Structural Health Monitoring of Civil Infrastructure
Long Term Monitoring of 4 Integral Abutment Bridges – J. Laman

- 4 MONITORED BRIDGES
- 64 to 80 CHANNELS/PER BRIDGE
- REMOTE DATA COLLECTION
Continuous, Remote Environmental Load Monitoring
Field Evaluation and Health Assessment of Bridges
Evaluation of FRP Composite Repairs for Concrete Structures

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Repair/Strengthening Applications

(FHWA)

(Wabo® MBrace)

(FHWA)
FRP Bonded Repairs

- Protective Coating
- 2nd Resin Coating
- Carbon Fiber
- 1st Resin Coat
- Epoxy Putty Filler
- Primer
- Concrete Substrate
Debonding Failures of FRP Strengthened RC Beams.

Failure of concrete cover along rebar

Crack Propagation

Delamination of FRP from end

Delamination from an interior crack

Adapted from: Buyukozturk & Hearing (1998); Smith and Teng (2002).
Evaluation of Bond Behavior using a Damage Approach

- RC beam
- Interphase, crack band, or damage band
- FRP laminate
- Concrete-Epoxy Interface (CEI)
- Concrete
- Epoxy
- Laminate
- WaboMBRACE

First Layer of Reinforcement
FRP
Damage resulting in debonding
0 50 mm
Analytical Approach using Damage Mechanics

Onset of Cracking

$$
\sigma_1 = f_t
$$

Damage evolution

$$
d = \frac{1}{G_F} \int_0^w \sigma(w) dw = \frac{\alpha}{G_F} \int_0^{\varepsilon^P} \sigma(\varepsilon^P) d\varepsilon^P
$$
Beams failing by Plate Debonding

- High stresses
- Crack propagation
- Failure of concrete cover along rebar

Graphs showing load-deflection behavior for beams B1, B3, B5, and B7.
SHM of FRP Composite Repairs

- Array of strain gages
- Fiber optics
- Digital Imaging
- Acoustic sensors
- Photoelastic coatings
Evaluation of Performance using Acoustic Sensors and Strain Gages
Ultrasonic Guided Wave Sensor

• PZT disk sensor
  – Diameter - 0.25 in (6.35 mm)
  – Thickness – 0.01 in (2.54 mm)
  – Radial vibration at 350 kHz
  – Placed in the epoxy bonding layer
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FRP Rupture
Sensors near anchorage region
Sensors near region of FRP rupture
Evaluation of GFRP-Concrete Bond using Photoelastic Coatings

Boothby & Bakis

Full-field strains in GFRP sheet measured with photoelastic (PE) coating applied to tensile surface
PE Fringes During Test

Flexural Crack

239 psi
533 psi
658 psi
901 psi
Strain Distribution

Unconditioned Specimen PE-43

Strain (microstrain)

Moment=0.12 kN-m
Moment=0.17 kN-m
Moment=0.26 kN-m
Moment=0.35 kN-m
Moment=0.40 kN-m
Moment=0.46 kN-m
Moment=0.52 kN-m
Moment=0.62 kN-m

Location (cm)
Center of Excellence in Structural Health Monitoring
Inaugural meeting - April 12, 2007

Thank You