Shear Performance of GFRP RC Beams

Maurizio Guadagnini
Kypros Pilakoutas
Peter Waldron

Department of Civil and Structural Engineering
Centre for Cement and Concrete
The University of Sheffield
Outline

• Shear resistance
• Experimental investigation
• Predictive approaches
• Validation
• Conclusions
Shear Resistance

\[ V = V_c + V_s \]

Shear Carrying Mechanisms

- Concrete in Compression
- Shear Reinforcement
- Aggregate Interlock
- Tooth Bending
- Dowel Action
Experimental programme

1st phase of testing

2nd phase of testing

$V_c$

Concrete shear resistance

$V_s$

Shear link contribution
1st Phase of testing

Steel RC Beams
$A_S = 434 \text{ mm}^2$

GFRP RC Beams
$A_{FRP} = 452 \text{ mm}^2$
1st phase of testing
Experimental set-up
Typical Load-displacement response

Load (kN) vs. Displacement (mm)

- SB 40
- GB 43

a/d ~ 3
Load-displacement response for GFRP reinforced beams

- GB 45: a/d ~ 1
- GB 44: a/d ~ 2
- GB 43: a/d ~ 3

X = shear diagonal failure
Strain distribution along the flexural reinforcement

New strain level proposed

Strain approach

Microstrains

Location of straingage (mm)

SB40 (90.59 kN)

GB43 (54.16 kN)
2nd phase of testing

GFRP links

CFRP links
Experimental set-up
Experimental set-up
Strain in the flexural reinforcement

New strain level proposed

Strain approach

Load (kN)

Microstrains

0 2000 4000 6000 8000

0 20 40 60 80 100 120 140 160
Strain in the shear reinforcement

- Strain approach
- New strain level proposed
Summary of results

SB 40 a/d ~ 3

@ 116 kN

SB 41 a/d ~ 2

@ 180 kN

GB 43 a/d ~ 3

@ 103 kN

GB 44 a/d ~ 2

@ 160 kN
Strain Approach

\[ F_{FRP} = F_{steel} \]

\[ \varepsilon_{FRP} = \varepsilon_{steel} = 0.0025 \]

Sheffield Approach

\[ \varepsilon_{\text{max,FRP}} = 0.0045 \]

\[ \phi = \frac{\varepsilon_{\text{max,FRP}}}{\varepsilon_{y,steel}} \]

Stress Approach

\[ F_{FRP} = F_{steel} \]

\[ \varepsilon_{FRP} \neq \varepsilon_{steel} \]

\[ A_e = A_{FRP} \cdot \frac{E_{FRP}}{E_{steel}} \]

\[ A_e = A_{FRP} \cdot \frac{\sigma_{FRP}}{\sigma_{steel}} \]
Strain Approach & Sheffield Approach

GB 43

GB 44
Conclusions

• Current modifications underestimate shear resistance of FRP RC elements
• Different approaches are needed for different codes
• Improved predictive approaches