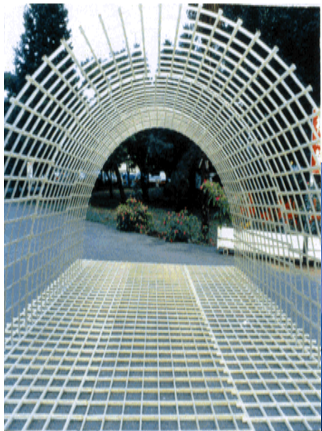
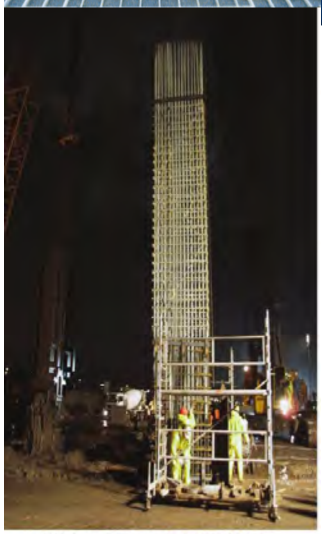




GFRP rebar cage being prepared for installation of the soft-eye.

FRP Distributors INC
Sustainable Concrete Solutions

Using Fiberglass (GFRP) Rebar in Infrastructure and Building Applications

Presented by

Malcolm McNeill, FRP Distributors Inc

Manufacturers Representative for BP Composites Ltd.

CANADA GREEN BUILDING COUNCIL • CONSEIL DU BÂTIMENT DURABLE DU CANADA • MEMBER





2,000 Year Old Concrete Roof

WHY CONCRTETE NO LONGER LAST 2000 YEAR'S…

Image above: Pantheon- Rome
Top Left : Gath-India
Bottom: Pointe de Guard Aqueduct- France

This unconventionally-shaped curb and the adjacent street have sustained substantial damage and deterioration.

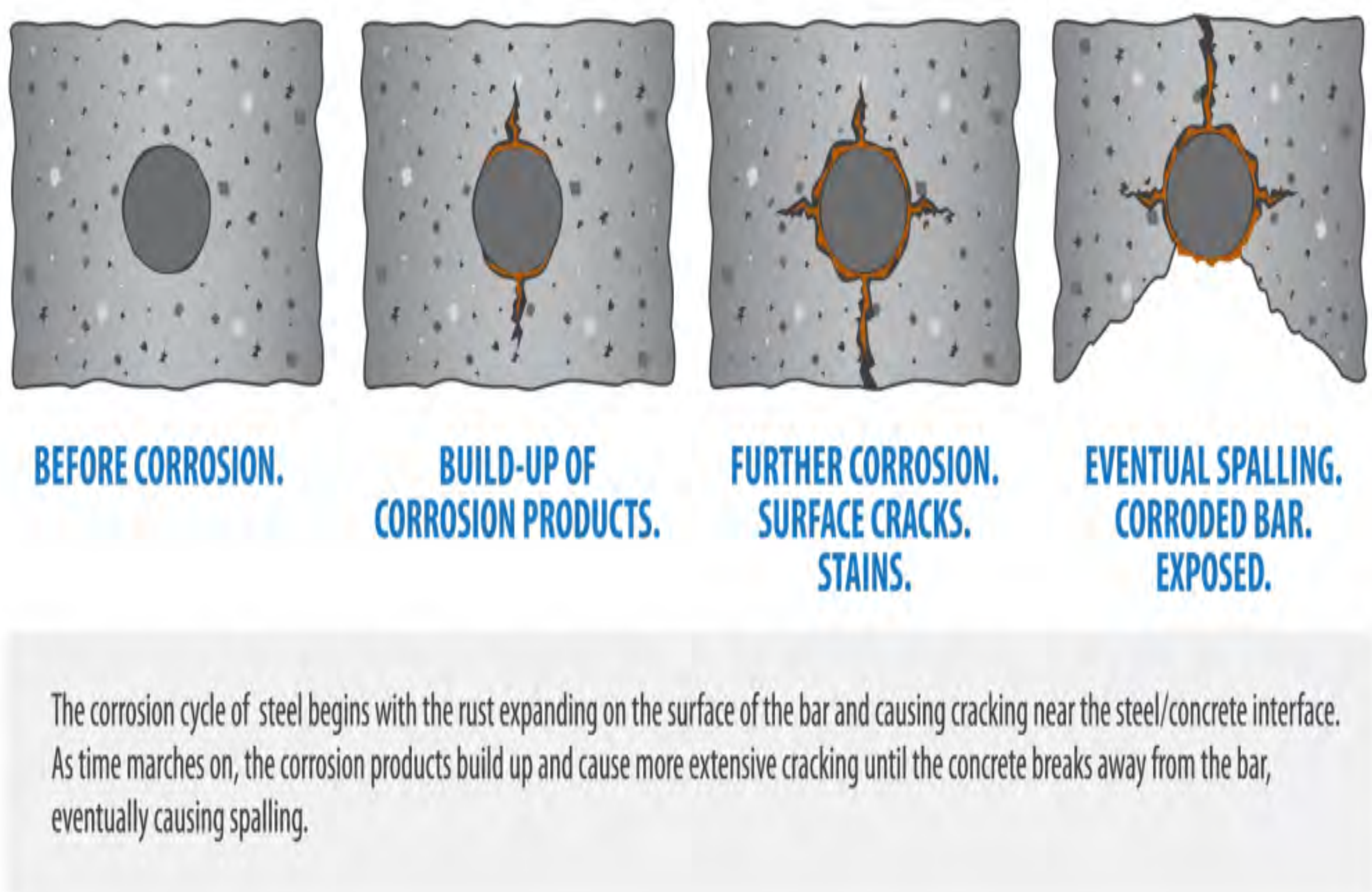
- **To prevent concrete from collapsing under cyclic fatigue loads 20th century constructors began incorporating steel rebar into concrete**

On left: vehicle traffic breaks apart un-reinforced concrete curb

Bottom image: earthquake causes un-reinforced concrete houses to collapse in Haiti

Durability Dilemma

- **Corrosion of reinforcing steel: primary reason behind the global infrastructure crisis of today.**

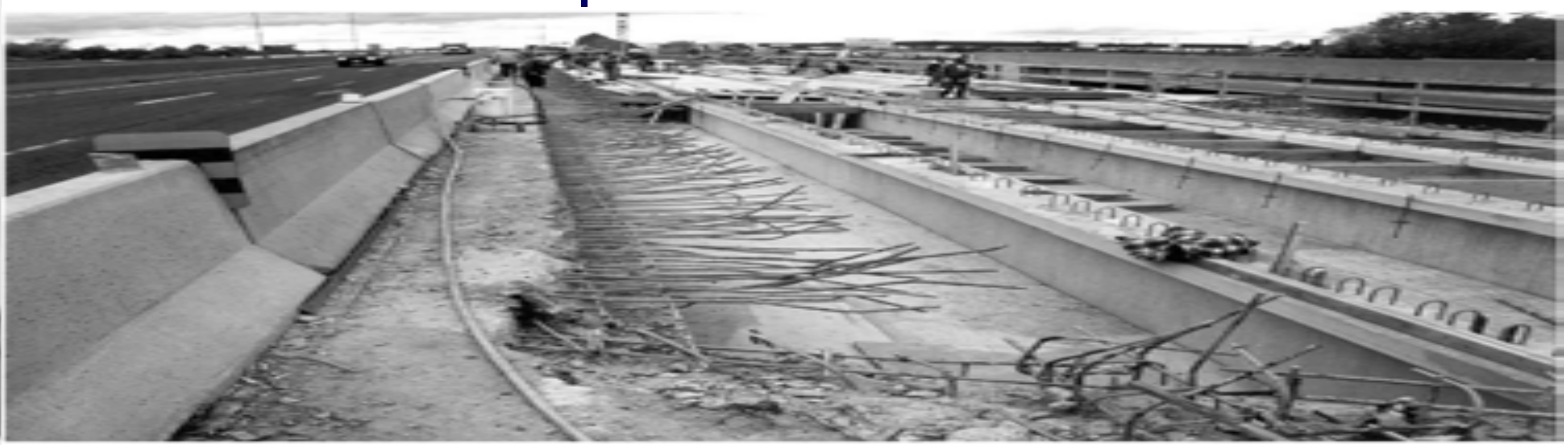


Durability Dilemma

- **Expensive remedial measures (HPC, patching with advanced repair materials, cathodic protection, epoxy-coated, micro-alloyed or galvanized steel) have been proposed**
- **Unfortunately, none has proven to be effective in providing a long-term solution.**

Images **of 16 year old epoxy coated steel reinforcement** from Humber River Ontario Bridge, MTO Ontario 1998

Estimated cost to repair this structure 5 times in the next 100?



Steels Corrosion Effect
Stage 1: Rust Staining

Original Cost to pour this entry way... $2,000

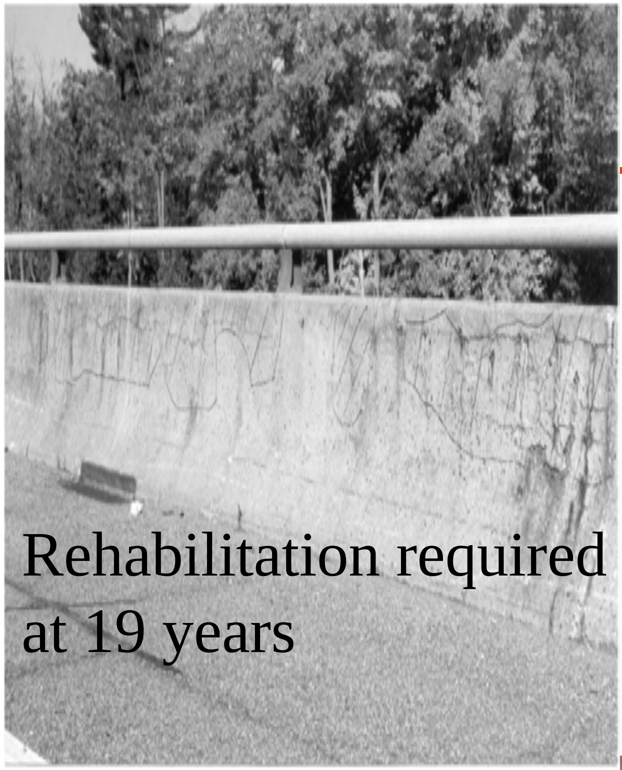
Current demolition cost....$1,000

Current Cost to pour a new slab ...$6,000

Total Cost of Rehabilitation....$9,000

Cost difference to use GFRP vs. Black Steel in this application **$300**

Steels Corrosion Effect
Stage 2: Cracking



On left: 19-year-old Ontario Epoxy Coated reinforced bridge barrier experiences delaminating cracks.

MTO 2005 Ontario, Canada

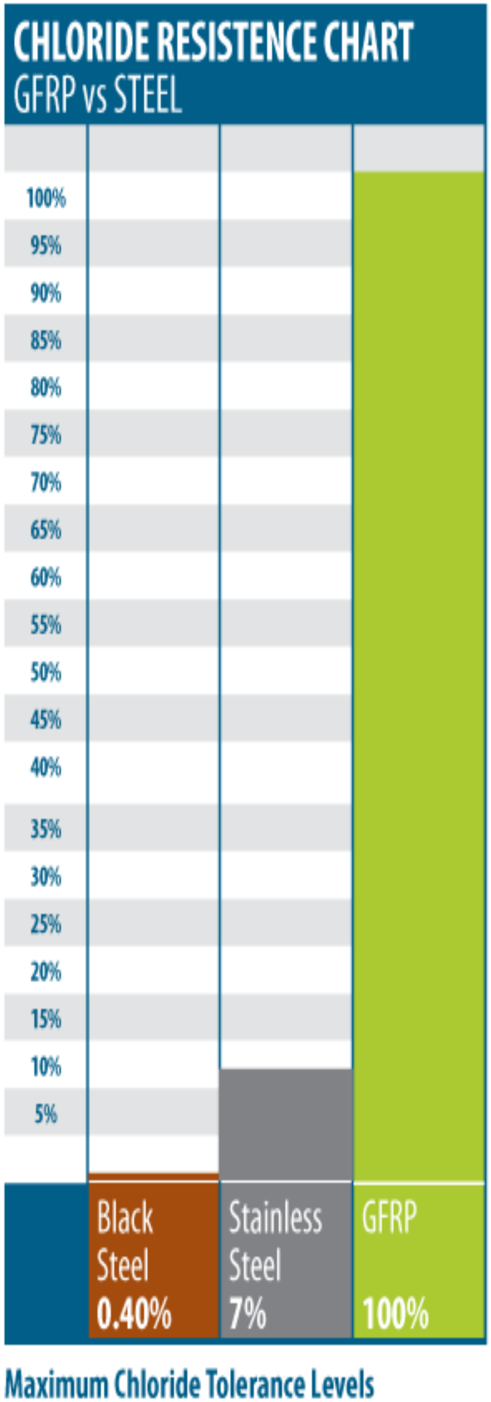
Below: 23-year-old Galvanized reinforced bridge deck suffering from corrosion induced cracking.

MTO 2007 Ontario, Canada

Steels Corrosion Effect
Stage 3: Spalling

Original Cost to Pour and Place Barrier…..... $650.00
Current pickup & demolition cost…………..$500.00
Cost to pour and place new barrier………$1,100.00
Total Cost of Rehabilitation…………… $2,150.00

Pricing November 18, 2010
Cost difference to use GFRP vs. Black Steel $21.00
Cost difference to use GFRP vs. Galvanized none



Steels Corrosion Effect
Stage 4: Collapse

13 year old swimming pool roof in Switzerland collapsed after failure of stainless steel rods due to chloride induced corrosion.

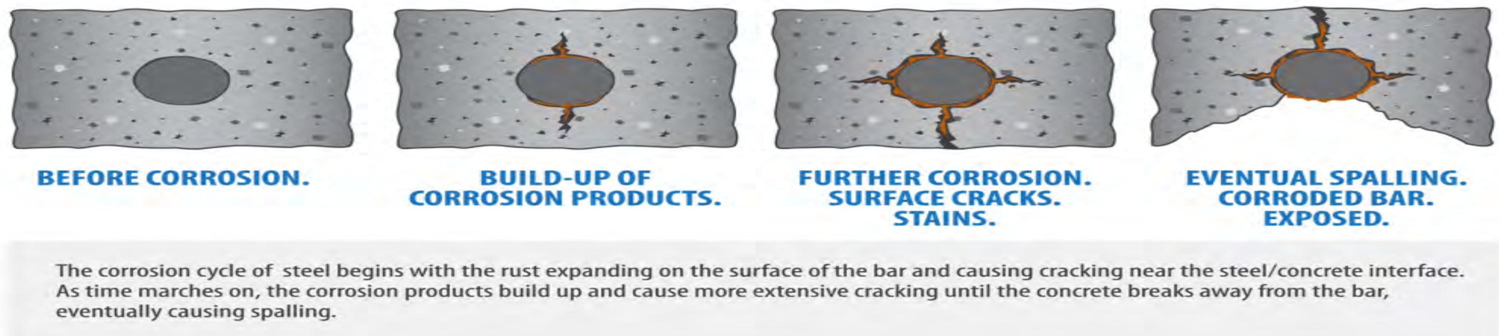
www.corrosiondoctor.com

Durability

- **Eliminate the source of corrosion problems. A better alternative: corrosion-free glass fibre-reinforced polymers (GFRPs)**
  - New construction (internal reinforcement)
  - Older structures (repair and strengthening)
- **Other attractive characteristics of GFRPs**
  - Light weight (1/4 the weight)
  - Ease of placement
  - Excellent mechanical properties
  - Damage tolerance
  - Magnetic neutrality

Durability Solution

- **GFRP eliminates the corrosion effect created by steel**



- **Image below: core sample from GFRP in Hall's Harbor, New Brunswick, Canada**

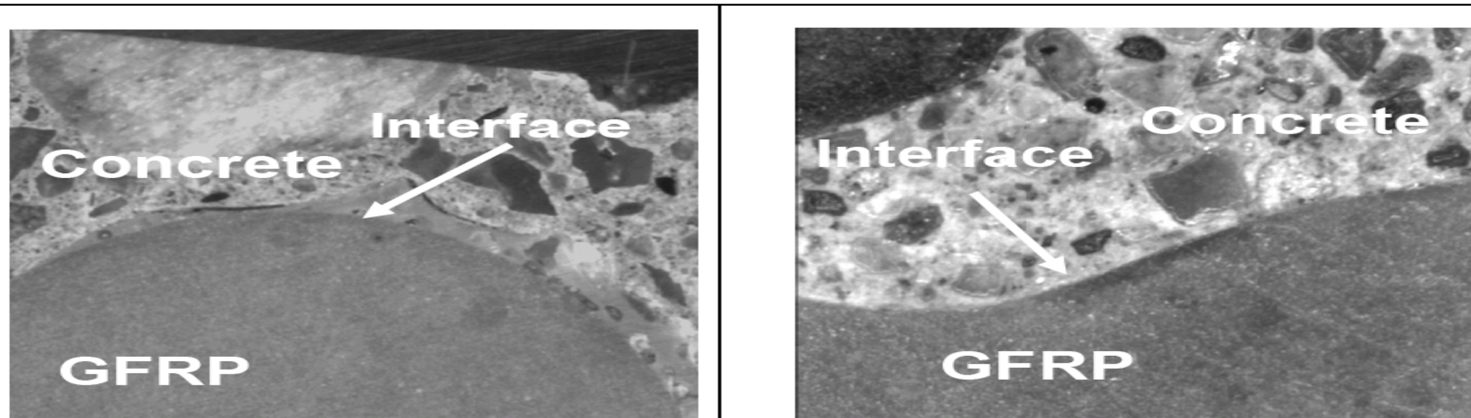
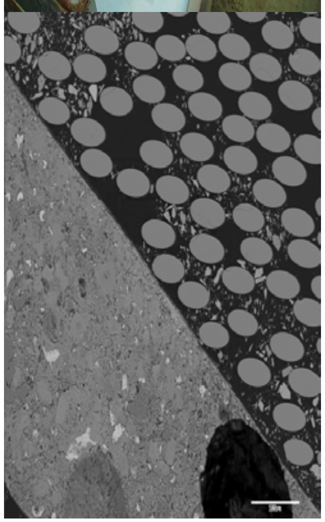


Figure 39: High Magnification Images of GFRP-Concrete Interfaces:
(Left) Sample from Hall's Harbor Wharf and (Right) Sample from Joffre Bridge (31-32)



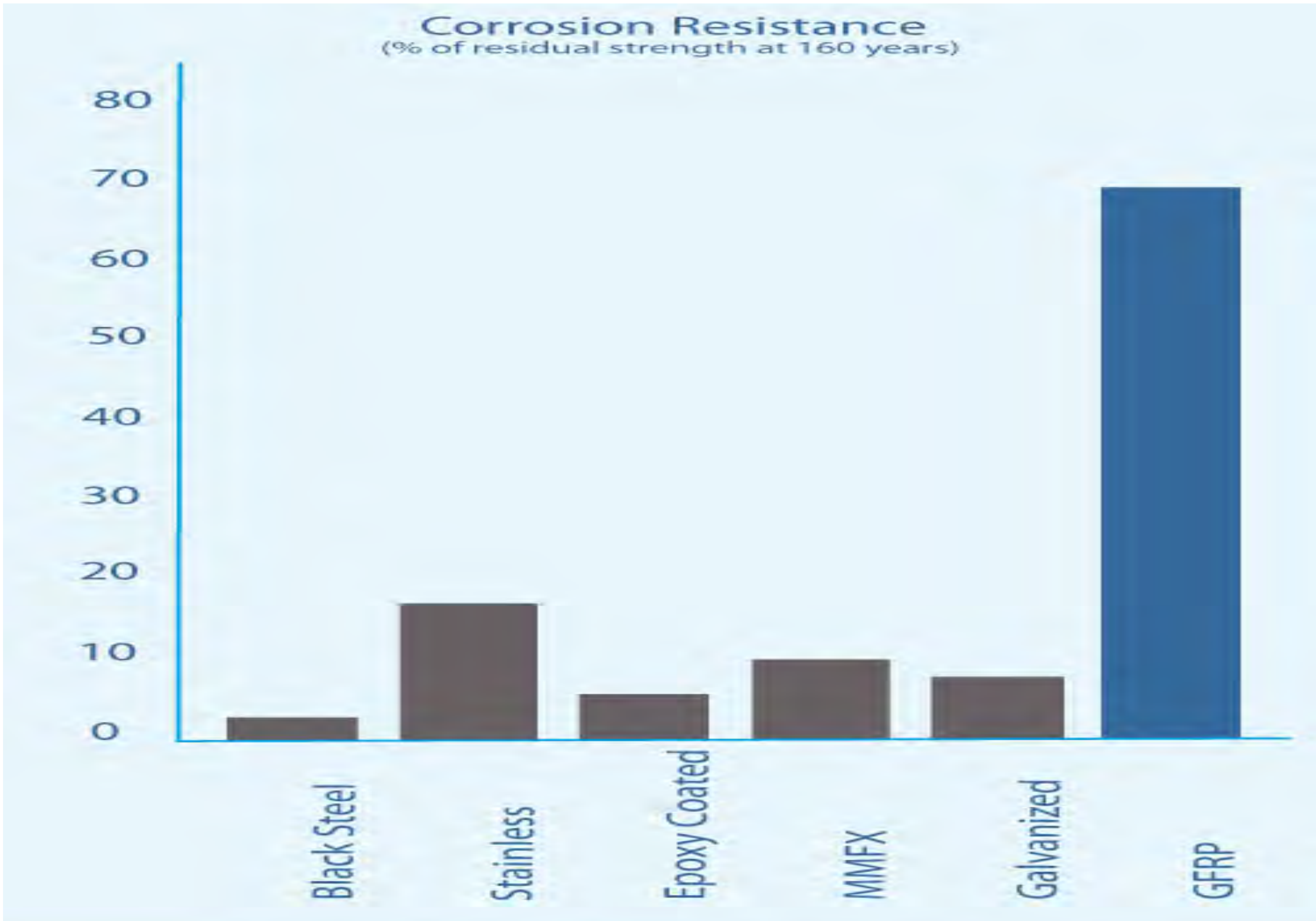
Studied in 12 Countries and 70 Universities

22 Researchers from 14 Canadian Universities concluded a life expectancy of 100 years or more:

- **EXCELLENT BONDING**
- **NO DEBONDING**
- **NO MICROCRACKING**
- **NO VOIDS**
- **NO RESIN MICROCRACKING**
- **NO GLASS FIBRE DEGRADATION**
- **NO SIGNIFICANT DELAMINATION/DEBONDING**
- **NO GLASS TRANSITION**
- **NO SIGN OF CHEMICAL DEGRADATION OF THE RESIN**
- **NO CHEMICAL DEGRADATION (HYDROLYSIS)**

Corrosion Resistance

- **Residual strength at 160 years**



Nemkumar Benthia, UBC, M. Boulfiza U. Saskatchewan. 2004



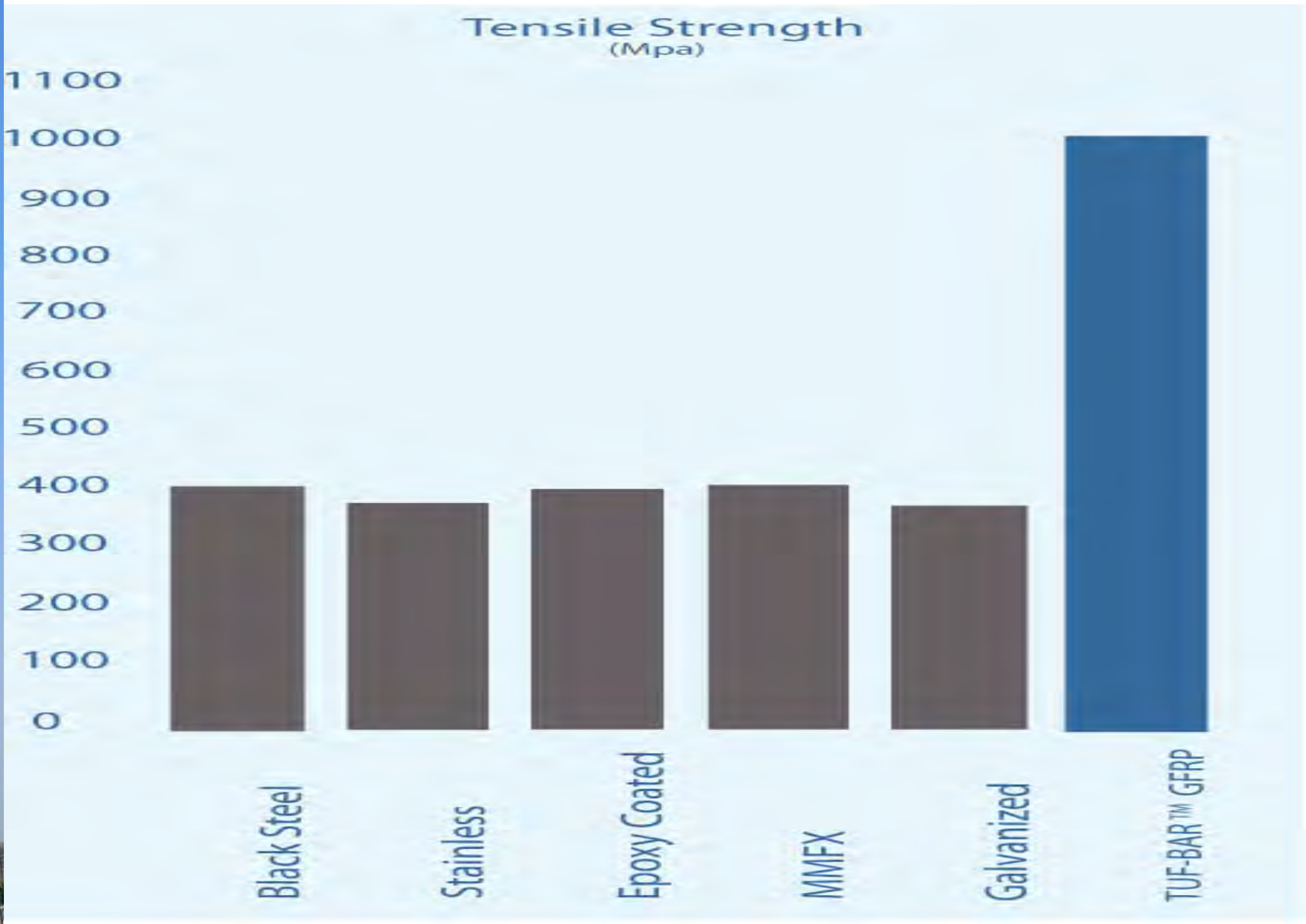
Property Comparison

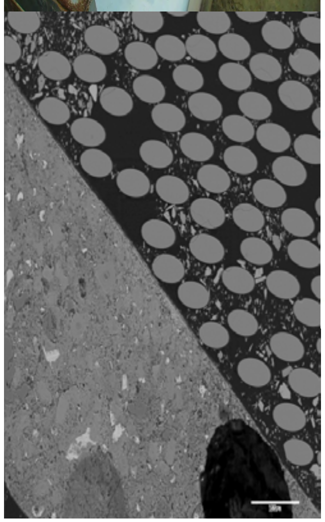
TUF-BAR™ GFRP VS STEEL

	Black Steel	Stainless Steel	*TUF-BAR* ™
Price		5x-10x Black Steel	**Equivalent to Galvanized**
Corrosion	Susceptible	Susceptible	**Non-Susceptible**
Weight			**1/4 of Steel**
Tensile Strength			**2x Steel/ Stainless**
Modulus	200 GPa	200 GPa	**40-60 GPa**
Bond Strength	8-11 MPa	8-11 MPa	**10-16 MPa**
Thermal Conductivity	Yes	Yes	**No**
Electrical Conductivity	Yes	Yes	**No**
Magnetic	Yes	No	**No**

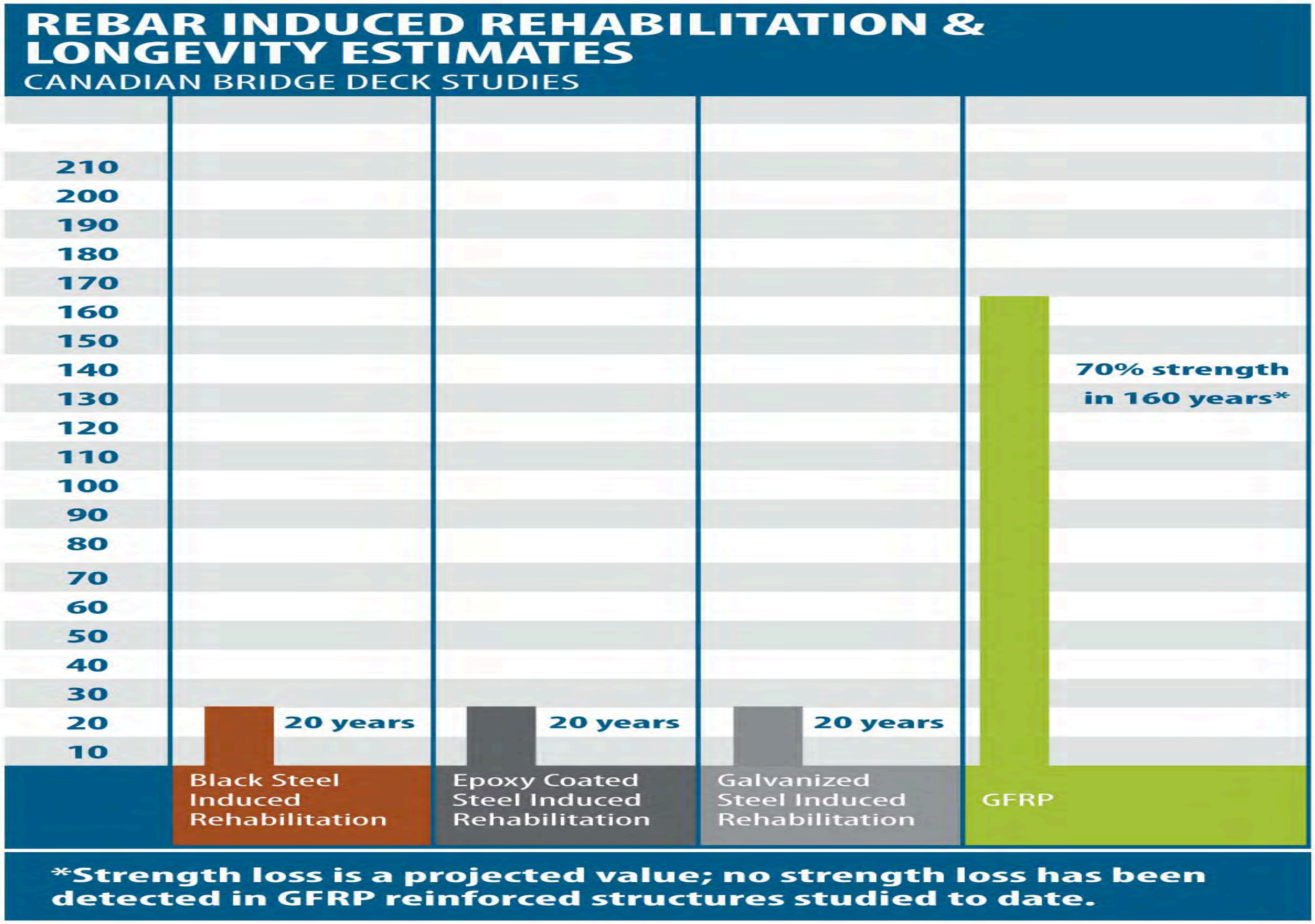
Tensile Strength

On left: light weight, high strength GFRP rebar reinforced panels are being used in some of the world's tallest building





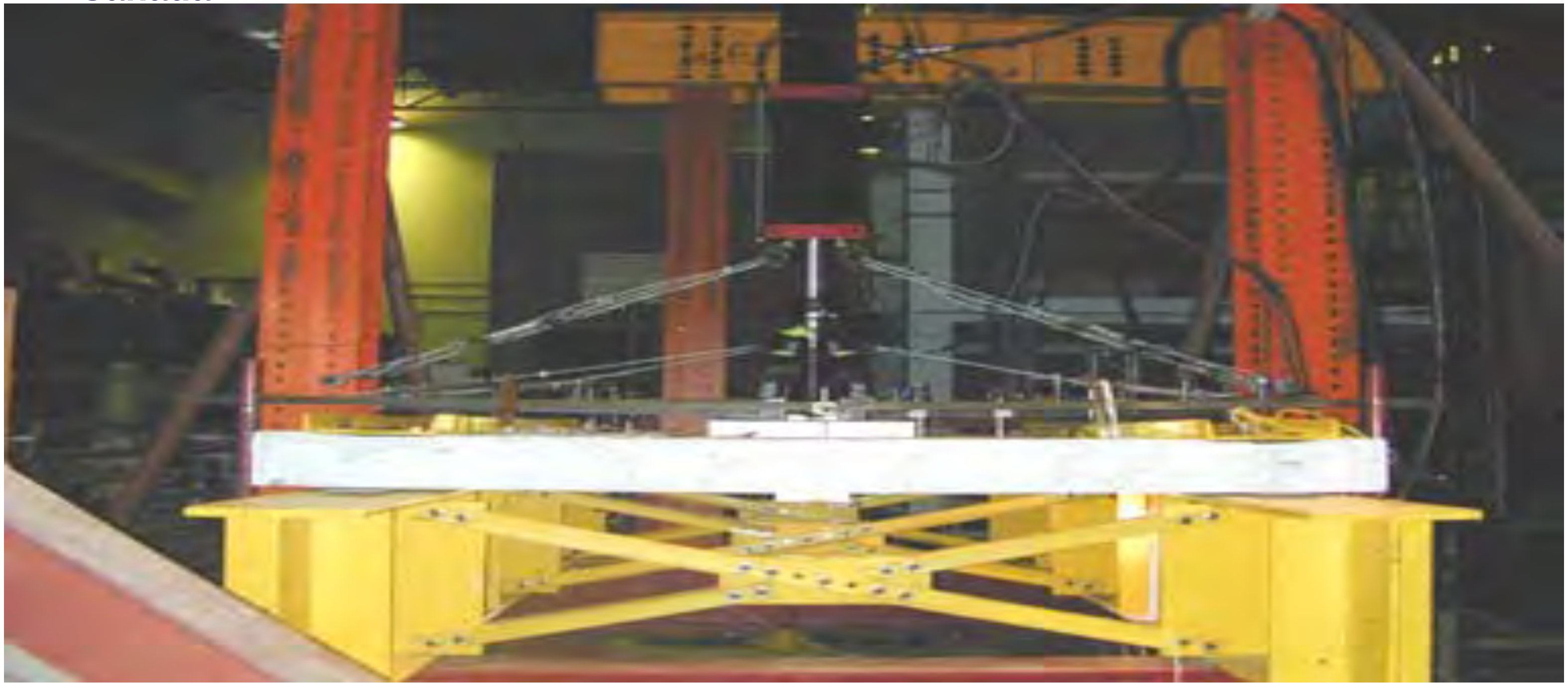
Durability



- Natural Sciences and Engineering-Research Council of Canada
- Durability of Fiber Reinforced Polymers in Civil Infrastructure (Canada) 22 Researchers, 4 Universities
- Ontario Ministry of Transport (2007), F. Pianca, H. Schell, G. Cautillo

Concrete Fatigue Resistance GFRP Versus Steel

- **Simulations of traffic going over concrete bridge deck slabs using 60 ton press**
- **Loading Fixture**
- **A. El-Ragaby 1, E. F. El-Salakawy 2 and B. Benmokrane 3**
- **1 PhD Candidate, Dept. of Civil Engineering, University of Sherbrooke, Canada**
- **2 CRC Professor, Dept. of Civil Engineering, University of Manitoba, Winnipeg, Canada**
- **3 NSERC Chair Professor, Dept. of Civil Engineering, University of Sherbrooke, Canada**

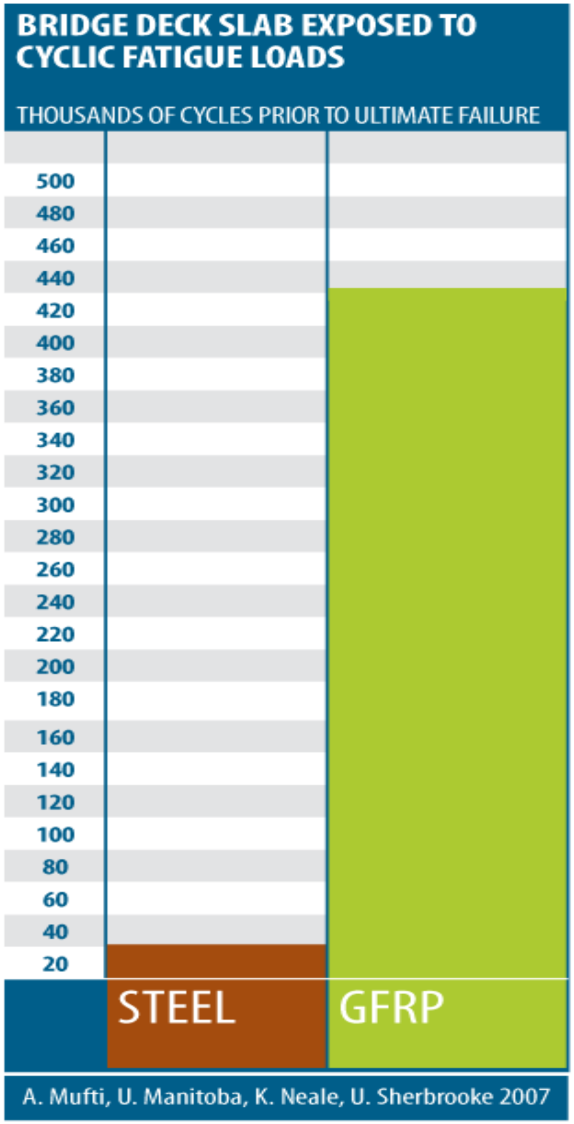


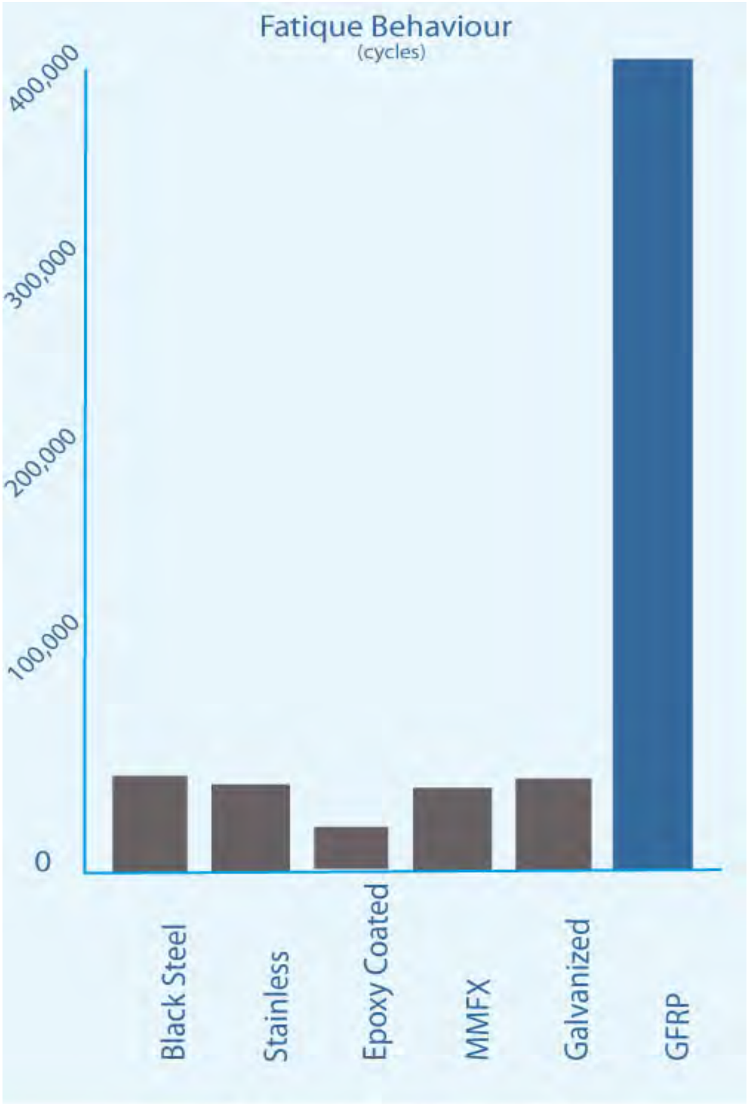
Concrete Fatigue Resistance
GFRP Versus Steel

GFRP Reinforced Concrete slabs exposed to heavy traffic:

- **will have fewer cracks**
- **will last 20 times longer**

Concrete Fatigue
GFRP slabs last 20 times longer

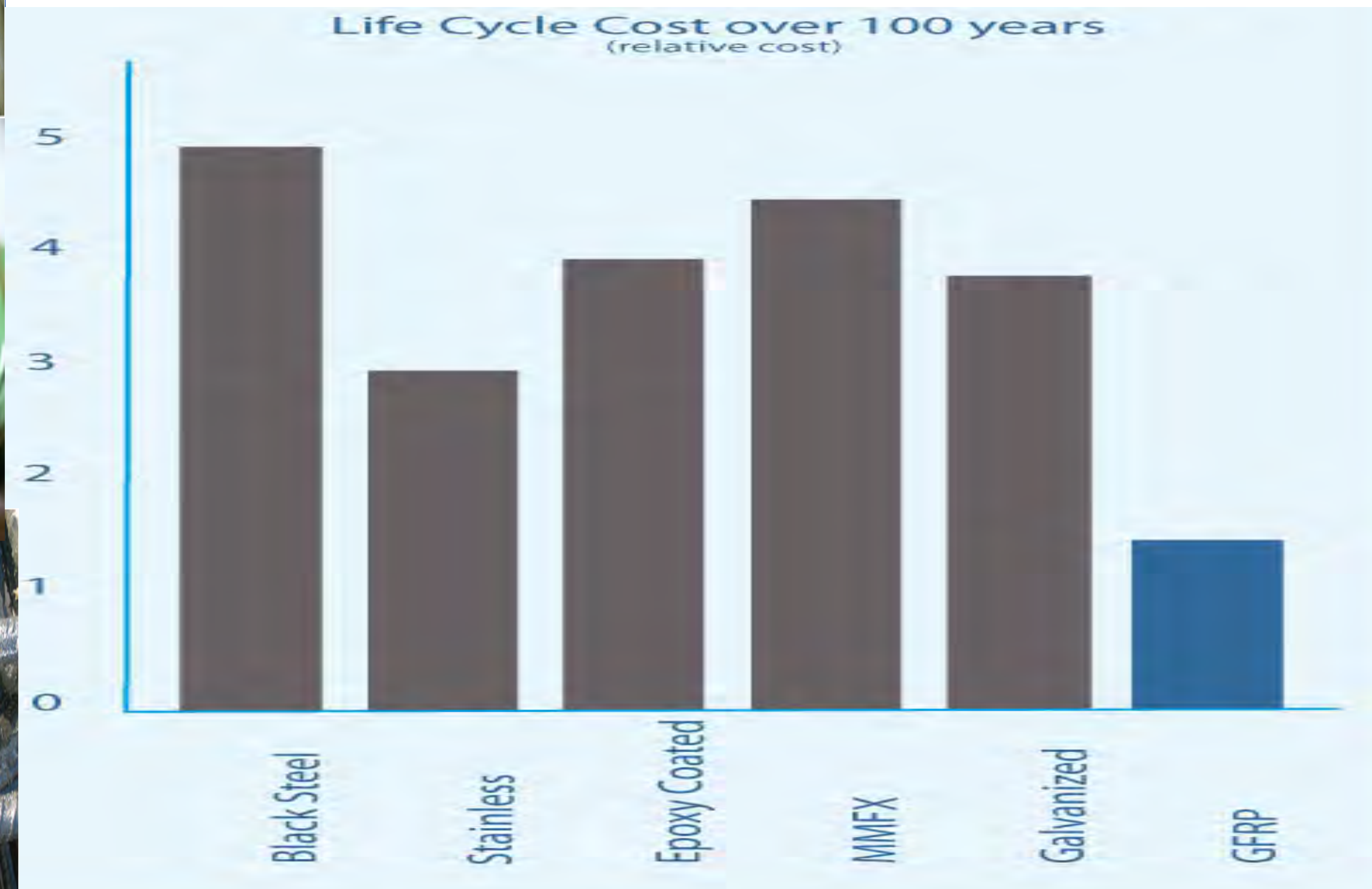




Adimi, M.R., Rahman, A.H., and Benmokrane, B. 2000

Life Cycle Costs GFRP

- **40-60% reduction in repair and demolition costs**



Gordon Spark, U. Manitoba, ISIS Canada. 2005


Conclusions from the Field Studies

- **Steel-reinforced concrete:**
  - **-begins to deteriorate after 10 to 15 years**
  - **-generally major repairs are required at 25 years.**
- **GFRP-reinforced concrete:**
  - **-will last beyond 100 years**
  - **-maintenance and demolition cost savings of 40 to 60% are projected**
  - **-concrete exposed to cyclic fatigue loads will last 20 times longer**

" GFRP is far more cost-effective than metallic reinforcement"

Chair Natural Sciences and Engineering – Research Council of Canada



CHBDC

Research teams recommended:

•That GFRP be allowed as the primary reinforcement design guidance can now be found in;

•CAN/CSA-S6-06
"Canadian Highway Bridge Code" (December 2008), 800p.

•CAN/CSA-S806-02 (R2007)
"Construction of Building Components with Fibre-Reinforced Polymers" Product Number 2012972
Update No. 3 was published as notification; it is now a National Standard of Canada.

See www.frpdistributors.com for additional info.