FOURTH INTERNATIONAL WORKSHOP ON FRP BARS FOR CONCRETE STRUCTURES

"Advances in concrete reinforcement"

August 8-9, 2024 - Toronto, Ontario

DAY 1 Thursday, August 8th - Regional Focus on FRP Rebar Use

Welcome Remarks: 8:00 - 8:15 am:

Prof. Brahim Benmokrane, P.Eng., PhD.

Chair IW-FRPCS4

University of Sherbrooke, Sherbrooke, QC, CANADA

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Center for Integration of Composites into Infrastructure

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Organizers:

- **Chair: Brahim Benmokrane,** Professor of Civil Engineering and Tier-1 Canada Research Chair, and Industry Research Chair, Director CRUSMAC, University of Sherbrooke, Sherbrooke, QC, CANADA

- **Co-Chair: Antonio Nanni,** Inaugural Senior Scholar Professor and Chair Dept. of Civil, Arch. & Environ. Engineering, University of Miami, Miami, FL, USA

- **Co-Chair: Steven Nolan,** Senior Structures Design Engineer, FDOT Structures Design Office, Tallahassee, FL, USA

Partners & Institutional Sponsors & Organizations

- University of Sherbrooke (UDS) & The University of Sherbrooke Research Centre on FRP Composite Materials for Structures (CRUSMaC)
- NSF I/U CRC Center for Integration of Composites into Infrastructure (CICI)
- University of Miami (UM)
- Florida Department of Transportation (FDOT)
- Ministry of Transportation Quebec (MTQ)
- Natural Science and Engineering Research Council (NSERC) of Canada

Background

- IWGFRPCS-1 (**Sherbrooke,** QC 2017); IWGFRPCS-2 (**Orlando**, FL, 2019); IWGFRPCS-3 (**Online**, 2021) **: Successful**

Motivations and Objectives of IW-FRPCS4

- Rapid growth and increasing interest in area of *FRP Rebar Durability, Design Considerations, Sustainability* and *Life Cycle Costing* (New materials and products requiring assessment of long-term properties (service life : 100+ years), structural testing and field implementation.
- *Expansion of Applications* (e.g. concrete bridge decks, marine structures, buildings, water treatment plants, etc.)
- The need of research, data and technical information for *Design Guides* and *Codes Development* for efficient design (Ex., Environmental reduction factors, Creep & Fatigue stress limits, Shear design & strain limit, etc.)
- Opportunity to exchange and circulate *State-of-the-Art* knowledge and *Technology Transfer* (End users, industry, engineers, and academia).

Goal of Workshop

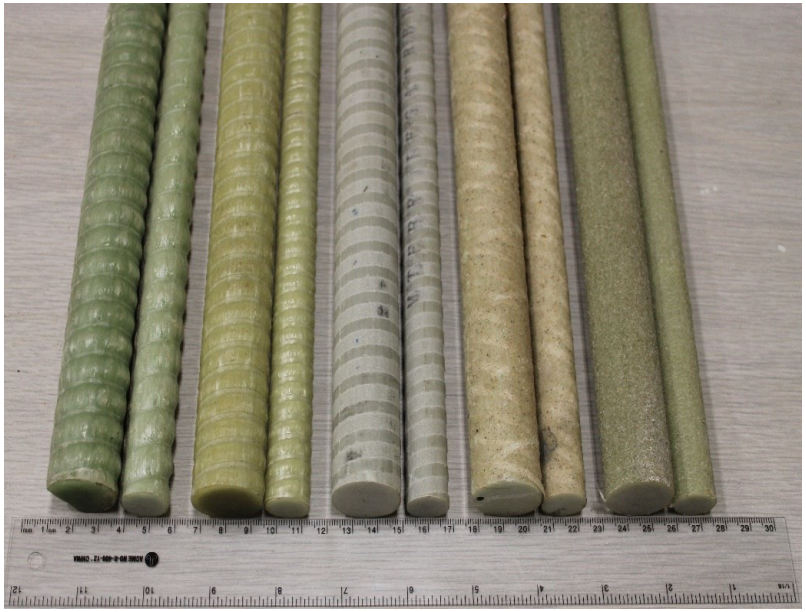
- Defining a path to broadly implement FRP bars for safe, economical, and resilient concrete structures.
- Non-corrosive FRP rebars are an effective alternative to steel-reinforced concrete, with a potential broad market of applications.
- This workshop is geared for stakeholders involved in concrete construction, including owners, manufactures, installers, distributors, engineers, architects, and provinces, state, and city/local officials.
- The workshop aims to define a path to more fully implement FRP bar and hybrid solutions for concrete structures.

Goal of Workshop

- Several GFRP bar manufacturers or suppliers qualified their products and obtained approvals from end-users and government authorities (such as FDOT, MTO and MTQ):

Mean Tensile Modulus: 60 GPa (High Modulus)
Minimum Guaranteed Tensile Strength: 1000 MPa

1. MST-BAR INC.
2. PULTRALL INC.
3. PULTRON INC.
4. SFTec INC.
5. SIREG USA
6. DEXTRA
7. ROECHLING
8. Etc.



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USE OF FRP REBARS IN REINFORCED CONCRETE STRUCTURES

Bridges

Parking Garages

Water Treatment Plants

Piers

Pavements

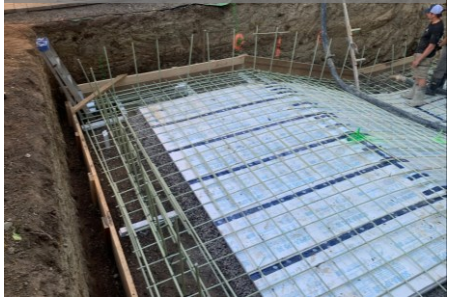
Buildings

Highways

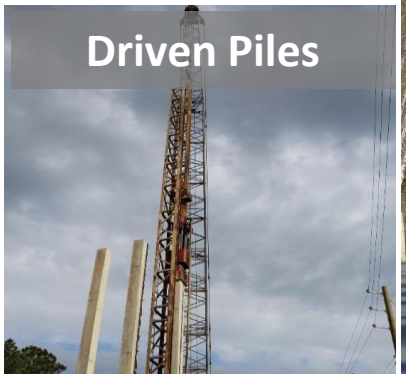
Cable-Stayed Bridges

Water Tanks

Foundations



Driven Piles



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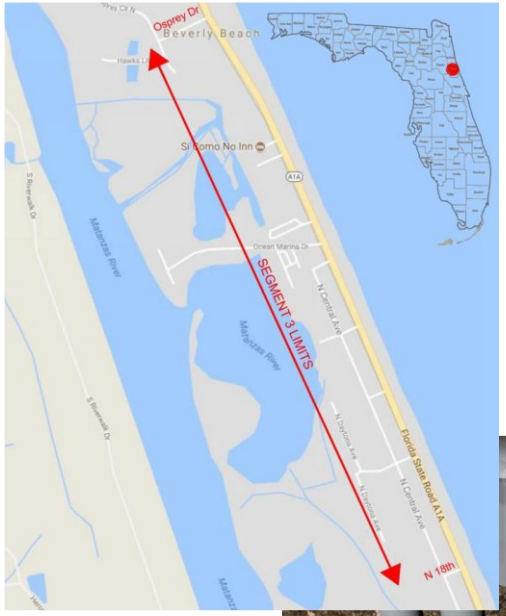
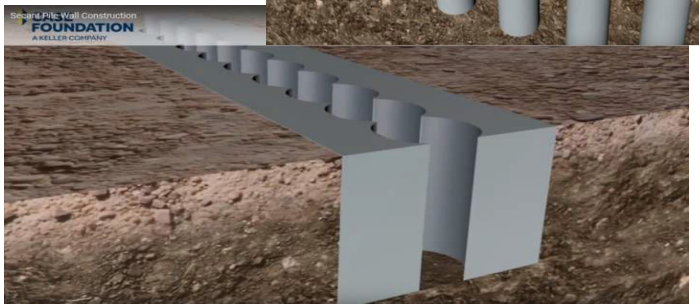
Florida Department of Transportation (FDOT) – Use of FRP rebars in bridges (cast-in-place and precast)

FDOT - Flagler Beach – Secant Pile Wall – Florida, USA



Sea Wall Length: 1.5 Km (DAYTONA BEACH)
Owner: Florida DOT
Contractor: Malcom Drilling & Superior Construction



FDOT - Flagler Beach – Secant Pile Wall – Florida, USA

Photo showing a part of GFRP reinforcement delivery on site for a seawall project in Florida (FDOT) – Greater than one million linear feet of GFRP reinforcing bar

Cages of 25 mm GFRP bars and 15 mm GFRP Spirals

Jizan Flood Mitigation Channel (Saudi Arabia)

- The Jizan Flood Mitigation Channel is to date, the largest project worldwide to be using GFRP rebar as its concrete reinforcement throughout
- This project is the 23-kilometer-long and up to 80-meter-wide flood mitigation channel in Jizan, Saudi Arabia.
- The channel lining comprises concrete reinforced with GFRP bars. About 11 million linear m of GFRP bars (11 000 km) were used to reduce project execution time and enhance durability of the structure in the region's harsh environment.

Jizan Flood Mitigation Channel (Saudi Arabia)

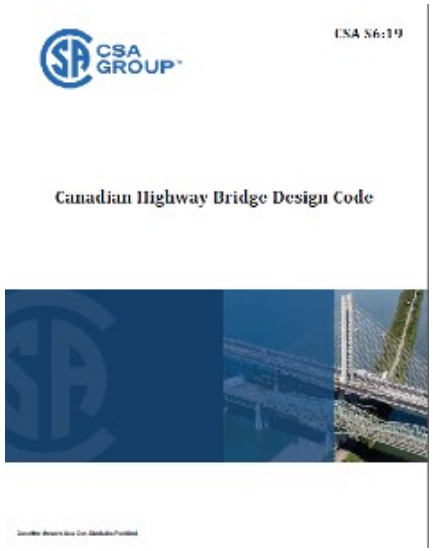
- Thickness of slab: 200 mm
- GFRP bar #4 (13 mm); 600 MPa; 50 GPa spaced at 200 mm
- GFRP bars placed at the top one-thord of the slab (75 mm) for crack control; Crack width:: 0.7 mm
- Plus de 200,000 m3 de béton (Class C25 (25 Mpa compressive strength at 28 days)
- First Cost: GFRP versus ECS (Epoxy coated steel): Reinforcing bars, concrete; bar supports and ties; labor; safety gloves.
  COST OF GFRP BARS = 79% OF ECS BARS
- Several projects by Saudi Aramco using GFRP bars

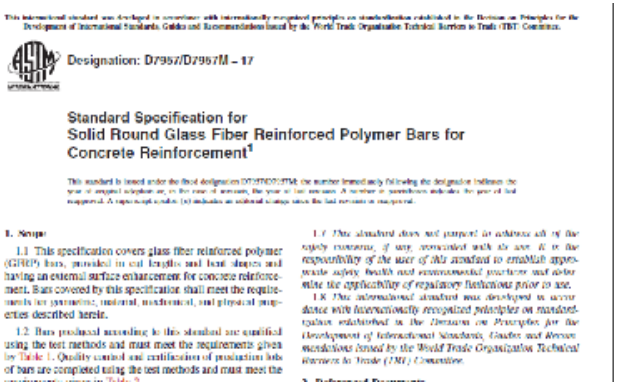
Current Field Applications in North America using GFRP Bars

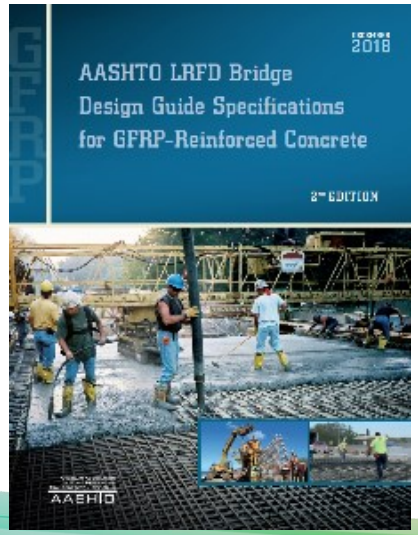
Example of engineering firms in North America that are familiar with the design using FRP bars:

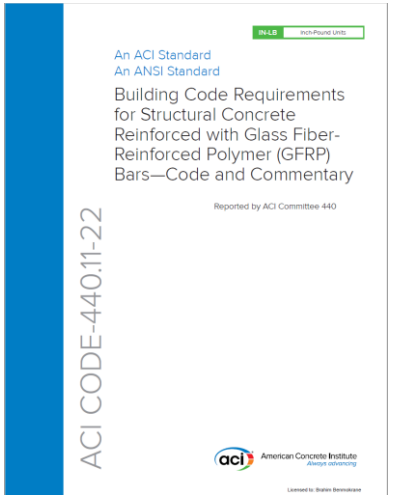
- WSP,
- AECOM,
- Stephenson Engineering,
- RJC,
- Stantec,
- Mott MacDonald,
- ARUP,
- Moses Structural Eng'rs, Entuitive,
- McIntosh Perry,
- Belanger Eng'r Associated,
- NORR,
- Blackwell Structural Engr's,
- IBI Group,
- EXP,
- CIMA+,
- GM Blue Plan,
- Parsons,
- AMEC Foster Wheeler,
- Brenik Eng'r,
- Dorlan Eng'r,
- Atkins & Van Groll Eng'rs,
- SNC-Lavalin,
- EMS,
- etc.

FRP Rebar Design Codes & Specifications in North America









IW-FRPCS4 Workshop Structure

Single session format (6 sessions)

- We urge you to keep your slides & initial remarks to **the allocated time** so that we can engage the audience with a meaningful discussion.
- It is important **to focus on the big issues** your agencies, organizations, or firms you represent must tackle and the hurdles/opportunities you see as designers and contractors, preferably highlighted by recent project experience. **For researchers, it is important to focus on the most important research needs to advance this technology.**
- The idea is that **we communicate the shared challenges** and discuss any effective strategies from your experience.

IW-FRPCS4 Workshop Structure

TECHNICAL PROGRAM OUTLINE

August 8, 2024 (8:00am – 5:45pm EDT) – 3 Sessions -

- Introductions: (8:00am-8:15am)
- Session 1a: Owners (Canadian) Perspectives & Lessons Learned (8:15am-10:00am)
- Session 1b: Owners (US & International) Perspectives & Lessons Learned (10:15am-12:00pm)
- Session 2: Contractors & Practitioners Perspective (1:15pm-3:00pm)
- Session 3: Hot Topics in FRP-RC (3:15pm-5:30pm)

August 9th, 2024 (8:00am – 3:00pm EDT) – 3 Sessions -

- Session 4: Standards & Specifications Perspective on the use of FRP Rebar (8:00-9:45am)
- Session 5: Advancing FRP Rebar Manufacturing & Product Development to meet Market Needs (10:00am-12:15pm)
- Session 6: FRP Rebar Research Needs and Advancements (12:15pm-2:30pm)
- Workshop Closure & Luncheon. (2:45pm-3:00pm)

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WE HOPE THAT YOU WILL ENJOY THE WORKSHOP

Professor Brahim Benmokrane
University of Sherbrooke
August 8, 2024

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WORKSHOP CLOSURE

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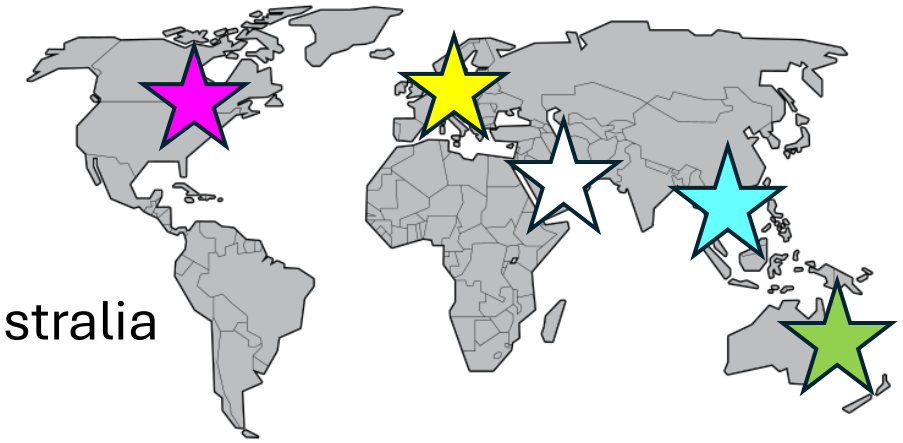
What did we learn yesterday

- Owner's Perspective's
  - Canadian
  - US
  - European
  - Saudi Arabia
  - SE Asia & Australia



- Emerging Applications
  - Hybrid Reinforced Columns
  - Climate driven shock & stressor risk quantification
  - Collaborative Opportunities with NEx and NEU

- Construction & Design Perspectives
  - Wind turbine foundations
  - Bridge construction
  - Geotechnics & Tunneling applications
  - Design Tools
  - Bridge Traffic Railing Improvements for Large Truck Impact
  - Importance of Connections & Splicing.

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What did we learn this morning:

- **Codes, Standards & Specifications Perspectives:**
  - Canada (CSA)
  - ACI International
  - AASHTO Design (US)
  - AASHTO Product Evaluation (CCR)
  - FRP Institute (Auditing & Education resources)

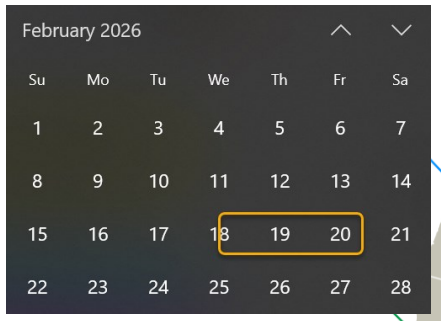
- **Industry Perspectives:**
  - Advancing Resin Systems
  - Higher Performance Bars, Bends, & Post-Installed embedment
  - NDT – Detection using GPa
  - EPD's and LCA
  - Coupling and Splicing

What did we learn this this afternoon:

- **Research Advancements & Needs:**
  - Lap-Splice length improvement
  - Bond & Development Length
  - Developments "Downunder"
    - Next Generation Bars
    - Segmental Precast Decks
  - Interface Shear
  - Lightweight Concrete
  - Extreme Cold & Fire Resistance
  - Thermoplastic Resin System

Announcements

- **IW-FRPCS 2026**
  - Option1: Miami or Orlando - Feb/Mar 2026 *(18-months)*
  - Option 2: Atlanta - Fall 2026 *(26 months)*
  - Option 3: Las Vegas - Spring 2027 *(31-months)*



*This map denotes the approximate location for each of the **28 separate billion-dollar weather and climate disasters that impacted the United States in 2023.***

Future ACI events:

- **Philadelphia, PA, USA.** November 3-6, 2024. Marriott Philadelphia Downtown
- **Toronto, Ontario, Canada.** March 30-April 2, 2025, Sheraton Centre Toronto
- **Baltimore, MD, USA.** October 26-29, 2025, Hilton Baltimore & Marriott Baltimore Inner Harbor
- **Rosemont/Chicago, IL, USA.** March 29-April 1, 2026, Hyatt Regency O'Hare
- Atlanta, GA, USA. October 11-14, 2026, Hilton Atlanta.
- **Las Vegas, NV, USA.** March 21-24, 2027, Caesars Palace Las Vegas

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