u>
- ACI 440.1R-15
  - 4th update to document
  - Current research added
  - Added direction on high temperature and fire effects
  - Design examples enhanced and reorganized.

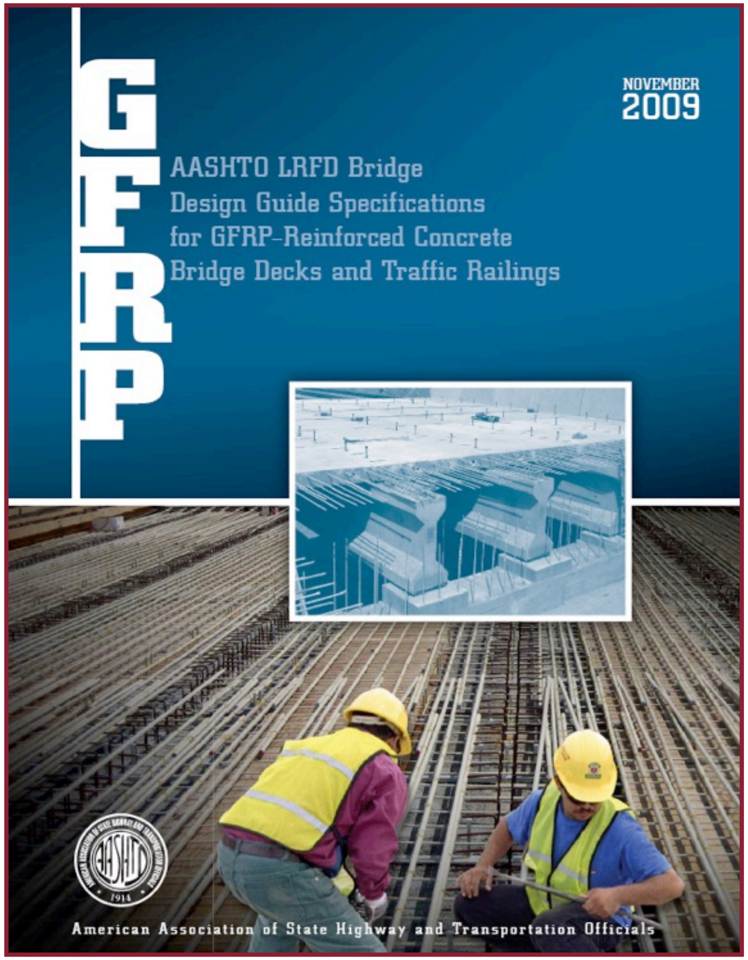

ACI 440.1R-15

Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRP) Bars

Reported by ACI Committee 440

aci American Concrete Institute
Always advancing

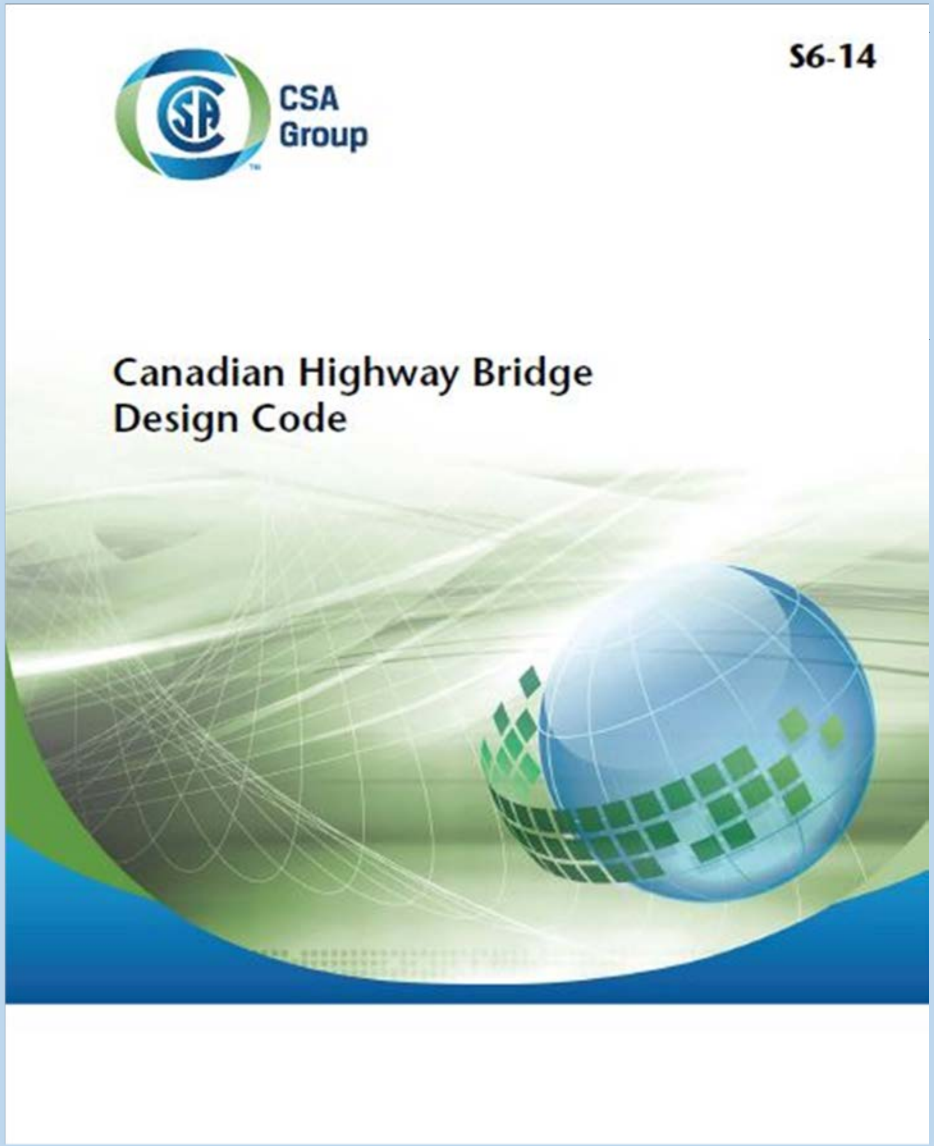
AASHTO design guide



- New AASHTO LRFD design guide specifications published 11/2009
- Bridge decks and traffic railings, glass FRP (GFRP) bars
- Specific properties of GFRP reinforcement, design algorithms and resistance factors, detailing, material and construction specifications

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Canada - Highway Bridge Design Code

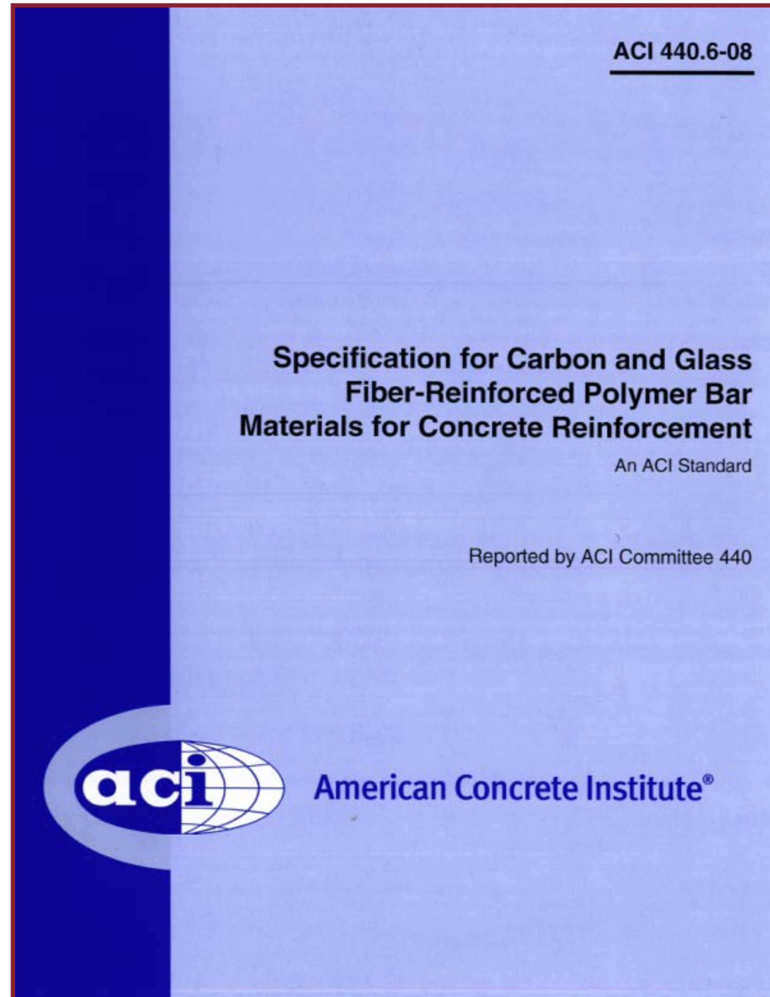


Technology transitioned from government-subsidized research projects to actual commercialization

Experience gained on viability of construction management practices where <u>FRP reinforcement is adopted through traditional bid letting processes and competitive bidding from multiple FRP bar suppliers</u>

ACI – FRP Rebar Materials Spec

- ACI 440.6-08, **mandatory language** (standard document)
- To be replaced by pending ASTM product specification


ACI 440.6-08

Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement

An ACI Standard

Reported by ACI Committee 440

American Concrete Institute®

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

ASTM D30 GFRP material specification

Table 1 – Geometric and mechanical property requirements

Bar Designation No.	Nominal Dimensions		Measured Cross-Sectional Area Limits mm² [in.²]		Minimum Guaranteed Ultimate Tensile Force kN [kip]
	Diameter mm [in.]	Cross-Sectional Area mm² [in.²]	Minimum	Maximum	
M6 [2]	6.3 [0.250]	32 [0.049]	30 [0.046]	55 [0.085]	27.3 [6.1]
M10 [3]	9.5 [0.375]	71 [0.11]	67 [0.104]	104 [0.161]	59.0 [13.2]
M13 [4]	12.7 [0.500]	129 [0.20]	119 [0.185]	169 [0.263]	96.1 [21.6]
M16 [5]	15.9 [0.625]	199 [0.31]	186 [0.288]	251 [0.388]	130 [29.1]
M19 [6]	19.1 [0.750]	284 [0.44]	268 [0.415]	347 [0.539]	182 [40.9]
M22 [7]	22.2 [0.875]	387 [0.60]	365 [0.565]	460 [0.713]	241 [54.1]
M25 [8]	25.4 [1.000]	510 [0.79]	476 [0.738]	589 [0.913]	297 [66.8]
M29 [9]	28.7 [1.128]	645 [1.00]	603 [0.934]	733 [1.137]	365 [82.0]
M32 [10]	32.3 [1.270]	819 [1.27]	744 [1.154]	894 [1.385]	437 [98.2]

- Agreed upon table of properties for designers

American Composites Manufacturers Association

ASTM D30 GFRP material specification

- Agreed upon industry criteria for limits, testing for
  - QC and
  - Characterization & Qualification

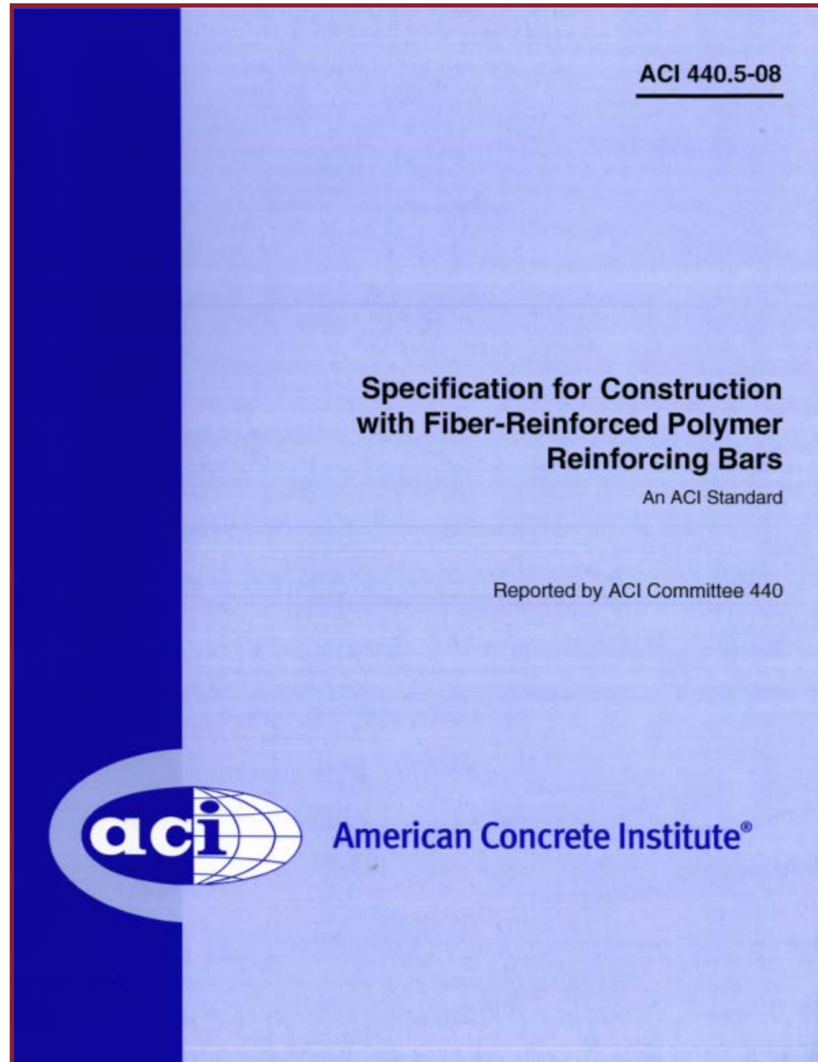
Table 3 - Physical property limits, test methods, and test purpose.

Property	Limit	Test Method	Purpose
Fiber Content	≥ 55% - volume ≥ 70% - mass	ASTM D2584 ASTM D3171	QA / QC
Glass Transition Temperature	≥ 100°C [212°F]	ASTM E1356 - DSC, or ASTM E1640 – DMA	Characterization / Qualification
Bar Size	Table 1	Measured Cross Sectional Area per ASTM D7205 paragraph 11.2.5.1	Qualification and QA / QC
Ultimate Tensile Force	Table 1	ASTM D7205	Characterization / Qualification and QA / QC
Mean Tensile Modulus of Elasticity	≥ 44,800 MPa [6,500,000 psi]	ASTM D7205	Characterization / Qualification and QA / QC
Mean Ultimate Tensile Strain	≥ 1.2%	ASTM D7205	Characterization / Qualification and QA / QC
Guaranteed Transverse Shear Strength	≥ 131 MPa [19,000 psi]	ASTM D7617	Characterization / Qualification
Guaranteed Bond Strength	≥ 7.6 MPa [1,100 psi]	ASTM D7913	Characterization / Qualification
Moisture Absorption in 24 hours	≤ 0.25% in 24 hours at 50°C [122°F]	ASTM D570, Section 7.4, or ASTM D5229 BWEP	QA / QC
Moisture Absorption to Saturation	≤ 0.75% to saturation at 50°C [122°F]	ASTM D570, Section 7.4, or ASTM D5229 BWEP	Characterization / Qualification
Alkaline Resistance	≥ 80% of initial mean ultimate tensile force following 90 days at 60°C [140°F]	ASTM D7705 Procedure A	Characterization / Qualification
Cracks and Voids	No continuous crack or void on both ends of more than three of seven consecutive 25 mm [1 in.] bar segments	Visual inspection	QA / QC
Guaranteed Ultimate Tensile Force of Bent Portion of Bar	≥ 60% of guaranteed ultimate tensile force of straight bars as listed in Table 1	ASTM D7914	Characterization / Qualification
Ultimate Tensile Force of Straight Portion of Bent Bar	Table 1	ASTM D7205	QA / QC

ACMA
AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

ACI – FRP Rebar Construction Spec

- ACI 440.5-08
  - o **mandatory language** (standard document)
- GFRP bar
  - o preparation,
  - o placement (including cover requirements, reinforcement supports),
  - o repair, and field cutting


ACI 440.5-08

Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars

An ACI Standard

Reported by ACI Committee 440

American Concrete Institute®

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

ACI – Standard Under Development

- New FRP Rebar Design Code
    - In 2014, ACI TAC approved a new standard development
- Dependent Code
    - Aligned with the exact chapters and structure ACI 318-14
    - Only chapters that impact FRP will be re-tooled to reflect the properties, characteristics, etc.
- This is expected to be a 3 year effort

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

ACI Test methods – 440.3R-12

ACI 440.3R-12

Guide Test Methods for Fiber-Reinforced Polymer (FRP) Composites for Reinforcing or Strengthening Concrete and Masonry Structures

Reported by ACI Committee 440

American Concrete Institute®

Designation: D 7205/D 7205M – 06

Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars[1]

This standard is issued under the fixed designation D 7205/D 7205M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method determines the quasi-static longitudinal tensile strength and elongation properties of fiber reinforced polymer matrix (FRP) composite bars commonly used as tensile elements in reinforced, prestressed, or post-tensioned concrete.

NOTE 1—Additional procedures for determining tensile properties of polymer matrix composites may be found in test methods D 3039/D 3039M and D 3916.

1.2 Linear elements used for reinforcing Portland cement concrete are referred to as bars, rebar, rods, or tendons, depending on the specific application. This test method is applicable to all such reinforcements within the limitations noted in the method. The test articles are referred to as bars in this test method. In general, bars have solid cross-sections and a regular pattern of surface undulations and/or a coating of bonded particles that promote mechanical interlock between the bar and concrete. The test method is also appropriate for use with linear segments cut from a grid. Specific details for preparing and testing of bars and grids are provided. In some cases, anchors may be necessary to prevent grip-induced damage to the ends of the bar or grid. Recommended details for the anchors are provided in Annex A1.

1.3 The strength values provided by this method are short-term static strengths that do not account for sustained static or fatigue loading. Additional material characterization may be required, especially for bars that are to be used under high levels of sustained or repeated loading.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 615/A 615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 883 Terminology Relating to Plastics
D 3039/D 3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D 3171 Test Methods for Constituent Content of Composite Materials
D 3878 Terminology for Composite Materials
D 3916 Test Method for Tensile Properties of Pultruded Glass-Fiber-Reinforced Plastic Rod
D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
E 4 Practices for Force Verification of Testing Machines
E 6 Terminology Relating to Methods of Mechanical Testing
E 83 Practice for Verification and Classification of Extensometer System
E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process
E 456 Terminology Relating to Quality and Statistics
E 1012 Practice for Verification of Test Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application
E 1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases
E 1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases
E 1471 Guide for Identification of Fibers, Fillers, and Core

[1] This test method is under the jurisidiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.05 on Structural Test Methods.

Current edition approved March 15, 2006. Published April 2006.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Rebar Test Methods

- ACI 440.3R-12
- ASTM D30

ACI Test Method	ASTM Standard
B.1. Bar Cross-Section	D7205
B.2. Bar Tension	
App. A. Bar Anchors	
B.3 Concentric Bar Pullout	D7913
B.4. Bar Transverse Shear	D7617
B.5. Bar Strength at Bends	D7914
B.6. Bar Alkaline Tension	D7705
B.8. Bar Creep Rupture	D7337

- ***ASTM Under development*** – Spec for GFRP Bars

ACMA
American Composites Manufacturers Association

Next steps

Areas of Collaboration

Invitation to collaborate with FDOT

1. Standards development
2. Sharing of technical reports and research information
3. New joint research on Florida’s most critical applications

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

FRP Community collaboration with Florida DOT

Standards development

- Iterate AASHTO LRFD design guide
  - Bring up to speed with 440.1R
  - Include more economical implementation (less conservatism i.e. unit strip design)
  - Include substructure and other elements besides decks & railings
- Task Group of T-6
  - FRP community to do heavy lifting
  - Florida DOT Will Potter to be liaison of task group to T-6

American Composites Manufacturers Association

FRP Community collaboration with Florida DOT

Prove durability in marine splash zone

- Core some structures with 15 years service
    - Full suite of analysis.. SEM, EDS as in TxDOT cores
- Put test beams in tidal zone
    - Pre-cracked beams under stress
    - Compare to steel reinforced

American Composites Manufacturers Association

FRP Community collaboration with Florida DOT

Test / Validate 6 concrete standard elements with most benefit to FDOT

- Substructure elements identified by FDOT
  - FDOT supplies section geometries / structural analysis /design
  - FRP community proposes economical detailing / implementation
- FRP Community tests full scale members at end of service life using C_e=0.70 or 70% of rebar to simulate theoretical 75 to 100 year end of service life
- Furnish drawings of economical detailing for given standard elements such as bulkhead caps

ACMA
AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION

Thank You

John P. Busel

Vice President, Composites Growth Initiative

American Composites Manufacturers Association (ACMA)

P: 914-961-8007

E: jbusel@acmanet.org

www.compositesinfrastructure.org/frp-rebar

AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION