How do I make my bridges more resilient to the damaging effects of natural disasters?

FRP materials could be the answer

David White, P.E.

W-4 Workshop

THE INTERNATIONAL BRIDGE CONFERENCE

BUILDING TRUST

U.S. INFRASTRUCTURE

- Overall grade of America's Infrastructure: D+
- Bridges: C+
- Over 600,000 bridges in U.S.
- 1 in 11 rated structurally deficient
- 4 in 10 bridges 50 years or older
- Total infrastructure needs: $4.59 trillion over 10 years

ADVANTAGES OF FRP REPAIRS

- Cost/scheduling benefits
- **“Get in, Get out, Stay out!”**
  - FHWA Mantra for accelerated construction
- Reduced maintenance costs
- Light weight materials puts less strain on infrastructure
- Non-corrosive materials are designed for long-term, sustainable performance
- Less expensive repairs allow for more structures to be repaired within fixed budgets

EVOLUTION OF STRUCTURAL STRENGTHENING

- Typically done with retrofitted steel since 1950’s
- Carbon fiber plates introduced in early 1990’s
- Glass fiber wraps used for seismic upgrades in 1990’s (wet layup systems)
- Carbon fiber wraps became material of choice for structural upgrades (wet layup systems)
- Presaturated (Prepreg) FRP fabrics introduced in 2015 to simplify installation for contractors and increase productivity.

SUSTAINABILITY v. RESILIENCY

- **Sustainability** – development that meets the needs of the present without compromising the ability of future generations to meet their own needs (*Brundtland 1987*)
- **Resiliency** – ability to respond, absorb and adapt to, as well as recover from a disruptive event (e.g. earthquake, hurricane, natural disaster).

HURRICANE IRMA PATH 2017

Sunshine Skyway Bridge

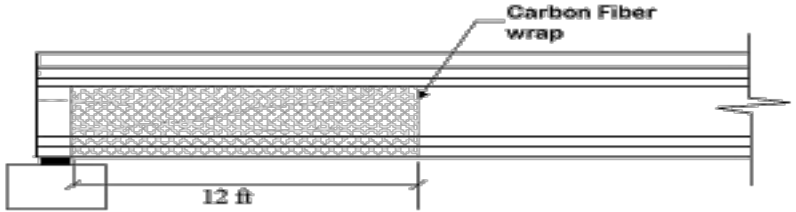
Tampa Bay

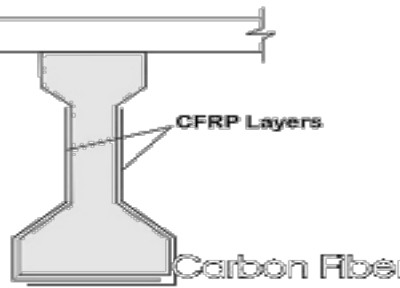
Ohio-Missouri Bridge

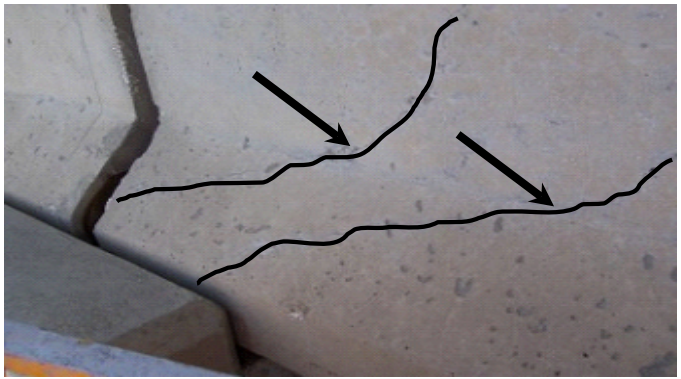
Florida Keys

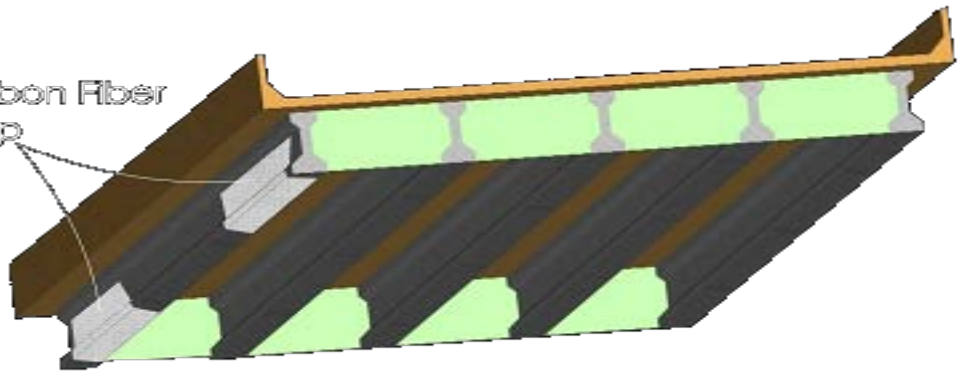
SUNSHINE SKYWAY BRIDGE
(opened 1987)

TRESTLE SPAN REPAIRS (2007)









TRESTLE SPAN REPAIRS

- Shear deficiencies at ends of AASHTO Type IV girders
- Shear cracks injected with epoxy
- Girders wrapped with bi-directional, carbon fiber fabric
- Protective coating applied over strengthened area

Mock-up on AASHTO Girders @ FDOT Lab for Skyway Project

TRESTLE SPAN REPAIRS


02/07/2007

SUNSHINE SKYWAY BRIDGE (2007)

SUNSHINE SKYWAY BRIDGE (2018)

SUNSHINE SKYWAY BRIDGE

2007

2018

SUNSHINE SKYWAY BRIDGE

2008 ICRI Award of Excellence in the Transportation Category

OHIO MISSOURI HISTORIC BRIDGE (2010)

Florida Keys

OHIO MISSOURI HISTORIC BRIDGE

Sustainable Construction

- Originally built between 1905 – 1912 as a railroad bridge
- Great Labor Day Hurricane knocked out the railroad network in 1935
- Bridge was widened in 1938 and converted to accept vehicular traffic as part of U.S. Highway 1
- Changed use to pedestrian bridge in 2001 when new Florida Keys bridges were built
- Repaired in 2010 as part of Florida Keys Overseas Heritage Trail – 60 mile long trail for cyclists and pedestrians
- Posted to National Register of Historic Places

STRUCTURAL PROBLEMS

- Aggressive coastal environment
- Salt water ingress caused significant corrosion of steel H beams and rebar

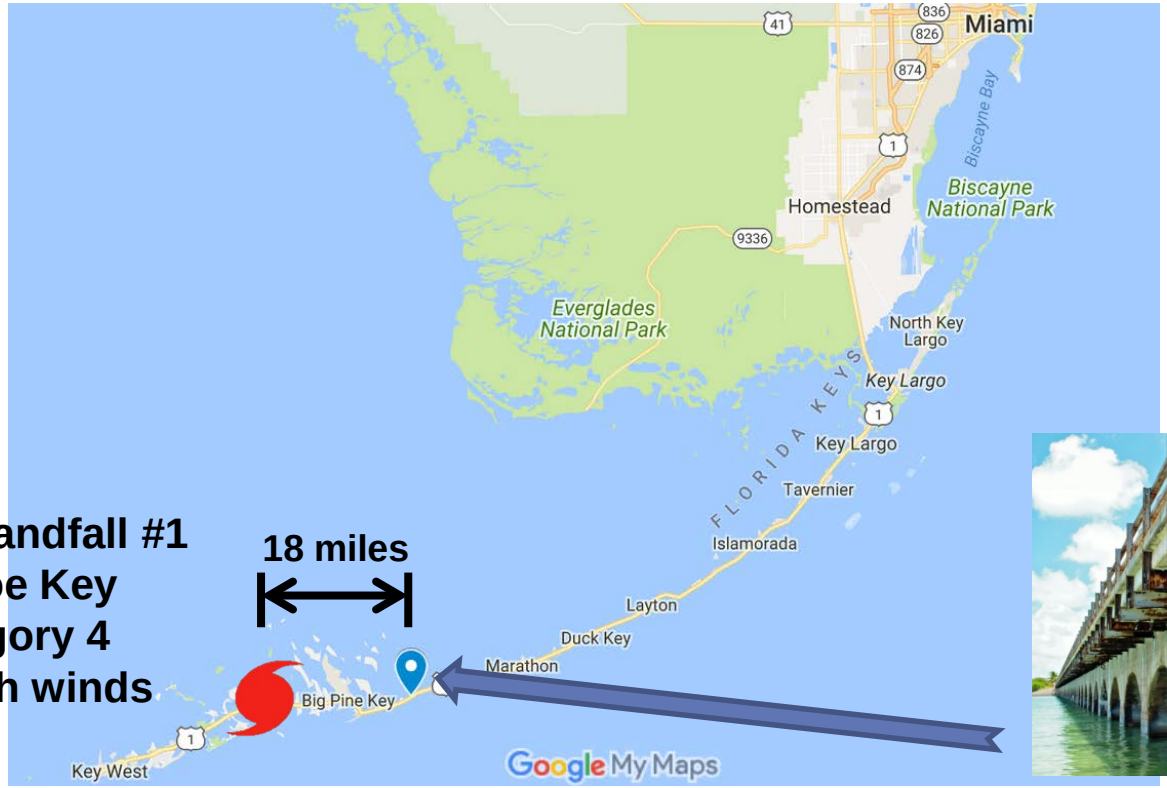
CONCRETE REPAIR

- Old asphaltic roadway removed down to lime rock fill atop superstructure
- New concrete slab poured on top of fill
- New FRP rebar dowelled into concrete with epoxy resin

FRP REINFORCEMENT

- Non-corrosive rebar for long lasting repair
- FRP rebar provides alternative support to deteriorated H-beams
- Additional FRP bars used to replace small rebar from original construction

HURRICANE IRMA 2017



Florida Landfall #1
Cudjoe Key
Category 4
130 mph winds

18 miles

RESILIENCY

- No significant damage to bridge post-Irma
- All 42 bridges of Florida Keys Overseas Highway deemed safe within 5 days after Irma struck
- “Resilience is central to life here” – *Newsday Travel section (3/21/18)*

SUSTAINABILITY

- Transforming bridge for public use was most significant benefit of project
- Benefits local communities for outdoor activities (fishing, biking, walking, etc.)
- Improves area to support vital tourism industry
- FRP materials allows for “rust proof” reinforcement and long service life

CULVER LINE VIADUCT

Owner:	New York City Transit Authority
GC:	Judlau Contracting
Subcontractor:	Fox Industries
Subcontractor:	Providence Construction
Supplier:	Sika

- Location - Brooklyn, NY
- Line opened in 1933
- Viaduct located between Carrol St. Station and 9th St. Station
- Nearly 1 mile in length
- Highest subway station above ground in the world (88 ft. above Gowanus Canal)
- Serves 90,000 passengers each day

CULVER LINE OVER GOWANUS CANAL


St. Mary's Playground
The playground is temporarily closed due to
falling debris from the subway tracks.
Thank you for your patience.

“TEMPORARY” SOLUTION

- Wrap concrete with black netting to prevent chunks of concrete from falling below
- Budget constraints meant dealing with “symptoms” and not “root cause”
- Short term solution turned in 15 year eyesore

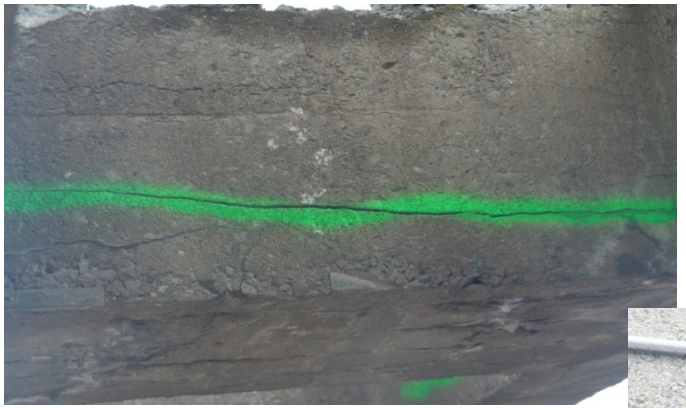
FRP REPAIRS (2011 – 2015)

- Remove existing black netting
- Perform structural concrete repairs
- Waterproof concrete deck
- Replace black netting with FRP composite materials
- Structural enhancement
- Prevent concrete from falling in future

PROBLEMS

- Failed deck waterproofing
- Concrete spalling
- Exposed steel

CONCRETE DETERIORATION



FRP REPAIRS - BEAMS

VIADUCT REPAIRS

HURRICANE SANDY 2012

- Shut down entire NYC Subway System for 3 days
- 100 mph wind gusts
- 250,000 vehicles destroyed
- $18 billion damages recorded in NYC
- **No damages to FRP repairs already installed**
- Work was shut down on Culver Line for only a few days and project continued without further delay

CULVER LINE VIADUCT REHABILITATION

CONCLUSIONS

- Thousand of projects have been successfully strengthened with FRP materials
- Composite are a viable means of strengthening and upgrading bridges
- FRP repairs are sustainable and durable
- FRP repairs are resilient, especially against natural disasters that can strike at any time

David White, P.E.

white.dave@us.sika.com

www.usa.sika.com