



Variation of Carbon Fiber Reinforcement Polymer for Web Bonded Shear Reinforcement

Presented by: Alex S. Larkin, Jovan Tatar

Supporting Faculty Member: Charles W. Dolan, PE, PhD

College of Engineering & Applied Science

Civil & Architectural Engineering

Background

- Continuation of earlier EPSCoR research performed by D. J. Stonebraker, D. L. Brown, C.W. Dolan titled “Effect of web bonded CFRP shear reinforcement on internal steel stress”
- Found that none of the steel yielded in on FRP specimens

Beam Repair Using FRP



<http://www.structuremag.org/images/0108-bb-1.jpg>

Slab Repair Using FRP



http://www.spsrepair.com/Article_Images/Figure%206.JPG

Double T- Beam Repair Using FRP



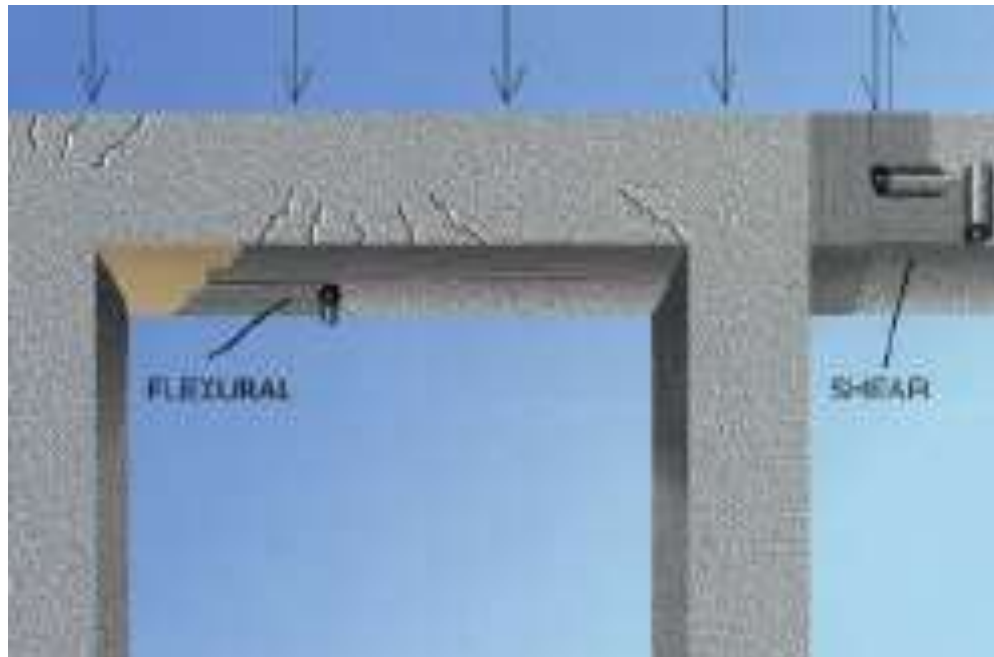
http://www.clas.ufl.edu/jur/200307/images/watson_221.jpg

Beam Repair Using FRP



<http://www-civ.eng.cam.ac.uk/cjb/frpdebond/kidlington6.jpg>

Complete Beam Repair Using FRP



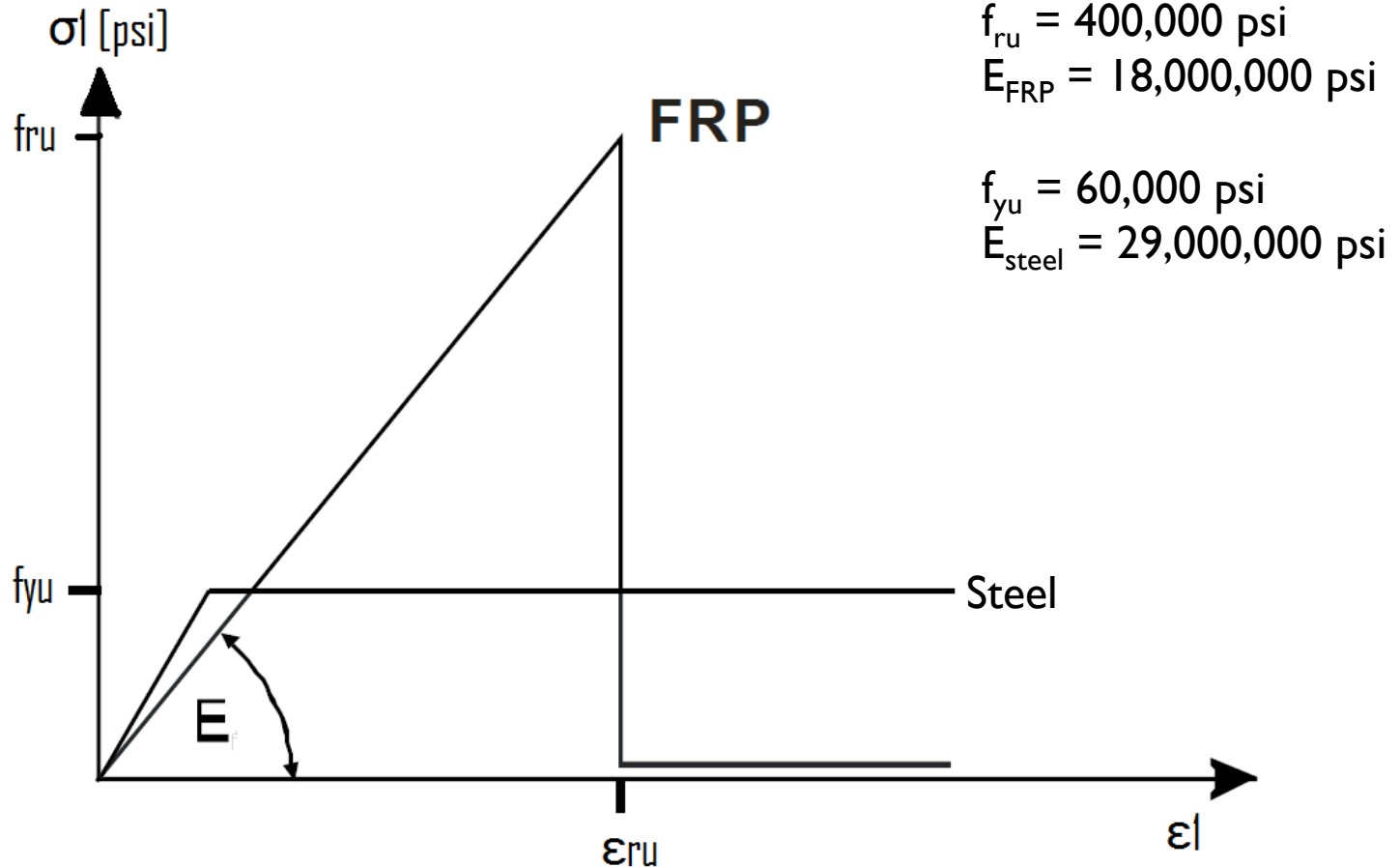
<http://www.mdacomposites.org/mda/images/psgbri4.jpg>

Column Repair Using FRP



http://www.spsrepair.com/Article_Images/Figure%204.JPG

Properties of Materials Used



Selecting Rebar Size

$$S_{\max} = \frac{Avfy}{0.75\sqrt{f'c}(bw)} \dots\dots\dots \frac{0.22(60,000)}{0.75\sqrt{4,000}(16)} = 17.4 \text{ in.} \dots\dots\dots \leq \frac{Avfy}{50bw} = \frac{0.22(60,000)}{50(16)} = 16.5 \text{ in.}$$

Maximum spacing can't exceed $\frac{d}{2} = \frac{22}{2} = 11 \text{ in.}$

With 11 in. , Required spacing $S = \frac{\phi Avfyd}{Vu - \phi Vc} = \frac{0.75(0.22)(60,000)(22)}{43,400} = 5 \text{ in.}$

No. 3 rebar fits easily within a 5 in. spacing , $\rho_{\min} = \frac{2(0.11)}{16(11)} = 0.001$, $\rho_{\max} = \frac{2(0.11)}{16(5)} = 0.003$

For 6" x 6" x 21" Specimen $\rho = \frac{0.11}{6 \times 6} = 0.003$ Okay

Initial Preparation

- Cut Rebar
- Grind smooth surface for strain gauge
- Apply strain gauges
- Connect strain gauge to lead wires



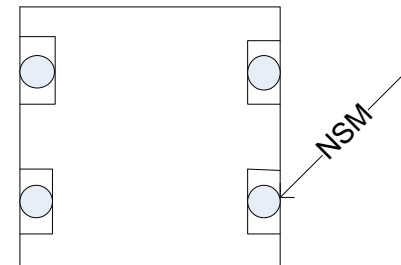
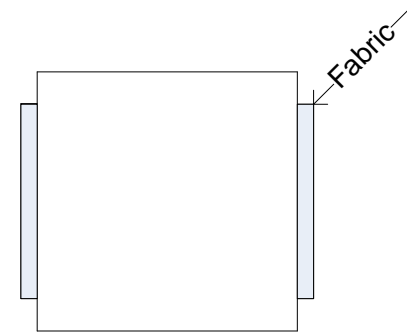
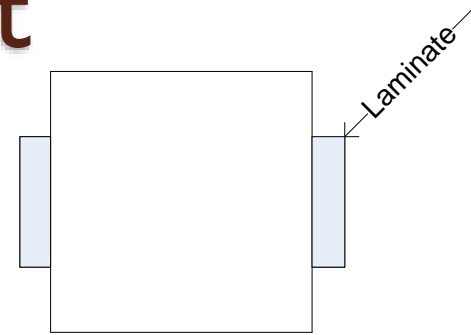
Casting Specimens

- Mix proper concrete proportion to achieve 5000 psi concrete
- Place rebar in proper position with temporary holder



Carbon Placement

- Laminate FRP
- Fabric CFRP
- NSM Carbon Rods



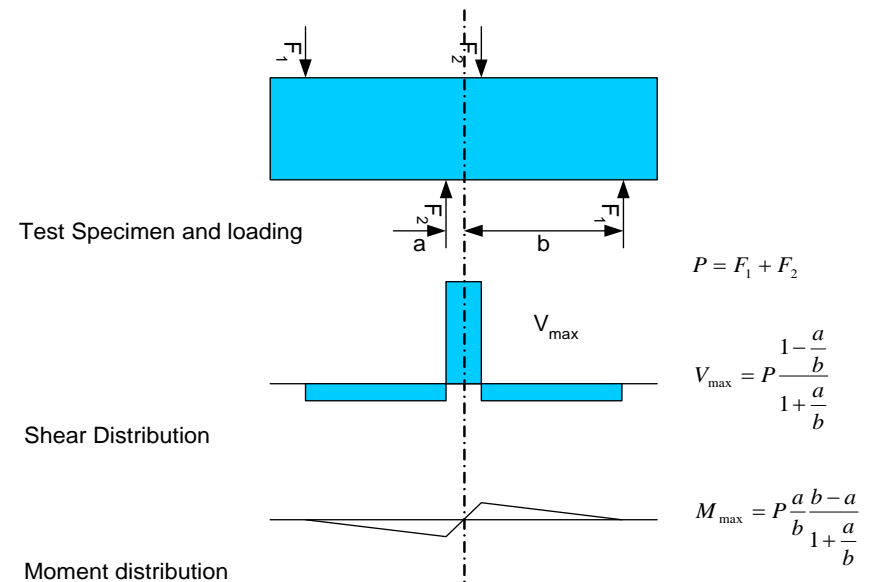
Preparing Carbon Fiber Reinforcement Polymer

- Applying epoxy to pre-cut CFRP

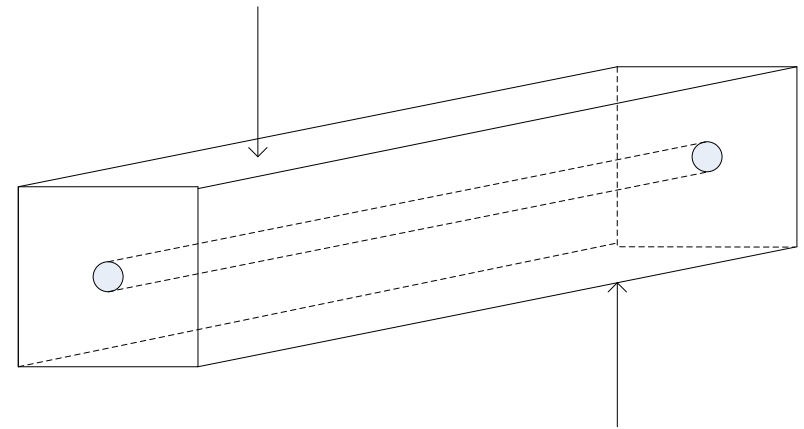


Testing Set Up

- Tinius Olsen Universal Testing Machine
- LabView for collecting data (linear potentiometer, strain gauges)



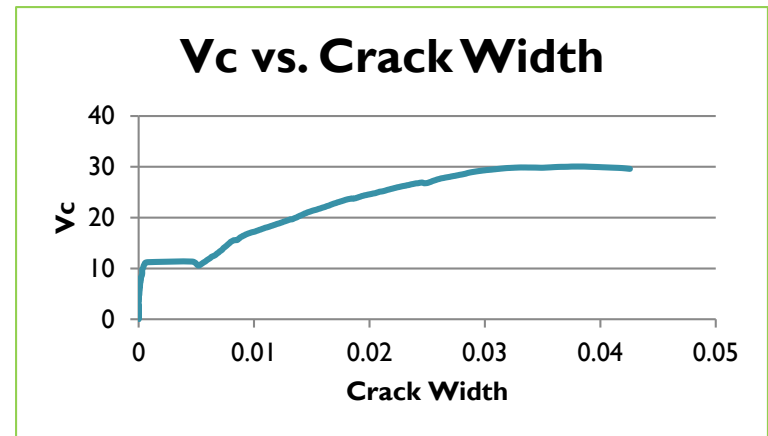
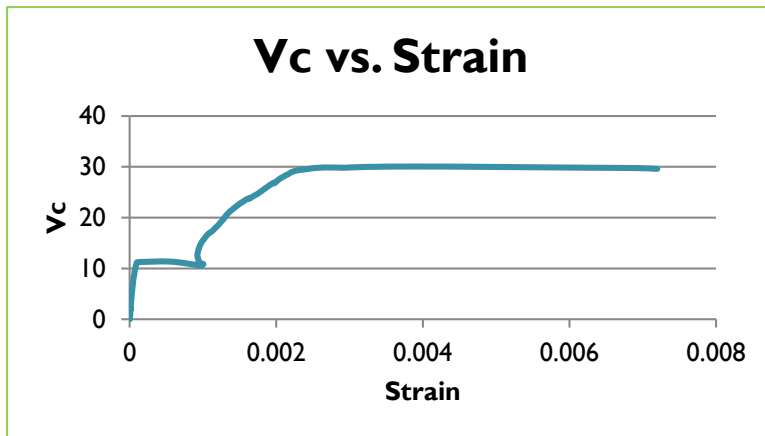
Testing Set Up



- Data Acquisition

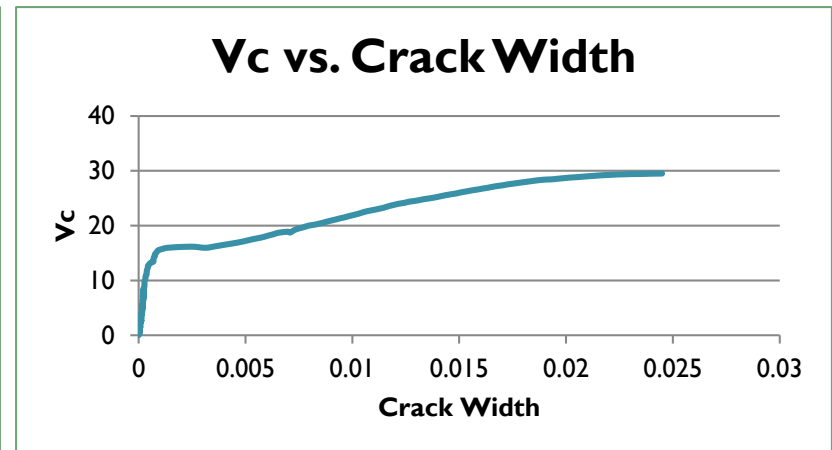
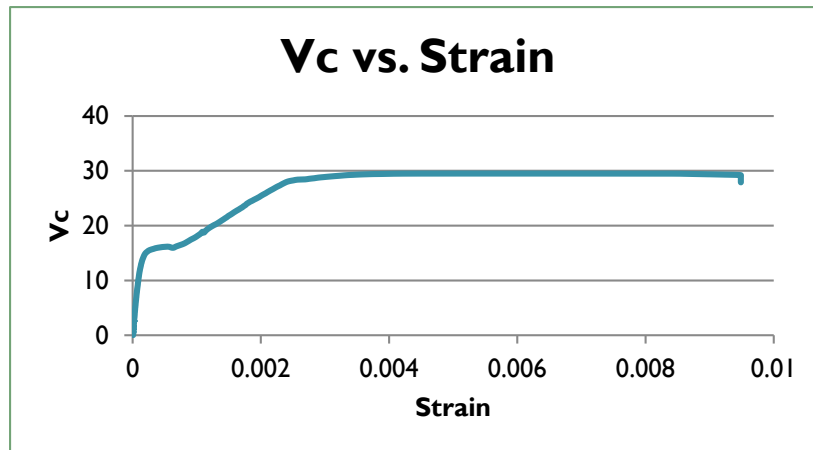
Testing 1 inch specimen

- Maximum shear force at failure is 30 kips



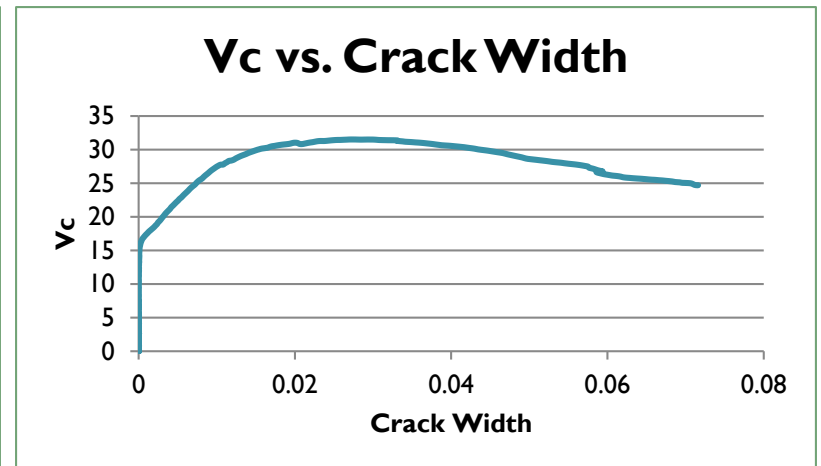
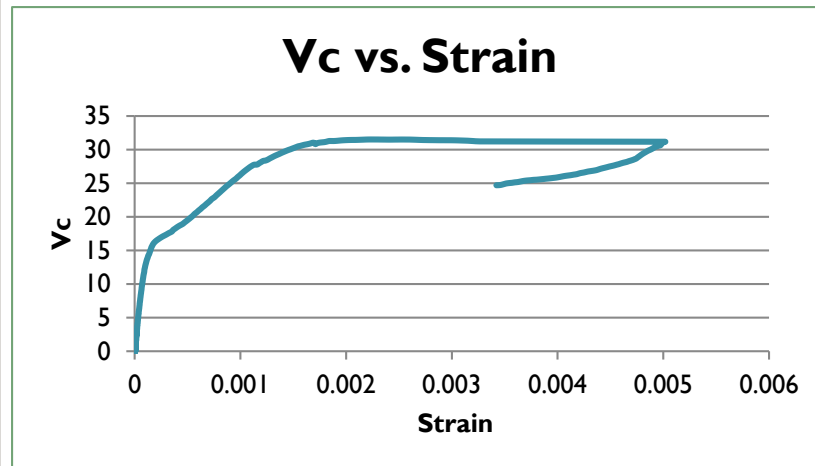
Testing 2 inch specimen

- Maximum shear force at failure of 30 kips



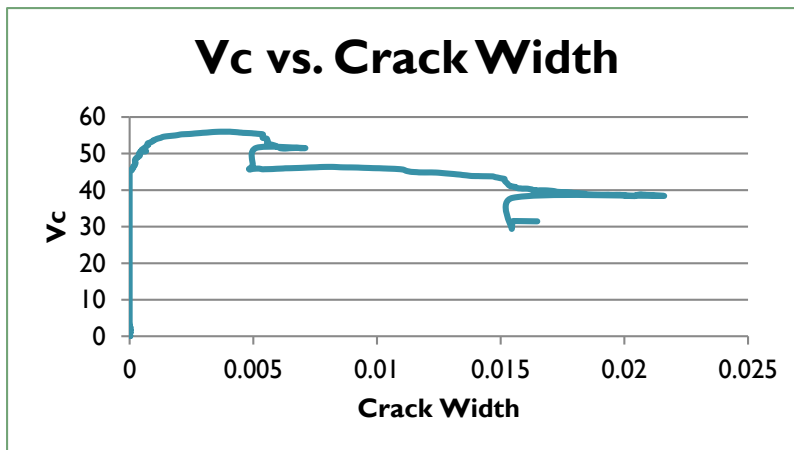
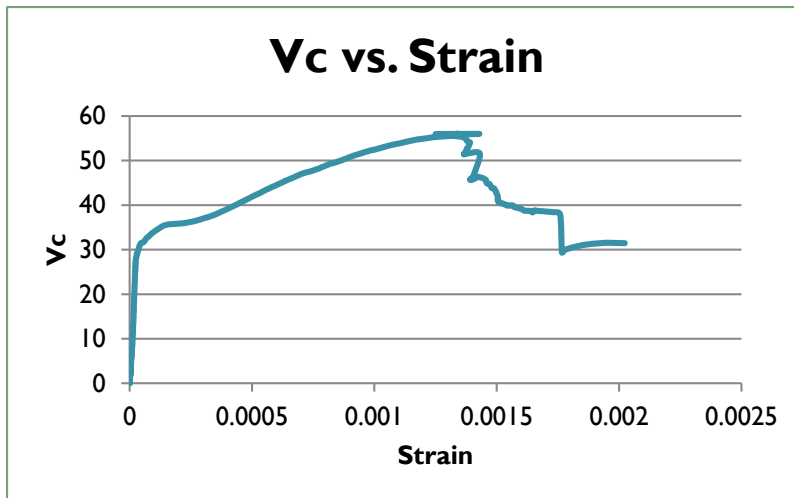
Testing 3 inch specimen

- Maximum shear force at failure is 32 kips



Testing four 3/8" diameter rods

- Maximum shear force at failure is 56 kips

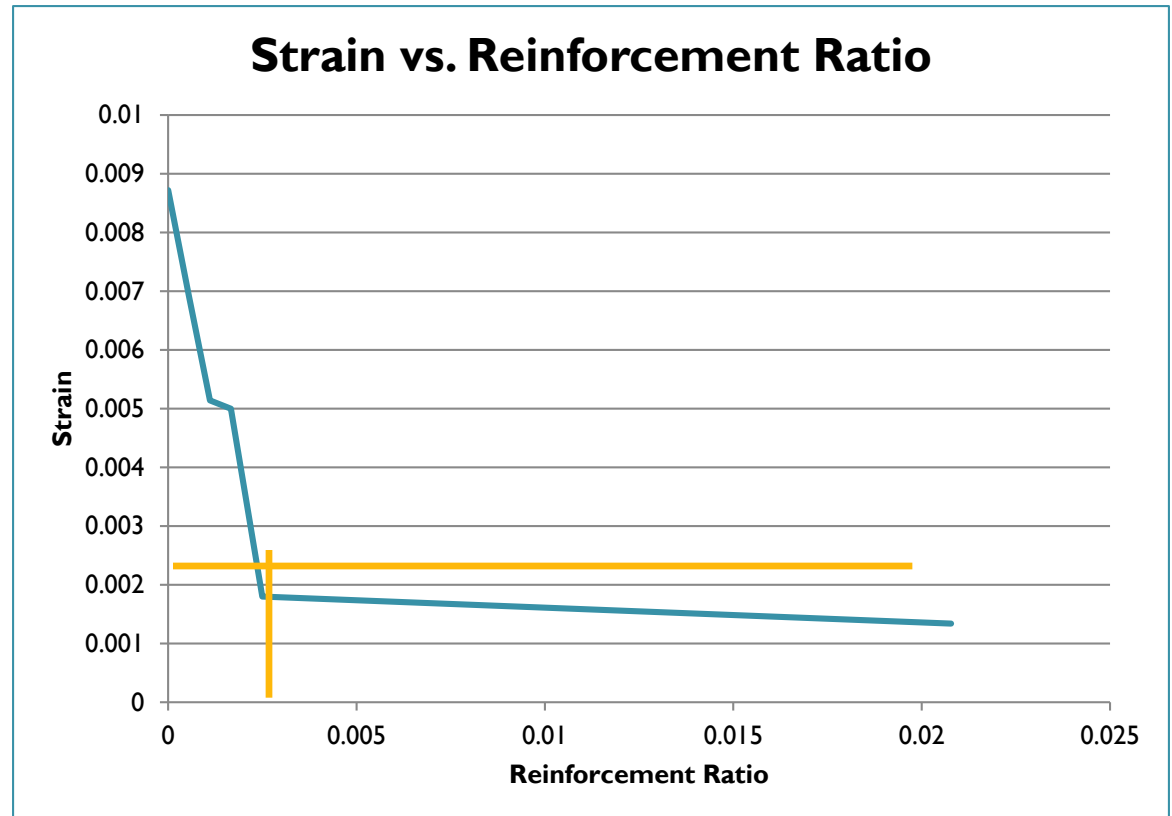


Reinforcement Ratios

Specimen	Strain	Reinforcement Ratio
Plain	0.00872	0
1 inch CFRP	0.00691	0.0006
2 inch CFRP	0.00514	0.0011
3 inch CFRP	0.005	0.0017
2in. X 0.04 in Carbon laminate	0.0018	0.0025
4 Carbon Rods (8mm Diameter)	0.00134	0.0208

Conclusion

Transition
Reinforcement Ratio is
approximately 0.0025



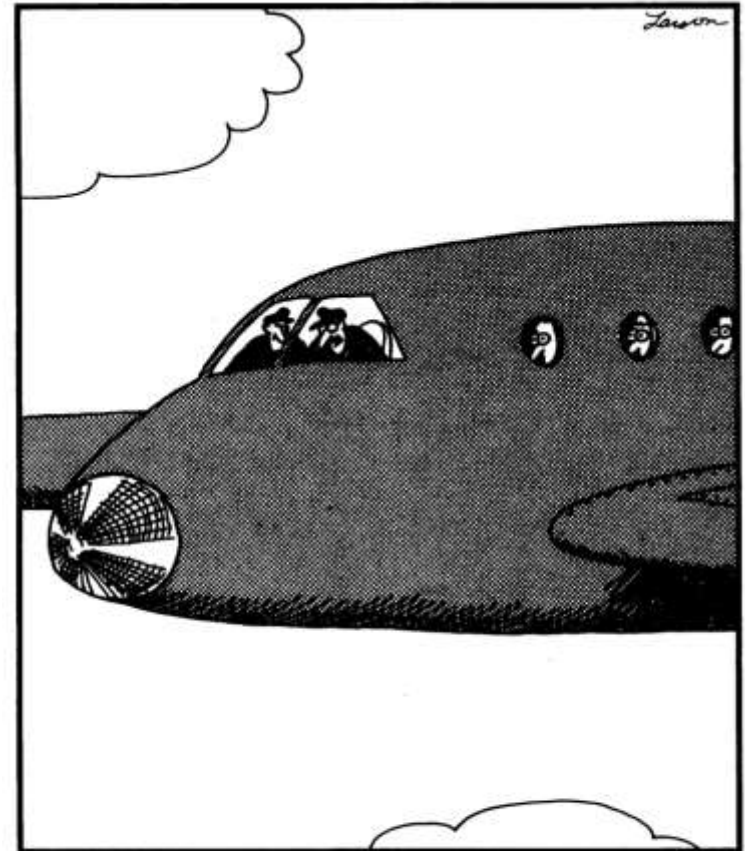
Future Approach

- Longer specimens to avoid bond failure between the concrete and steel reinforcement.
- Attach potentiometer brackets far from projected crack area.
- Use steel plates underneath the load points to prevent bearing failures.

Acknowledgments

- EPSCoR; promoting undergraduate research
- H.T. Person Endowment; financial support
- Charles W. Dolan; supporting faculty member
- Ryan Fertig; support with casting specimens & initial concrete mix
- Hermon Russom; support with casting specimens
- Marvin Perry; testing set-up

Questions



“The fuel light’s on, Frank! We’re all going to die! ...
Wait, wait. ... Oh, my mistake—
that’s the intercom light.”