Strengthening & Rehabilitation of Bridge Structures Using Fiberwrap Materials

Gaetano Bologna, P.E.
Externally-Bonded FRP Systems

Wet Lay-Up

Dry fiber sheets or fabrics impregnated with resin on-site

Pre-Cured / NSM

Pre-cured Composite shapes manufactured off-site
Comparison of Mechanical Properties

![Stress-Strain Graph](image)

- **Tyfo® SCH Systems**
- **Tyfo® SEH Systems**
- **Gr 60 Steel**

- Stress: 125ksi, 100ksi, 80ksi, 60ksi, 45ksi, 30ksi
- Strain: 0.002, 0.006, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06
Full Scale Column Testing at UC San Diego
Full Scale Column Testing at UC San Diego

Control

- $f_c = 29.6\, MPa$ (4290 psi)
- Mainbar ($f_y = 508\, MPa$)
  - #14 - 24
  - $p_l = 1.33\%$
- Hoop ($f_{yh} = 298\, MPa$)
  - #4 - $12\, p_l = 0.10\%$

![Graph showing shear force vs. displacement for UNIT L1 with different models and results.](image-url)
Full Scale Column Testing at UC San Diego

Strengthened

Graph showing experimental and theoretical shear force vs. displacement for UNIT L1-R, with various model predictions and material properties listed.
PennDOT I-84 Scranton Seismic Upgrade
PennDOT I-84 Scranton Seismic Upgrade 17 Year Inspection (2012)
Flexural Strengthening

Effective fiber strain is basis for design

\[ A_f = n w_f t_f \]

\[ f_s = E_f \varepsilon_{fe} \]

\[ f_{fe} = E_f \varepsilon_{fe} \]

\[ \varepsilon_{fe} \]

\[ \varepsilon_{si} \]

\[ \varepsilon_c \]

\[ C \]
Flexural Strengthening

Completely wrapped

3-sided "U-wrap"

2 sides

\[ h \quad d \quad d_f \]

\[ b_w \]

(a)

(b)

(c)
GDOT Girder Strengthening
Lima, Peru Metro Retrofit
Caltrans - North Spring Street Viaduct
Rhode Island DOT - Stillwater Viaduct
Timber Pile Repair (Underwater Applications)
Tyfo® Fiber Anchor Systems

- **Tension Force Development**
  - Fiber Anchor area per unit width shall be equal or greater than the installed Fibrwrap® laminates.
  - Fiber Anchor splay shall be no greater than 60-degrees. Typical details use 45-degree splay.
  - Bonded area shall be sufficient to transfer tensile forces.
Performance Specification Requirements

• Trained and Certified Installers
• Structural & Durability Testing
• Third-Party Material Approvals
• Clearly Defined Design Criteria
• Stamped Calculations and Drawings
• Material Pull-Tests (ASTM D3039)
• Bond Tests (ASTM D4541)
• Remedial & Repair Procedures
Thank You

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