Best Practices Utilizing FRP in Repairing Concrete Infrastructure

MICHAEL P. YEE
MIKE@RTCONSULTS.COM
NACE COATING INSPECTOR LEVEL 3 #50795

RICHARD TARABORELLI P.E.
RICH@RTCONSULTS.COM

RTCONSULTS PLLC

Table of Contents

The Main Issues

Concrete degrading from weathering or atmospheric conditions

Chemical attack from containing waste or chemical solutions

Rebar corrosion resulting in concrete spalling

The Typical Composite

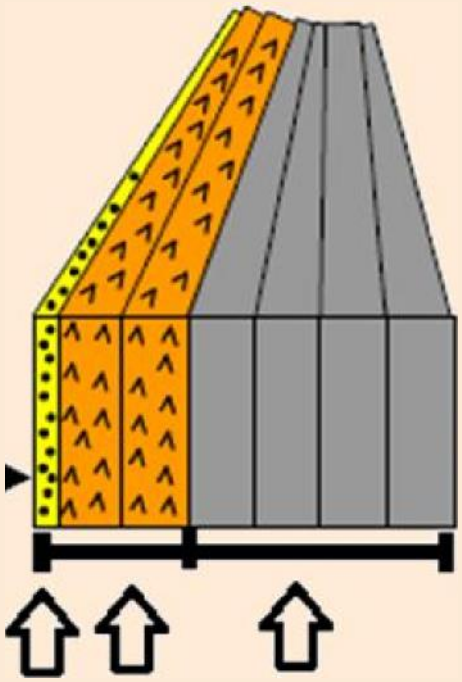
Hand Lay-up Laminate

(Ex. Pipe, Tank, Ducting, etc.)

Interior

Corrosion
FRP Barrier

Veil and
Mat layer



Exterior

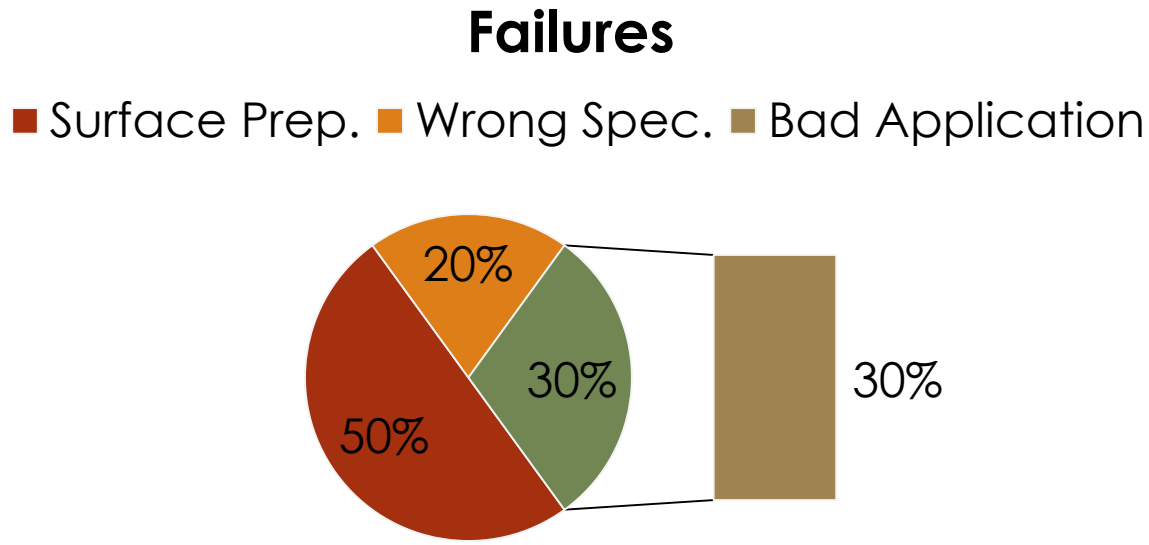
Substrate: Concrete
(Provides the
Strength)

Different ratios of resin/glass depending on design

Coating and Linings

In the realistic world:

- Surface Preparation Issues (+50% failures easily)
- Ambient Conditions/Application
- Wrong specification for environment



Lessons Learned from Projects

Know the environmental conditions

Understand the service conditions and life cycle cost

Maintenance and Inspections

Quality Control

Surface Preparation Measurements

ICRI concrete pads

Roughness consistency

Moisture testing

Water Sealer and mix design

ICRI CSP 3 (Mech)

General Cleaning Requirements

ASTM D 4258- Solvent/Detergent Cleaning

ASTM D 4259- Removing Laitance

ICRI No. 310.1R-2008 Rebar Corrosion Repair

ICRI No. 310.2R-2013 Concrete Surface Prep.

ACI 311.1R Concrete Inspection

ACI 440.2R-08 Externally Bonded FRP Systems

SSPC SP13/ NACE 6 Surface Preparation of Concrete

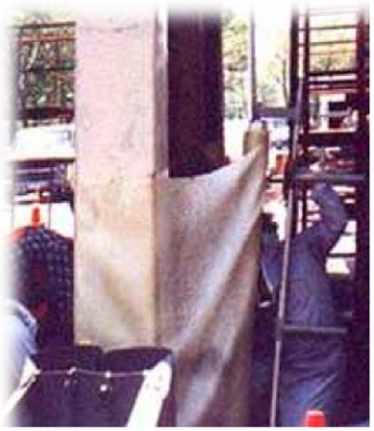
Application Methods

Hand Lay-up with mat and resin

Preformed systems and molds

Wraps and reinforced system layers

Chopped glass with resin (not recommended)

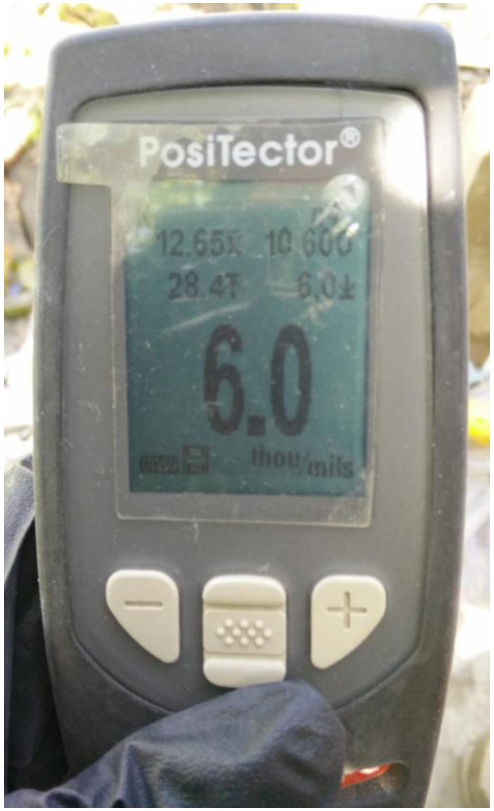


Issues to Correct and Test

FRP's strength comes from the crosslinking of the resin and also the glass combined with it.

Applying FRP or any coatings on questionable concrete will not have a reliable service life.

Coatings/FRP over existing concrete will likely result in a few localized areas of failures.



Coating/FRP Adhesion with Concrete

Moisture issues

Surface preparation issues (blast vs mechanical)

Type and quality of concrete issues (4000 psi)

Testing with different profiles on the surface

Lack of knowledge of concrete itself in regard to inspectors

ICRI CSP 5 (Abrasive Blasted)

Surface Preparation Issues

Our lab ran seven peel tests and pull off tests on the adhesion of concrete.

Adhesion was seen to go up to a certain surface profile and then back down.

Very difficult to get consistent adhesion to subgrade due to mixture quality.

Instruments Used

Lab Results

Method of Surface Preparation	Adhesion rate (psig)	ICRI Standard
Mechanical Abrasion	**542**	**3**
Mechanical Abrasion	**515**	**3**
Mechanical Abrasion	**592**	**3**
Mechanical Abrasion	**425**	**2**
Abrasive Blasted	**724**	**4**
Abrasive Blasted	**700**	**5**
Waterproofing Added on Surface	**363**	**3**

Average DFTs: 123.6 mils, 3 mat (1.5oz) and 2 C- glass veil FRP System

Surface Preparation Lab Results

The use of water blocking agents lowered adhesion rate

Abrasive blast is superior to mechanically prepared surfaces in all scenarios

Over numerous moisture cycles, laminate loses adhesion depending on location.

Modification and Installation

Osmotic pressure from water table or source

Expansion joints

Install drainage pipes for water to exit

Reinforcement is required for successful longevity

FRP linings are secondary walls

Let the Results Speak for Themselves

“You can expect what you inspect- nothing more.”

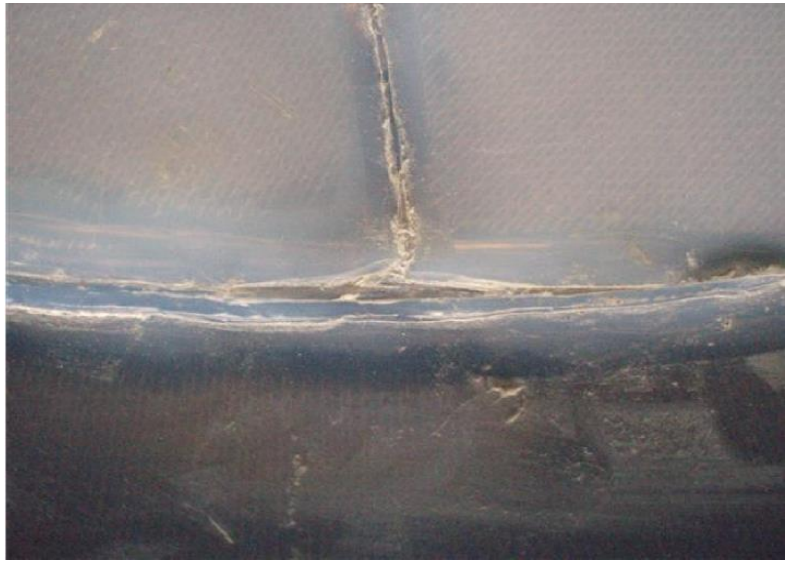
-John H. Mallinson

You must know what you require and know how to identify it. Quality Inspections are needed.

Issues Affecting Laminate Performance

In the realistic world:

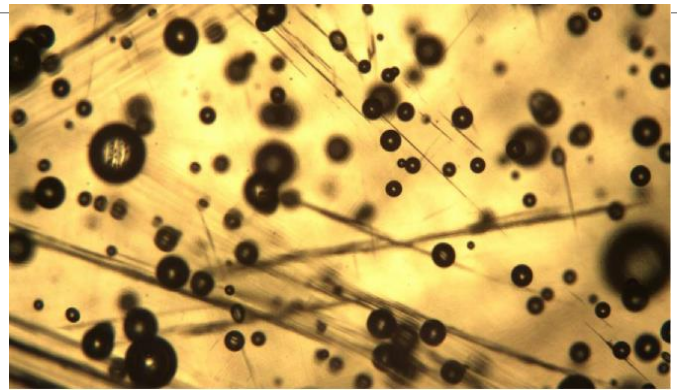
- Poor curing (initial)
- Diffusion
- Applied stress
- Embrittlement
- Micro-cracking
- Swelling
- Impact
- Environmental cycling
- Aging (Time)



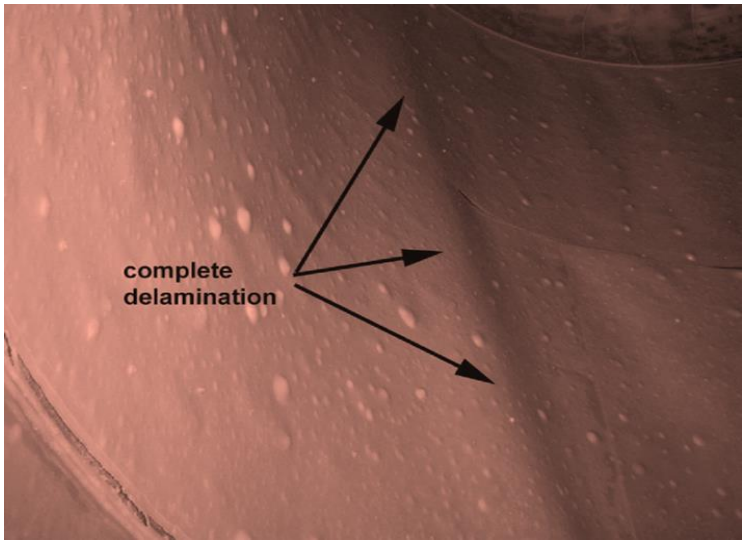
Lack of Fusion and Poor Fit

More Issues

Dry Spots



Air Voids Defects



Blisters Delamination from Substrate

Quality Assurance Through Inspections

Compliance

- Drawings
- Design Specifications
- Materials (lot numbers)
- Ambient Conditions
- Standards (ASME RTP-1)
- Verify Quality Control
- Pass/Fail Criteria

Quality is What Will Last

FINAL INSPECTION

- Documents Review
- Non Conformance Reports
- Cutouts
- Resin Cure
- Peel Adhesion Test (picture)
- Dimensions and thickness
- Physical properties

What 99.5% adhesion looks like : Use Crowbar

Lessons Learned
Keys to a Successful Project

Proper Material Selection for Service

Comprehensive and descriptive specifications

Qualify experienced GRP manufacturer

Know the limitations of the composite

Quality assurance throughout the process

Inspect, Inspect, Inspect…

Questions?