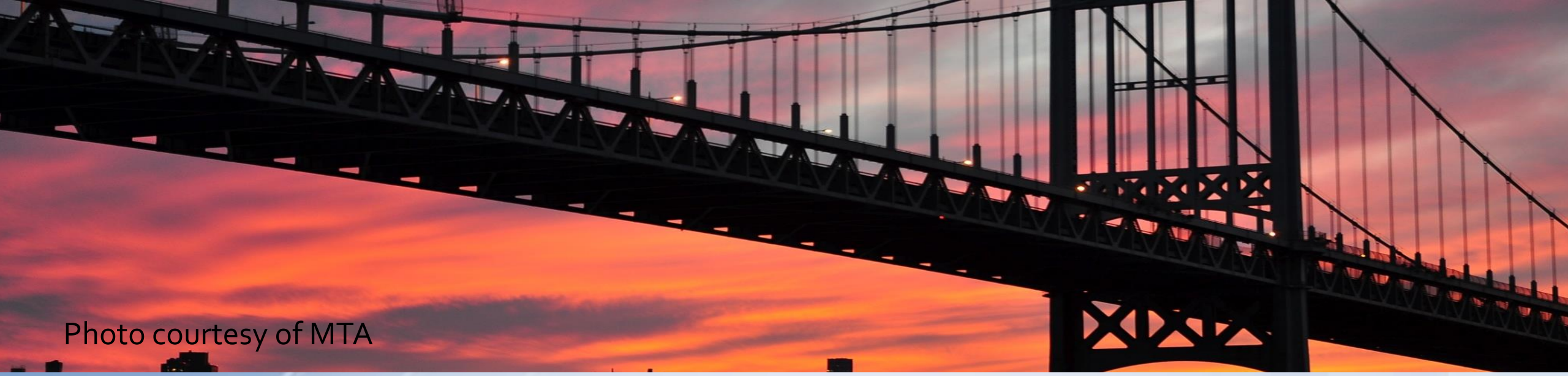


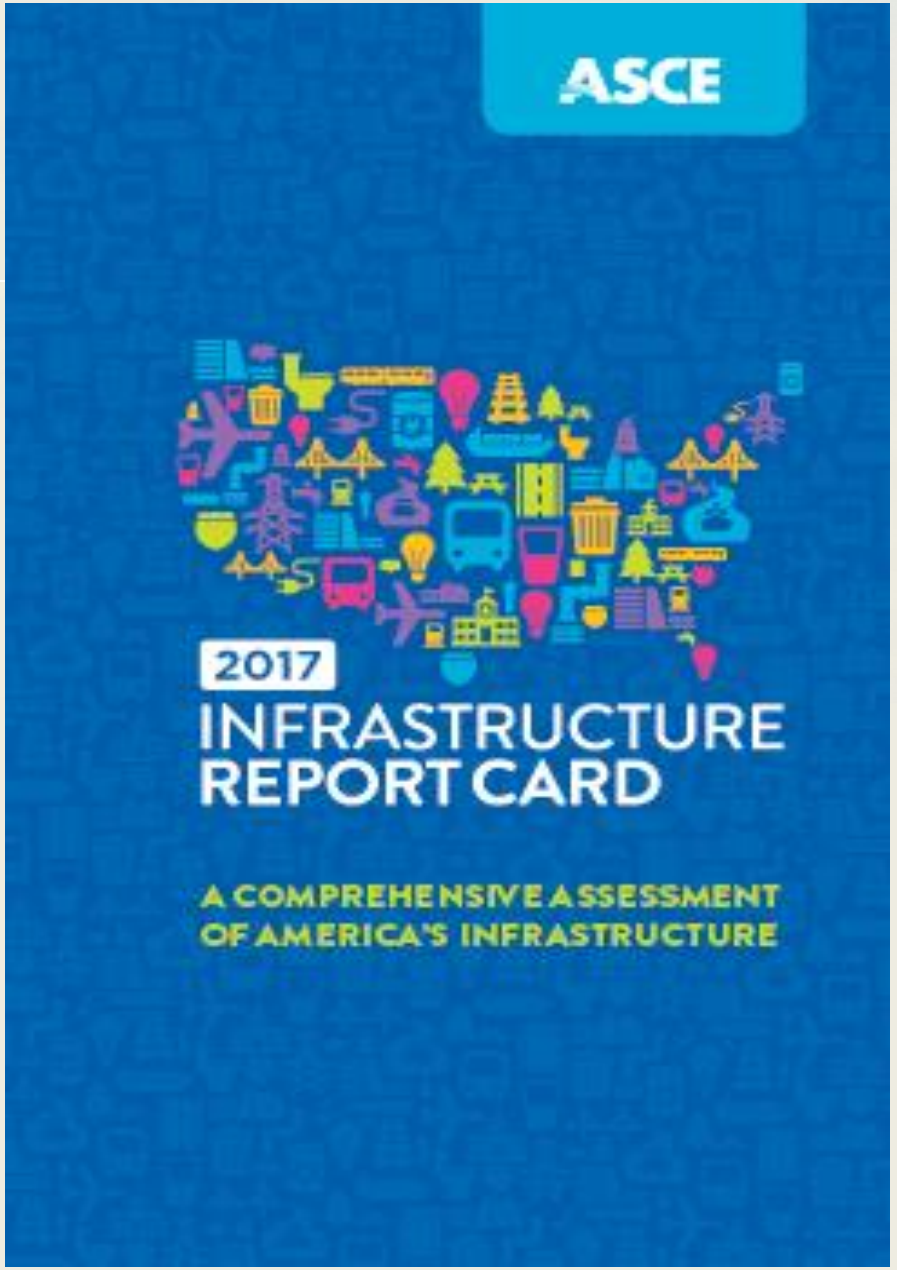
Photo courtesy of MTA

Bridge Preservation with Presaturated FRP Composite Materials

David White, P.E.
Sika Corporation

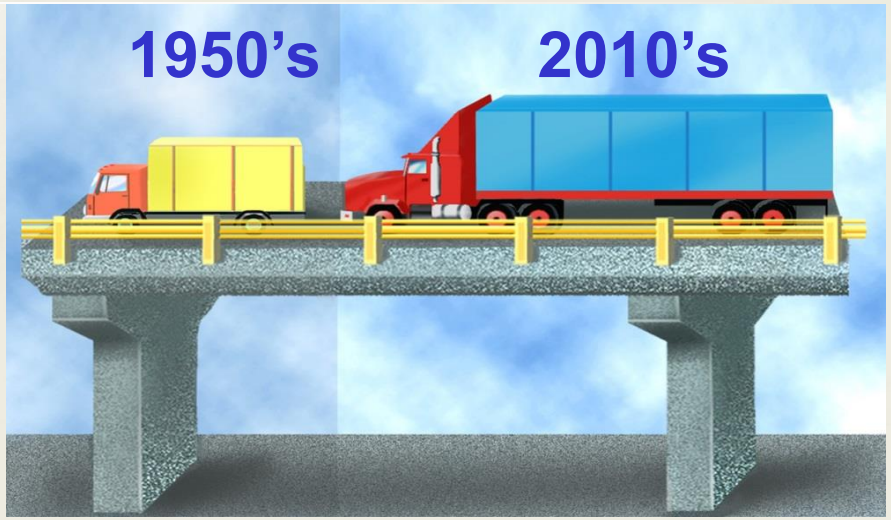
U.S. INFRASTRUCTURE

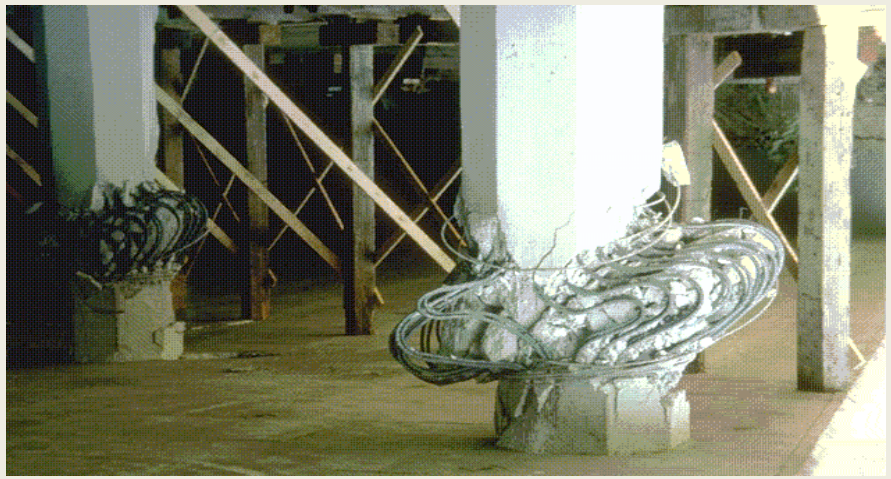
- Overall grade of America's Infrastructure: D+
- Bridges: C+
- Over 600,000 bridges in U.S.
- 1 in 11 rated structurally deficient
- 4 in 10 bridges 50 years or older
- Total infrastructure needs: $4.59 trillion over 10 years



WHY DO STRUCTURES NEED STRENGTHENING?

- Insufficient reinforcement
- Corrosion damage
- Change in use
- Structural damage
- Seismic upgrade
- Blast hardening
- Storm hardening

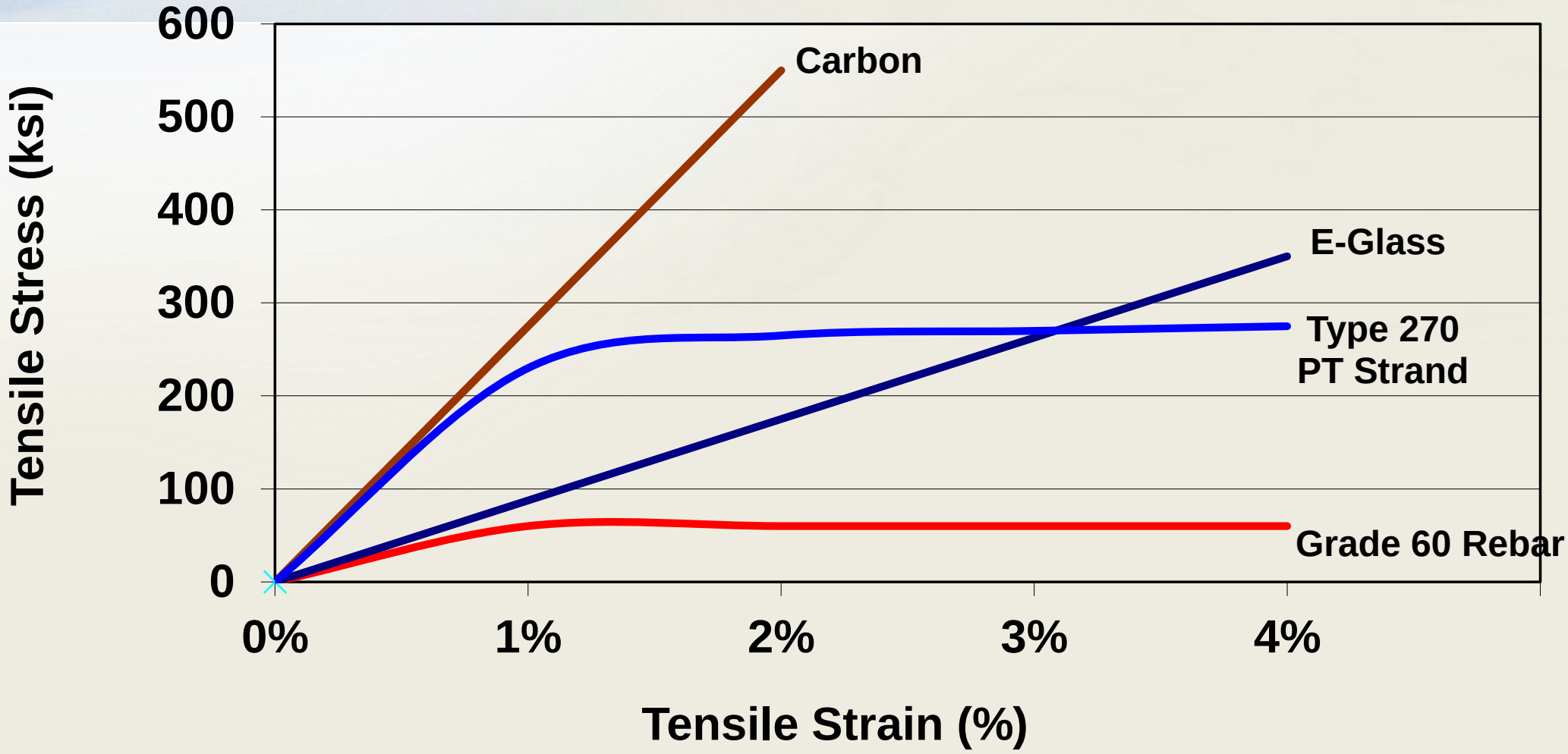




ADVANTAGES OF FRP REPAIRS

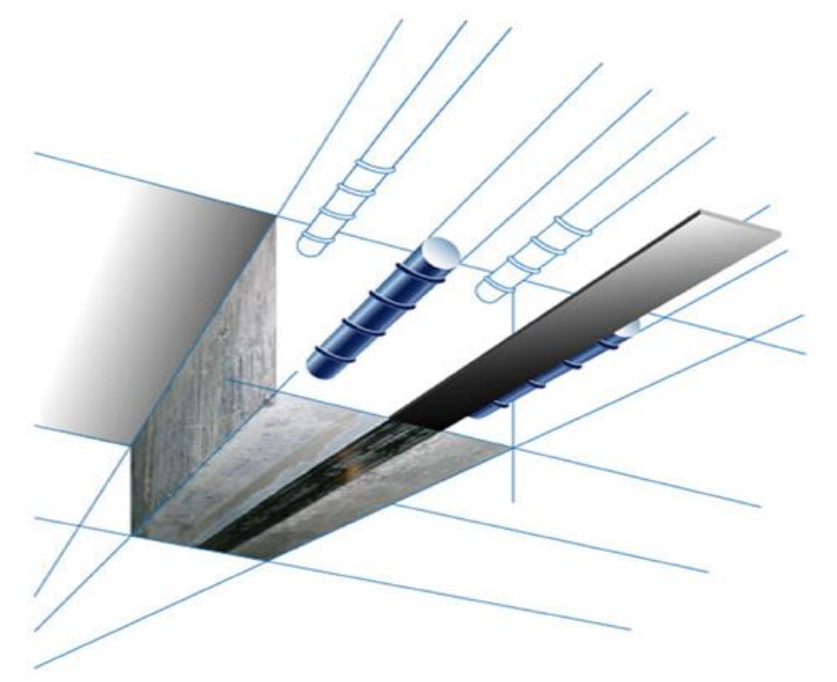
- Cost/scheduling benefits
- **"Get in, Get out, Stay out!"**
  - FHWA Mantra for accelerated construction
- Reduced maintenance costs
- Light weight materials puts less strain on infrastructure
- Non-corrosive materials are designed for long-term, sustainable performance
- Less expensive repairs allow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

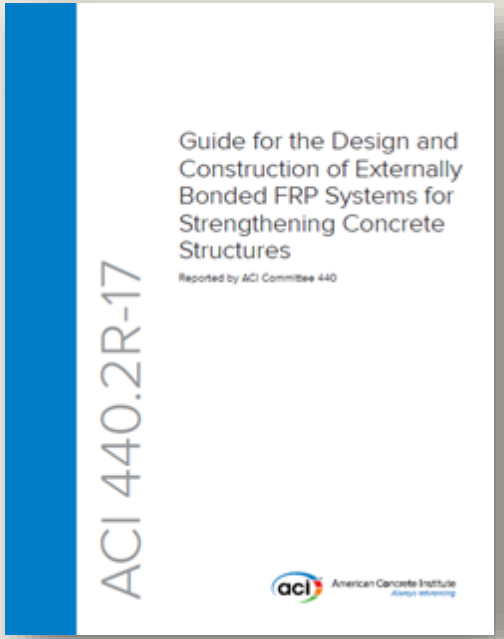
MATERIAL PROPERTIES

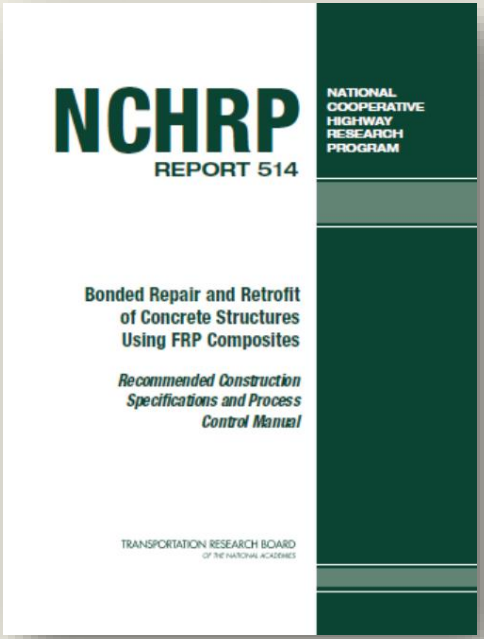


DESIGNING WITH FRP

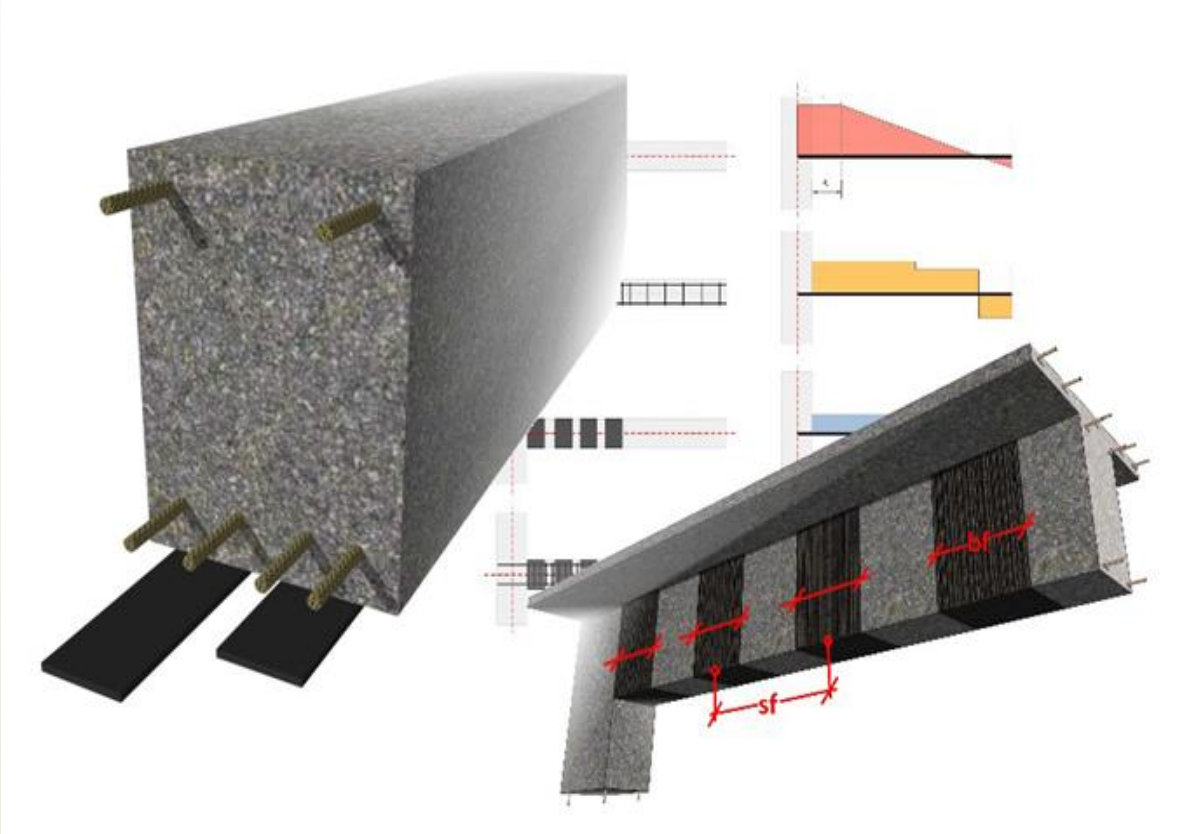
- Strengthening limits imposed to maintain ductility in member
- Provides secondary reinforcement
- Proper design takes into account fire and life safety measures

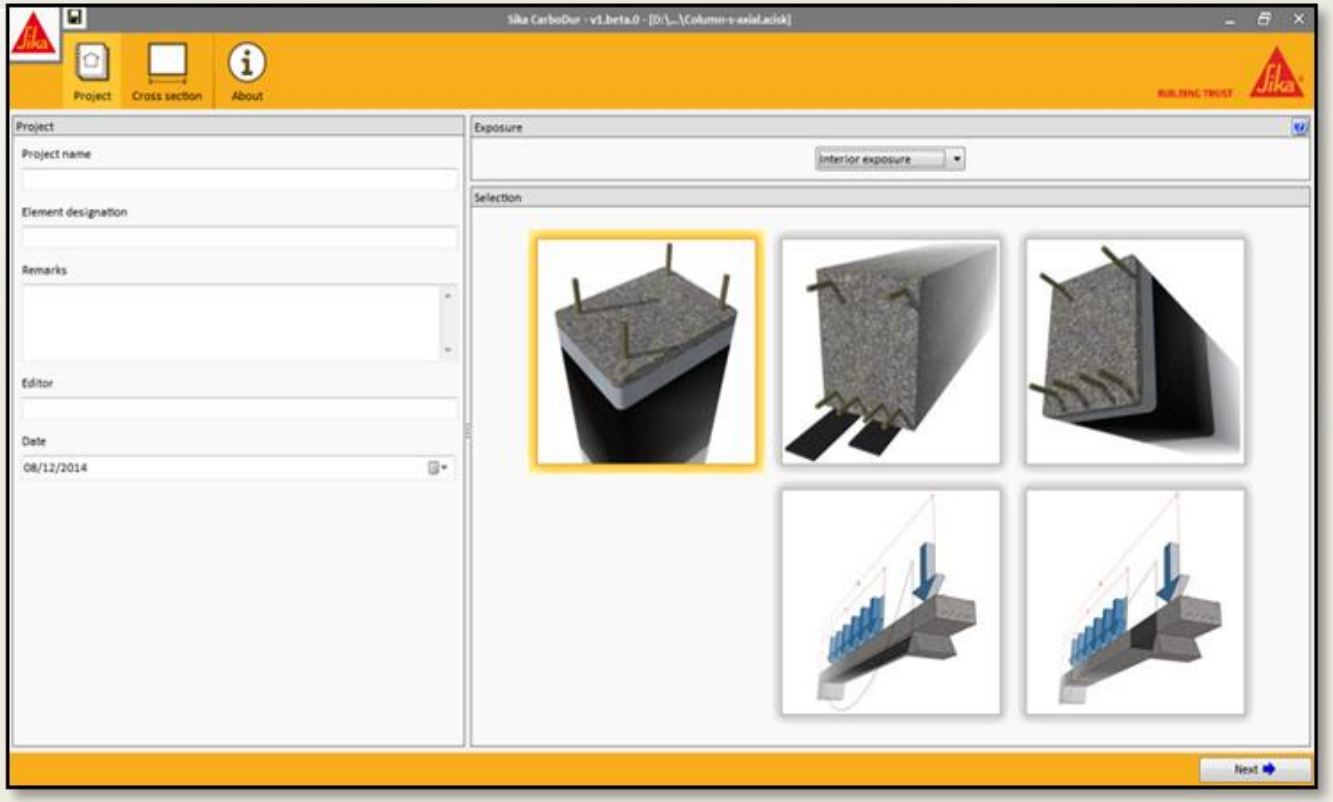






FRP DESIGN SOFTWARE



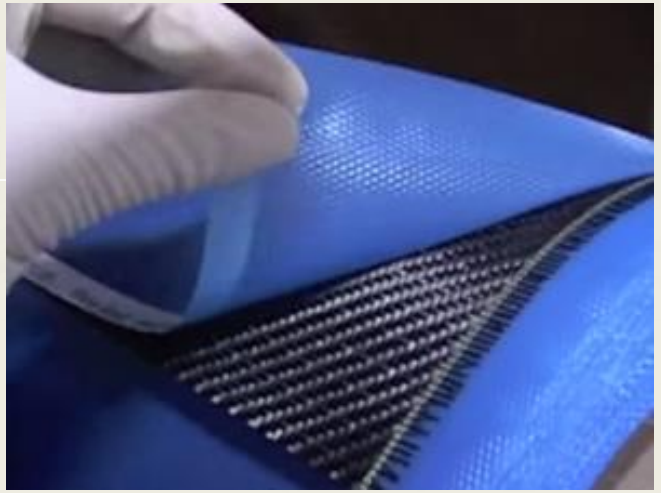


EVOLUTION OF STRUCTURAL STRENGTHENING

- 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. Similar prepregs used in marine industry since early 1980's.

WET LAYUP REPAIRS

PRESATURATED (PREPREG) FABRICS



- Prepregs are reinforced fabrics that have been pre-impregnated with a resin system
- Eliminates the step to saturate the fabric in situ
- Typically uses a B-stage epoxy that is partially cured and requires cold storage to prevent premature curing
- Most prepregs require an oven or autoclave to cure making them impractical for infrastructure projects
- Have been used successfully in aerospace, wind energy and other industries since 1970's

ADVANTAGES OF PRESATURATED FABRICS

- Improved quality control – manufactured in ISO 9001 facility
- Optimized resin:fiber ratio (factory controlled)
- No mixing/saturating resins onsite (except for primer)
- Presaturated fabrics easier to cut
- Fabrics can be airfreighted (non hazmat)
- Moisture cured systems allow for use in wet/damp environments
- Hermetically sealed packaging protects fibers/resins
- **Reduced labor**
- **Faster installation**

NEW GENERATION PRESATURATED FABRICS

- Moisture cured polyurethane resin saturant
- No refrigerated storage/transit required
- No autoclave equipment needed to cure
- System cures at ambient temperature
- Repeatable strength due to consistent resin:fiber ratio
- Installation possible in wet or submerged conditions
- No VOC's and low odor makes entire installation user-friendly
- **First factory-saturated FRP system for concrete repair and strengthening**

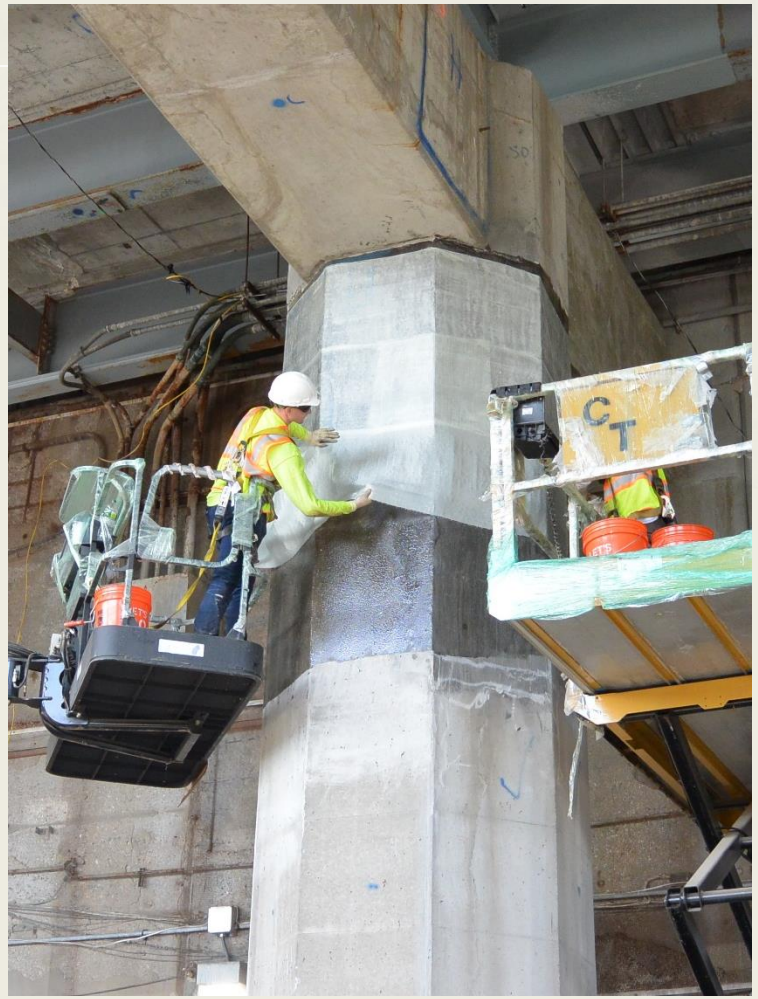
WET LAY-UP SYSTEM

1. Provide resin
2. Provide fabric
3. Prepare concrete
4. Mix epoxy saturant
5. Mix epoxy primer
6. Prime concrete
7. Cut fabric onsite
8. Set up saturator
9. Saturate fabric (saturator or table/rollers)
10. Install fabric
11. Cure fabric
12. Clean up saturator and tools
13. Dispose of resin pails

~~WET LAY-UP SYSTEM~~ PRESATURATED SYSTEM

1. ~~Provide resin~~
2. Provide fabric
3. Prepare concrete
4. ~~Mix epoxy saturant~~
5. Mix epoxy primer
6. Prime concrete
7. Cut fabric onsite
8. ~~Set up saturator~~
9. ~~Saturate fabric (saturator or table/rollers)~~
10. Install fabric
11. Cure fabric
12. ~~Clean up saturator and tools~~
13. ~~Dispose of resin pails~~

NO FIELD SATURATION REQUIRED

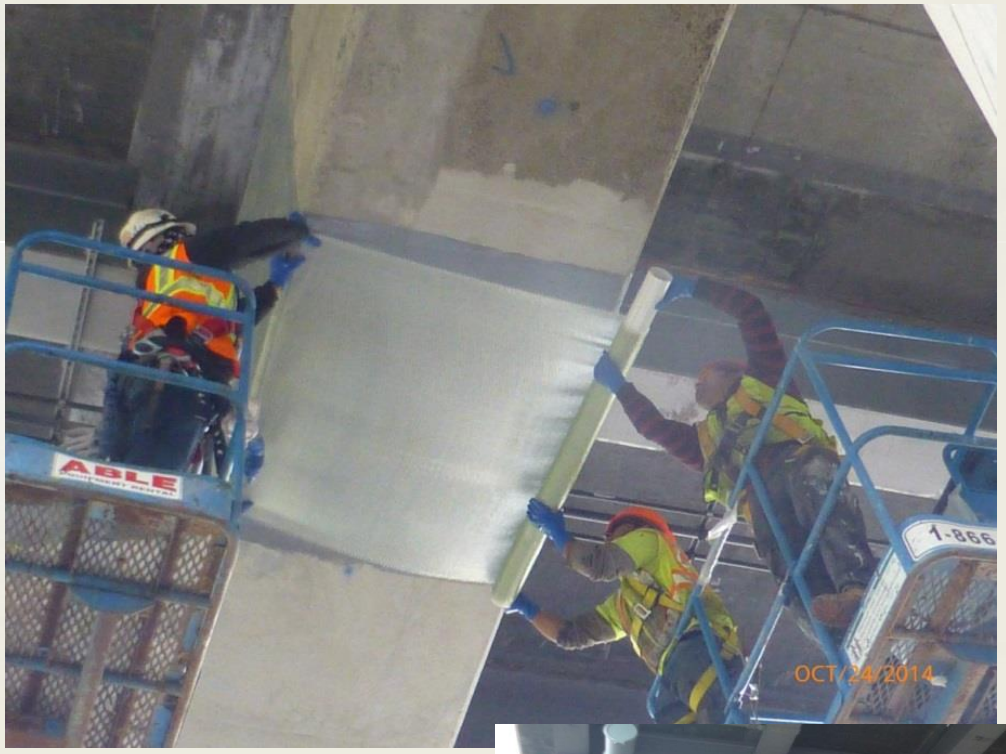


RFK BRIDGE (TRIBOROUGH BRIDGE), NYC

RFK BRIDGE

RFK BRIDGE

Earlier repairs completed with wet layup FRP

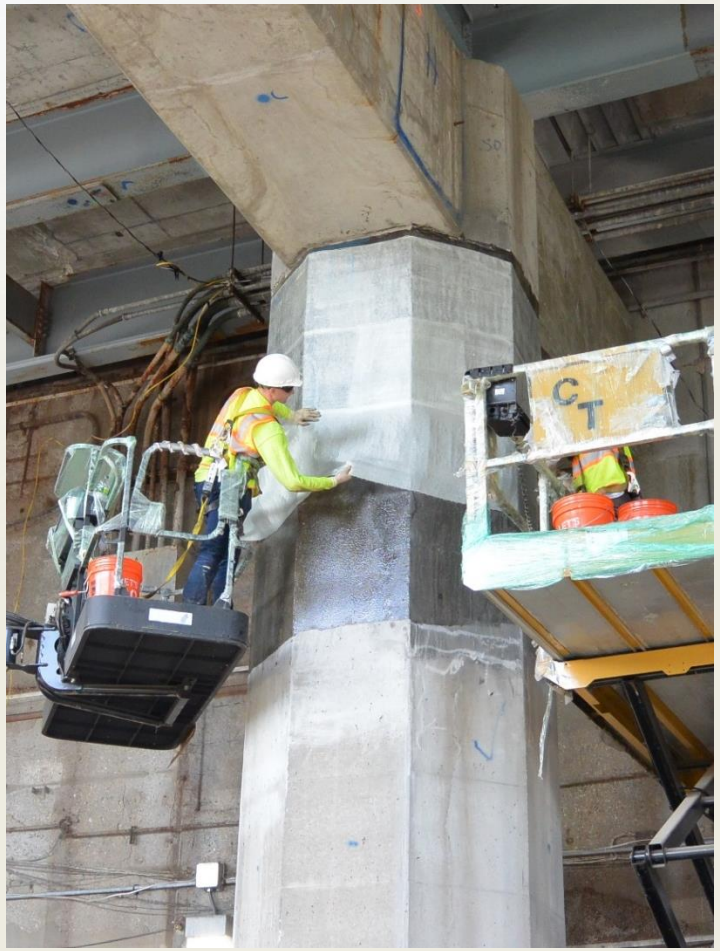


RFK BRIDGE

2nd phase completed with Presaturated FRP fabrics

RFK BRIDGE

Presaturated FRP fabric installation

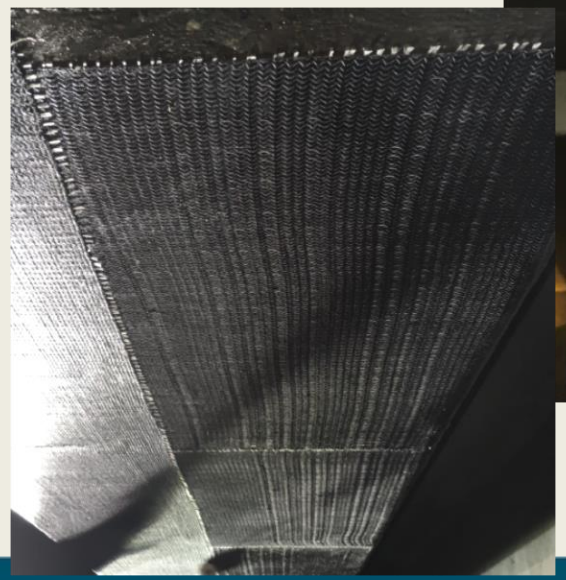


I-15 BRIDGE – POCATELLO, ID

- Damage to girders from high load truck
- 3-layers CFRP bottom flange
- 2-layers CFRP U-wrap around girder
- 1-layer CFRP along web

I-40 BRIDGE – ALBUQUERQUE, NM

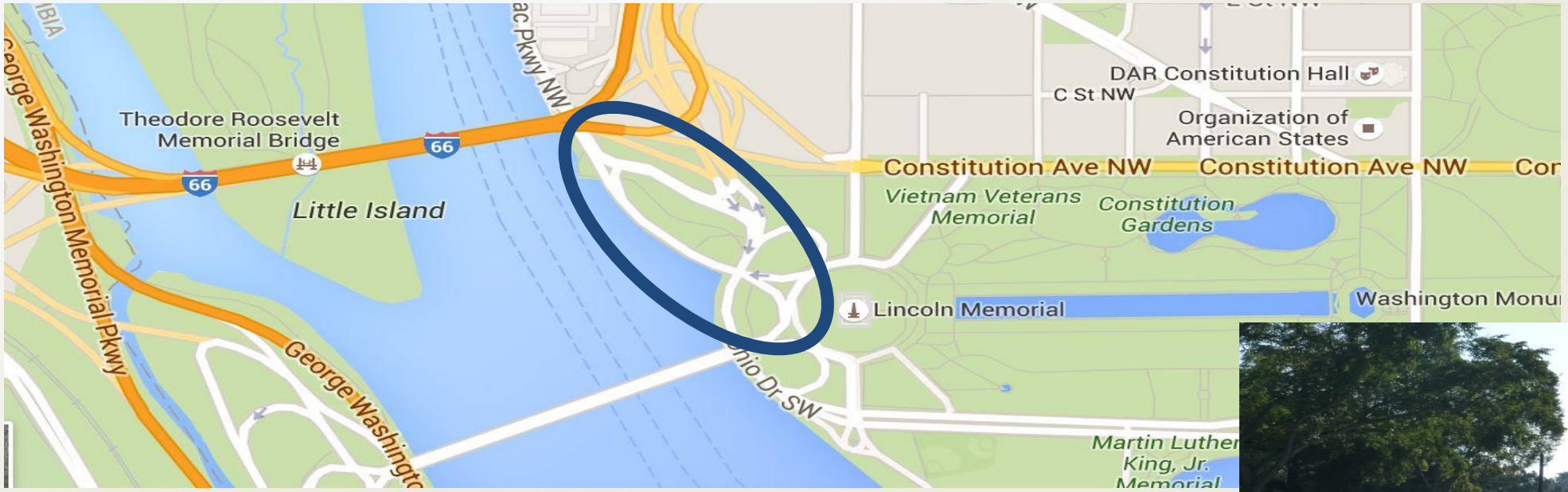
- 6 girders on each bridge damaged by trucker hauling high-load piece of equipment
- Night time construction to minimize traffic delays
- Concrete patched and 1,400 sf repaired with presaturated CFRP fabrics



NATIONAL PARK SERVICE STORAGE AREA BRIDGE
WASHINGTON, DC

- Adjacent to Lincoln Memorial within National Mall
- Southern entry point of Rock Creek & Potomac Parkway
- Bridge constructed 1934 by Arlington Memorial Bridge Commission (AMBC)
- ADT = 13,383 vehicles
- Classified as Structurally Deficient (2014)
- 7 columns wrapped under active roadway
- Repair contractor: Kiewit Infrastructure Co.

NPS STORAGE AREA BRIDGE – NATIONAL MALL



NATIONAL PARK SERVICE BRIDGE

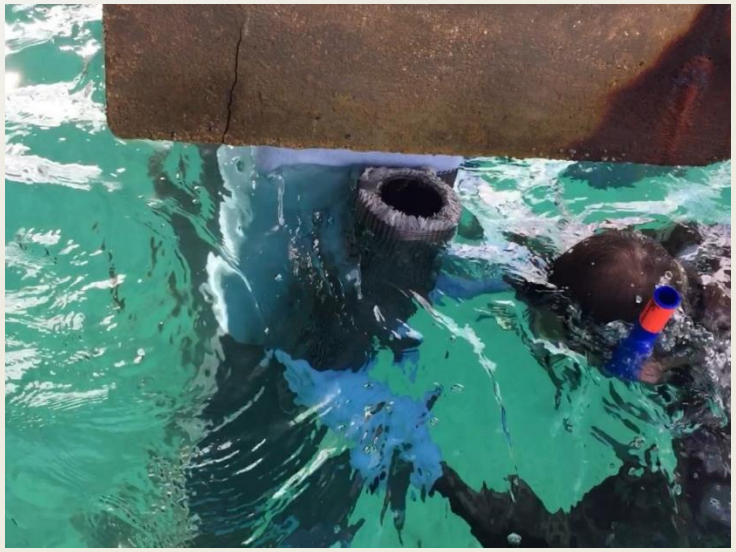
NATIONAL PARK SERVICE BRIDGE

NATIONAL PARK SERVICE BRIDGE

NATIONAL PARK SERVICE BRIDGE

FUTURE WORK – UNDERWATER INSTALLATIONS

- Moisture cured urethane saturant will cure in high humidity and submerged conditions
- Damp/wet concrete repairs possible
- Pile jacketing repairs



CONCLUSIONS

- U.S. infrastructure is literally crumbling before our eyes and is in critical need of repair
- Extending the service life of existing bridges is one key element of sustainable repairs
- FRP Composites have been used successfully to retrofit thousands of bridge projects around the world for over 25 years
- FRP Composites are available in many shapes and functions to repair all types of bridge elements
- New Presaturated Systems offer significant advantages over current FRP systems and can reduce labor, gain efficiency and save owners time and money

THANK YOU FOR YOUR ATTENTION

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